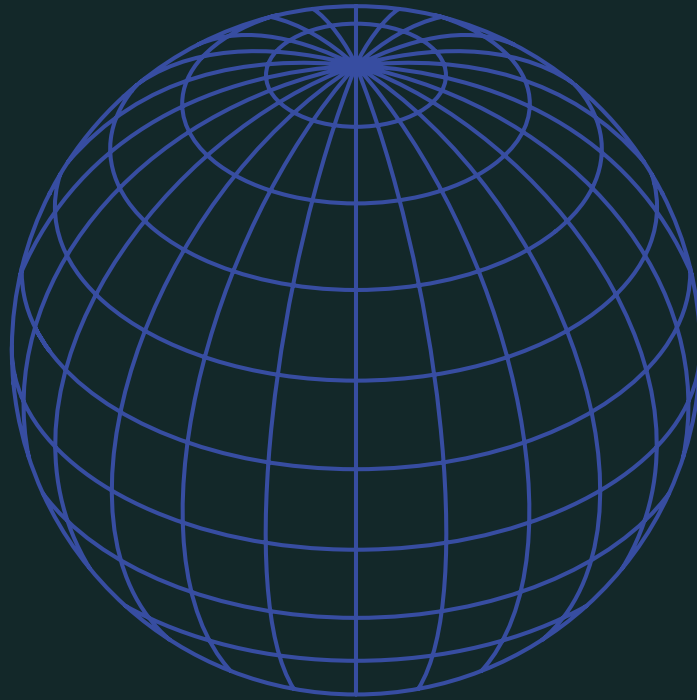




Whitepaper

A Global Look at Central Bank Digital Currencies

From Iteration to Implementation



About



The Block is an information services company founded in 2018. Its research arm, The Block Research, produces research content that covers the digital asset, fintech and financial services industries.

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KPMG LLP is an independent U.S. member firm of KPMG International Cooperative ("KPMG International"). KPMG's Cryptoasset Services is a dedicated practice focusing on crypto and digital assets solving core challenges for our existing and new clients. The Block collaborated with KPMG Cryptoasset Services to research and analyze the state of CBDC adoption and technology.



BRD is a global company that's bringing blockchain-enabled financial services and infrastructure to the modern generation. BRD is a venture-backed company that has raised \$56mm from SBI Holdings, Ripple, and other top investors focused on banking, FinTech, and the blockchain. BRD is the maker of both Blockset by BRD for the enterprise market and the BRD mobile apps for over 5M consumers worldwide.

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Founded in 2018, HashKey Capital is a world-leading blockchain investor and digital asset manager. It provides accredited and professional investors with secure access to a diversified range of digital assets. HashKey Capital has a core investment focus on underlying blockchain technology, digital assets, and crypto-financial infrastructures backed by research-driven strategy and deep industrial experience. For more information, please check <https://www.hashkeycap.com/>

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Abstract

Modern digital financial innovations – namely the rise of electronic money (e-money) – have brought to light deficiencies in existing money and payment systems. Furthermore, the emergence of crypto assets and private stablecoins, particularly Bitcoin in 2008 and Libra in 2019, have sparked intense debate around the role and authority of central banks; some are even speculating on a coming financial paradigm shift worldwide. Monetary authorities contend that society’s trust in money and overall financial system stability are a byproduct of central bank guardianship. However, central bankers do recognize the need to keep up with the latest private sector innovations. While a number of central banks have been working on central bank digital currency (CBDC) research and experiments out of the public eye since at least 2015, recent developments in the digital assets industry have proliferated interest and hastened the frequency of public work. In fact, a 2019 survey by the Bank for International Settlements (BIS) found that nearly 80% of central banks polled were engaged in full CBDC research efforts and various levels of experimentation, up from ~60% in 2017. This white paper examines the growing body of CBDC literature across central banks and international organizations, in conjunction with interviews The Block Research conducted with various stakeholders, to present the global view on central bank digital currencies today: exploring the history, motivations, early technical designs and implementations of the world’s most advanced CBDC proposals.

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Executive Summary

The purpose of this white paper, written for practitioners and enthusiasts alike, is to present a global perspective on the state of central bank digital currency (CBDC) developments to date.

As more countries begin to explore digital currency options and central banks ramp up CBDC pilot experiments, our hope is that this paper can serve as a valuable resource for all stakeholders coordinating to solve this multidimensional puzzle.

Enclosed is an examination of the growing body of CBDC literature across central banks and international organizations, such as the Bank for International Settlements (BIS) and the International Monetary Fund (IMF). In conjunction with interviews The Block Research conducted with various subject-matter experts, we present the global view on central bank digital currencies today: exploring the history, motivations, early technical designs and implementations of the world's most advanced CBDC proposals.

While not completely exhaustive of every initiative globally, the white paper strives to present the most up-to-date snapshot of publicly disclosed CBDC proposals, including both retail and wholesale applications. Questions relating to monetary policy, financial stability, policy considerations, among others, have been proposed across the CBDC literature, and were beyond the scope of this report.

Key finding from the report include:

- While only a handful of central banks are likely to progress toward full project implementation and issue a digital currency within the next 5 years, several have already completed or are in the process of initiating advanced stage pilots.
- Redesigning cash to be digitally native offers a wide opportunity set, from transaction efficiency to asset programmability. However, it still remains to be seen what the true appetite is among policymakers and central bankers. Therefore, public-facing progress will continue to inch forward methodically, but slowly. Meanwhile, the digital assets industry offers a relative low-risk alternative for idea generation and live experimentation.

- The world's first retail CBDC pilots taught stakeholders that private market participation is necessary to maintain competitiveness and adapt to technological change. Furthermore, jurisdictions provided a clear legislative path to project implementation, creating regulatory sandboxes for authorized pilot testing. The success of these first-movers is a testament to the importance of public-private partnerships.
- Most CBDC proposals maintain the two-tier monetary system architecture that rose to prominence in advanced western economies. Central banks believe it is unpragmatic to disintermediate financial institutions, opting instead for strategic utilization of licensed intermediaries to assist with CBDC life cycle processes; these agents often not only include traditional commercial banks, but non-bank service providers as well.
- Over the past 5 years, central bankers' views on CBDC have evolved to become more accepting of collaborative innovation, particularly from the standpoint of joint research and knowledge sharing. In terms of implementation, the challenge isn't necessarily the technology, but the prerequisite social coordination across all stakeholders, as well as disputes over key policy questions in relation to CBDC design and governance.
- A common misconception about central bank digital currencies is that privacy can't exist while transacting. One leading central bank recently explored CBDC anonymity with leading distributed ledger technology (DLT) firms; together they tested a novel proof of concept (POC) using "anonymity vouchers." This POC successfully anonymised CBDC transfers in a distributed ledger environment.
- Privately-issued stablecoins and CBDCs are not contradictions, but rather complements by design; both require trusted, secure and regulatory compliant financial networks to support digital assets. Should a retail CBDC proposal involve asset tokenization using private-public key cryptography, the current digital assets market infrastructure (wallets, exchanges, custodians, stablecoin providers, etc.) would likely play a supporting role.

PART I

Lessons from the early retail CBDC pilots

Sweden: e-Krona [PG.46](#)

Sweden's central bank, the Riksbank, started exploring CBDC in response to a secular decline in cash usage; cash in circulation as a percentage of GDP is now around 1% (down from 4% in 2004), while only about 6% of total household payments were made with cash in 2018. The e-Krona project was initiated in Q1 2017, when the project group developed a three-phase action plan. Phase 3 is currently underway; after three years of CBDC research, the Riksbank launched an e-Krona pilot. Working with Accenture, the Riksbank is testing payment, deposit, and transfer capabilities for a digital version of the Swedish Krona, along with other features in a distributed ledger technology (DLT) environment using R3's Corda. Given Sweden's well-developed financial and payment markets, if launched, an e-Krona could offer a new look at the impact of CBDCs on the competitive landscape of a well-developed payments markets.

Uruguay: e-Peso [PG.54](#)

Like Sweden, Uruguay has seen a decline in both the use and circulation of cash. The Banco Central del Uruguay (BCU) also piloted one of the first general purpose retail-focused CBDCs. Known as the e-Peso, Uruguay's CBDC pilot ran from September 2017 to April 2018 and tested the issuance and distribution of digital banknotes for use in P2P, B2B, and B2C payment use cases. The pilot did not use DLT, instead opting for digital wallets that operated through state-owned telecommunications provider Antel. Key features of the system included: anonymity of P2P transactions, instantaneous settlement, offline transactions, and unique cryptographic signatures on each e-Peso bill with a specific denomination (no fractionalization).

Ukraine: e-Hryvnia [PG.58](#)

Ukraine has made meaningful progress on its retail CBDC proposal, and arguably has provided the most publicly available technical perspective among European nations. The National Bank of Ukraine (NBU) successfully tested an electronic form of its hryvnia currency, the e-hryvnia, in 2018. E-hryvnia pilot results were formally released in June 2019. In February 2020, the NBU shared its CBDC vision and e-hryvnia project findings with global central bank representatives at the "Central Bank Digital Currencies: New Payment Opportunities" international conference in Kiev.

PART II

Pilots of the Caribbean: Emerging Market retail CBDC implementations

The Bahamas: Project Sand Dollar [PG.70](#)

Project Sand Dollar is a Bahamian Payments System Modernization Initiative (PMSI) that is upgrading financial market infrastructure and digitizing the Bahamian dollar. Today, the Sand Dollar is a live CBDC pilot implementation currently being tested within the districts of Exuma & The Abacos Islands and is an official line item on the Central Bank of the Bahamas (CBOB) balance sheet. Geared towards improving financial inclusion and serving a country that has geographical payment infrastructure constraints (a network across 700 fragmented islands), the Bahamian Payments System Modernization Initiative has provided the CBDC pilot a more direct path towards implementation relative to other central bank proposals. Looking ahead, pilot data will assist the national Sand Dollar rollout, which is expected in Q4 2020.

DXCD Caribe Network: The Digital Eastern Caribbean Dollar [PG.84](#)

The Digital Eastern Caribbean Dollar Pilot Project, or DXCD Caribe, is part of the Eastern Caribbean Central Bank (ECCB)'s Strategic Plan 2017-2021, an initiative created to modernize the Eastern Caribbean Currency Union (ECCU) financial system. Barbados-based fintech company Bitt is working with the ECCB to issue a digital Eastern Caribbean dollar (DXCD) – using Bitt's Digital Currency Management System (DCMS) stack, the DXCD network is built on a custom version of IBM's Hyperledger Fabric blockchain platform. After Covid-19-related delays, DXCD is set for live deployment activities at the end of Q3 2020. DXCD will initially be piloted in Antigua and Barbuda, St. Kitts and Nevis, Grenada, and St. Lucia.

PART III

The Wholesale CBDC Pilots: opportunities within interbank settlement and cross-border payments [PG.100](#)

One area of technological innovation that has interested central banks is the use of central bank digital currency for wholesale payment applications, known as wholesale CBDC (W-CBDC). Central banks are exploring whether W-CBDC could reduce settlement risks, provide 24/7 up-time, widen interoperability with other settlement systems, reduce cross-border payments, and more.

Executive Summary

We examine the history and unique findings of some of the most well-known publicly-disclosed wholesale CBDC experiments by central banks to date, including:

Project Stella (European Central Bank and Bank of Japan) [PG.106](#)

Project Stella is a joint research project conducted by the ECB and the BOJ. It explores the opportunity for DLT to improve financial market infrastructure to support payment and securities settlement. Project Stella outlines the 4-stage technical path to issue and maintain DLT-based digital money for reserve and settlement balances at a central bank.

Project Ubin/Jasper (Monetary Authority of Singapore and Bank of Canada) [PG.116](#)

Project Ubin began as a collaborative project across the Monetary Authority of Singapore (MAS), the Association of Banks in Singapore (ABS), and several international financial institutions to explore the use of distributed ledger technology for clearing and settlement use cases. The Ubin Project was a multi-year, multi-phase project. Currently, all five phases have been completed. In Phase 4, the MAS and Bank of Canada conducted a successful cross-border payment experiment using CBDCs. Looking ahead, the research and experimentation from Project Ubin is helping to shape future live commercial solutions that leverage DLT and tokenized fiat – the latter could include central bank-issued digital currency.

Project Inthanon/LionRock (The Hong Kong Monetary Authority and Bank of Thailand) [PG.130](#)

Inthanon-LionRock is a joint initiative launched by the Hong Kong Monetary Authority and the Bank of Thailand to explore wholesale CBDC use for cross-border payments. The joint research project of the Hong Kong Monetary Authority and the Bank of Thailand reflects a broader collaborative trend of central banks working together to test wholesale CBDC use cases via exploratory pilots.

Many of these wholesale CBDC projects involve potential applications for wholesale tokenized fiat issued by the private sector rather than a digital token issued by the central bank. In other phases of experimentation, central banks focused on testing unique aspects of distributed ledger technology, rather than tokenized central bank money.

Wholesale CBDC and DLT-based settlement experiments conducted by

central banks are still highly exploratory in nature. Should the handful of central banks that have been public with their proof-of-concepts and early experimentation move to implement some of these systems, previous adoption curves by central banks on implementing real-time gross settlement (RTGS) systems, and more recently retail-fast payment systems, suggest that wider adoption of W-CBDC and/or DLT-based settlement systems is still at least over a decade away.

PART IV

China's Digital Currency Electronic Payment system [PG.136](#)

China DC/EP - China's Digital Currency Electronic Payment (DC/EP) offers arguably the most developed experiment of CBDC in an advanced economy. However, there are more questions than answers surrounding the proposal as there is still no official People's Bank of China (PBOC) DC/EP policy or documents that explain the design details. In December 2019, the PBOC partnered with seven state-owned companies — the Industrial and Commercial Bank of China, Bank of China, China Construction Bank and the Agricultural Bank of China, China Telecom, China Mobile, and China Unicom — to roll out the DC/EP test. In April 2020, the PBOC confirmed it had been internally testing DC/EP in 4 cities, including Shenzhen and Suzhou, while the Agricultural Bank of China released a mobile test app to support the project. While PBOC governor Yi Gang recently said the central bank does not yet have a timetable for the official launch of a digital yuan, Yi did confirm that DC/EP may be piloted at the 2022 Beijing Winter Olympics.

PART V

A brief look at other CBDC discussions within advanced economies

United Kingdom [PG.152](#)

The Bank of England was one of the first central banks to initiate public research on CBDCs with its “One Bank Research Agenda” discussion paper in 2015. In March 2020, the BOE published a paper describing its CBDC efforts and how a BOE-issued digital currency would work, as well as the opportunities it would present. However, the BOE has reiterated that it is only exploring the benefits, challenges, and practicalities of a potential digital issuance, and has not yet determined whether it will introduce a CBDC.

Executive Summary

Europe [PG.155](#)

One of the first central banks to officially study digital assets, the ECB released its Virtual Currency Schemes report in October 2012 and created a CBDC task force at the end of 2016. Wholesale CBDC activity has mainly occurred under Project Stella, through which the ECB has published research works and executed four POCs to date. In collaboration with Accenture and R3, EUROchain developed a POC built on R3's Corda platform, testing novel privacy features for lower-value CBDC transactions.

Canada [PG.159](#)

The Bank of Canada is one of a handful of central banks that have actively researched CBDCs publicly since 2016. The central bank has a number of ongoing working papers and is testing piloted wholesale implementations through a 4-phase project known as Project Jasper. In early 2020, it concluded that the bank does not yet see a “compelling” case to issue a Canadian digital dollar. Instead, the BOC has issued a contingency plan to prepare for scenarios that could warrant the launch of a CBDC.

Japan [PG.160](#)

Outside of its Project Stella partnership with the ECB to test wholesale CBDC and DLT applications, the BOJ formally began research into CBDCs with five other major central banks in 2020. In July 2020, reports surfaced suggesting the Japanese government will include a CBDC plan in its upcoming policy framework. Following the report, the BOJ set up a new dedicated team to further study digital currencies.

United States [PG.163](#)

The U.S. Federal Reserve has largely been conservative in public-facing discussion, research, and pilots surrounding CBDC. Instead, the U.S. provides a study of the private market leading solutions to CBDC, driven by alternative private digital currencies such as Libra, stable-coin initiatives and industry advocacy initiatives for a Fed-issued digital dollar such as the Digital Dollar Project. In August, the Federal Reserve Bank of Boston entered a "multi-year collaboration" to build and test a “hypothetical” open-source central bank digital currency platform with the MIT Digital Currency Initiative.

Introduction

● Central Bank Digital Currency - Key Events

○ 1994	○ 1996	○ 1999	○ 2007
A subsidiary of the Bank of Finland launches the Avant card, an "electronic purse" tied to a card that could be reloaded with money	BIS publishes report on "Implications for Central Banks of the Development of Electronic Money" noting proliferation of e-cash	Milton Friedman predict reliable e-cash that provides anonymity similar to that of cash will develop on the internet	M-Pesa, a service to send mobile e-money, launches in Kenya. In 2 years it is used by more than half the population of Kenya
○ 2016	○ 2017	○ 2018	○ 2019
<p>BOE Chief Economist questions whether CBDC could solve Zero Lower Bound interest rate problem in speech</p> <p>The National Bank of Ukraine (NBU) announces e-hryvnia</p> <p>Bank of Canada, Payments Canada and R3 launch Project Jasper to study how DLT could impact payments and interbank settlement - Mar 2016</p> <p>Bank of Japan and ECB launch Project Stella to study use of DLT on financial market infrastructure (FMIs) - Dec 2016</p> <p>Over 90 central banks attend event in Washington DC to discuss plans and ideas for CBDC</p> <p>BOE releases first publicly published paper by a central bank using the term CBDC and discussing macroeconomic implications - July 2016</p>	<p>Sweden's Riksbank e-krona project begins Mar 2017</p> <p>Central Bank of Uruguay launches E-Peso pilot Nov 2017</p> <p>MAS and The Association of Banks in Singapore (ABS) announce consortium to explore RTGS with DLT Oct 2017</p> <p>Central Bank of Uruguay launches E-Peso pilot Nov 2017</p>	<p>Riksbank releases E-krona project report 2 Oct 2018</p> <p>NBU starts e-Hryvnia retail CBDC pilot Feb 2018</p>	<p>BIS releases central bank survey that finds ~70% are "engaged" in CBDC work Jan 2019</p> <p>Eastern Caribbean Central Bank and Bitt sign contract for CBDC pilot Feb 2019</p> <p>Central Bank of The Bahamas selects NZIA Limited as tech partner for Project Sand Dollar-Mar 2019</p> <p>South African Reserve Bank releases CBDC expression of interest into CBDC Apr 2019</p> <p>Facebook Libra v1 whitepaper is released June 2019</p> <p>National Bank of Cambodia launches "Bakong Project" pilot July 2019</p>

○ 2008	○ 2012	○ 2014	○ 2015
<p>₿ Satoshi Nakamoto releases Bitcoin white paper</p>	ECB releases "Virtual Currency Schemes" report, declaring digital assets fall under ECB responsibility Oct 2012	<p>JP Koning publishes "Fedcoin" blog post</p> <p>Central Bank of Ecuador starts "Dinero Electronico," making it first country to roll out digital cash Dec 2014</p>	<p>The People's Bank of China starts digital currency electronic payment (DC/EP) research</p> <p>Bank of England (BoE) publishes research agenda that considers possibility of issuing digital form of cash as a core part of the agenda Feb 2015</p> <p>Ethereum, an open-source smart contract platform launches July 2015</p>
○ 2020			
<p>Senior official at PBOC announces country will "soon roll out" its CBDC "DC/EP" Aug 2019</p> <p>IMF officials say 'synthetic CBDC' with public/private partnership better option for CBDCs Sep 2019</p> <p>Hong Kong Monetary Authority and Bank of Thailand complete Project Inthanon-LionRock POC for wholesale use cases Dec 2019</p> <p>Central Bank of The Bahamas releases "Project Sand Dollar" whitepaper and begins pilot in Exuma Dec 2019</p>	<p>World Economic Forum publishes CBDC policy toolkit to help central banks decide if CBDC is right for them Jan 2020</p> <p>National Bank of Cambodia announces plans to launch Bakong, an interbank payments platform Jan 2020</p> <p>Bank of Canada says they will make CBDC contingency plans, but sees "no compelling case" to issue at this time Feb 2020</p> <p>Bank of Canada researchers say zero-knowledge proof privacy tech still too immature for CBDC use June 2020</p> <p>BIS new central bank survey finds 80% of central banks are "exploring" CBDC Jan 2020</p>	<p>BoE joins with Bank of Canada, Bank of Japan, ECB, Riksbank, and Swiss Bank to explore CBDCs Jan 2020</p> <p>The Digital Dollar Project is announced to accelerate public conversation of the Fed exploring a CBDC Jan 2020</p> <p>ECB announces its working on retail CBDC as part of an investigative task force May 2020</p> <p>PBOC confirms it has been internally testing DC/EP in 4 cities Apr 2020</p> <p>Libra launches v2 white paper, suggests hope that as CBDCs develop, these could directly integrate with Libra network Apr 2020</p>	

Money and Payment Systems are Currently Under the Spotlight

Fiscal and monetary authorities from around the world are watching closely as the circulation of consumer cash and credit shifts increasingly to non-bank payment service providers (PSPs) and financial technology companies.

As the technology landscape evolves, digital financial innovations — particularly advancements in electronic money (e-money) and online mobile platforms — are conditioning consumers to expect instantaneous, around-the-clock payments.

The International Monetary Fund (IMF) notes that e-money already prevails in regions such as Kenya and China, with the value of Chinese e-money transactions through WeChat Pay and Alipay surpassing the worldwide volume of Visa and Mastercard combined.³

The Monetary Authority of Singapore defines e-money as an “electronically stored monetary value in a payment account that can be used to purchase goods or services, or to transfer funds to another individual.”

Technology companies are disintermediating financial institutions at

Volume of cashless payments is growing rapidly in recent years, especially in Emerging Markets

	2014	2015	2016	2017	2018	2014-18 CAGR
China	36,620	66,709	96,639	133,920	198,362	52.6%
India	4,644	6,995	10,926	15,811	24,430	51.4%
Russia	11,367	14,338	19,174	25,797	34,836	32.3%
Saudi Arabia	498	587	736	947	1,286	26.8%
Indonesia	4,773	6,029	7,416	8,985	11,044	23.3%
Argentina	1,385	1,548	1,845	2,049	2,375	14.4%
Turkey	3,748	4,165	4,620	5,325	6,274	13.7%
Korea	18,896	21,131	23,215	25,717	28,230	10.6%
Mexico	3,495	3,798	4,030	4,546	5,068	9.7%
South Africa	3,432	3,798	4,386	4,484	4,940	9.5%
Australia	9,060	9,936	11,003	12,257	12,941	9.3%
Italy	4,709	5,177	5,698	6,035	6,700	9.2%
Switzerland	1,799	2,022	2,146	2,327	2,547	9.1%
United Kingdom	21,270	23,080	25,152	27,139	29,778	8.8%
Sweden	3,900	4,202	4,777	4,995	5,380	8.4%
Netherlands	6,452	6,796	7,174	7,800	8,707	7.8%
Spain	6,490	6,475	7,069	8,176	8,607	7.3%
United States*	128,237	135,139	142,962	154,448	N/A	6.4%
Germany	17,620	19,370	19,931	21,009	22,260	6.0%
Brazil	27,582	28,251	28,954	31,065	34,600	5.8%
Canada	11,531	12,000	12,610	13,315	14,452	5.8%
France	18,958	20,208	20,908	21,964	23,498	5.5%
Belgium	3,436	3,239	3,436	3,852	4,254	5.5%
Singapore	3,886	4,029	4,256	4,391	4,687	4.8%

* For the US, 2018 data were not available, so the Compound Annual Growth Rate (CAGR) shown is for 2014-17. Source: BIS Red Book, J.P. Morgan

Figure 1: Total number (volume) of cashless payments by country, millions
Source: BIS Red Book, J.P. Morgan

the monetary unit level; cash and bank deposits are giving way to e-money, as it offers consumers a more convenient and personalized means of payment. If current trends continue, the potential implications for payment systems, monetary systems and, ultimately, the global financial system could be quite profound.

Statistics from the BIS Red Book¹² highlight that cashless payments have risen sharply since 2014, particularly in emerging economies. China has seen cashless payments increase by more than 5 times over from 2014 to 2018, while demonstrating that cashless economies can increase financial access at scale.

The prevalence of cashless economies has led many to wonder if the world at large is heading toward becoming a cashless society. Yet, almost paradoxically, despite the rise of cashless payments, the use of cash (and cash in circulation relative to GDP) is still increasing in most countries, according to the latest BIS Red Book data in 2018. Recent trends from the Covid-19 crisis¹³ — worries over viral transmission from cash have pushed contactless card usage even higher, while economic uncertainty has driven a rise in precautionary cash holdings — have only clouded this picture further for the time being.

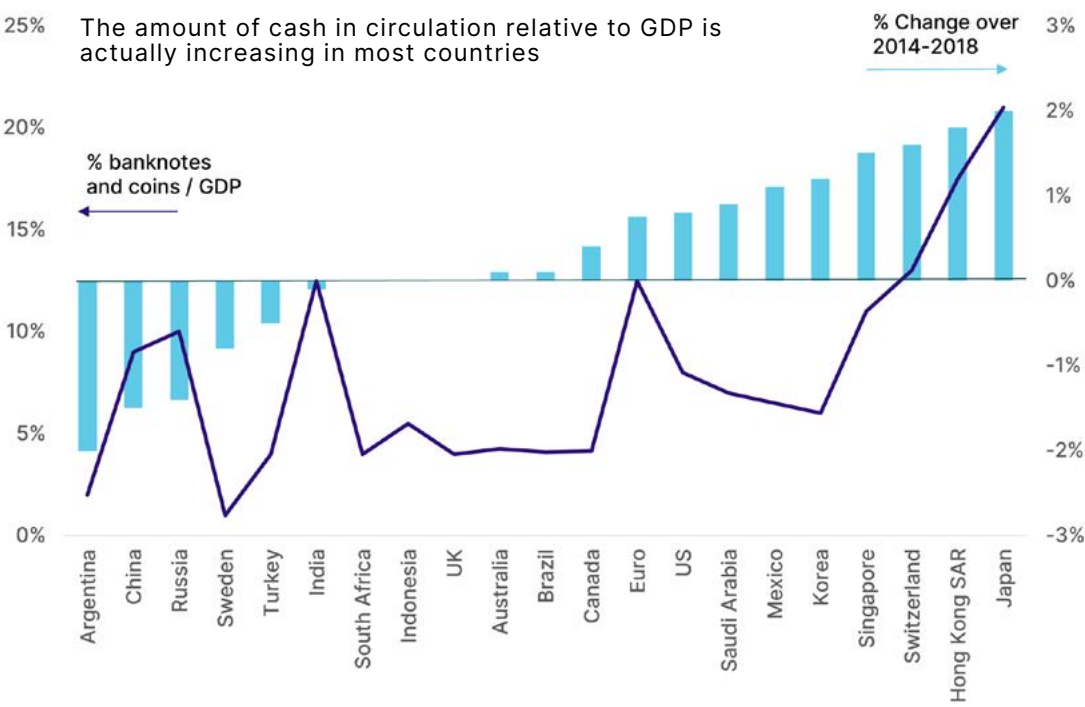


Figure 2: Change over 2014-2018 and total 2018 level of banknotes and coins in circulation relative to country GDP
Source: BIS Red Book, J.P. Morgan, The Block

Central bank mandates extend beyond just managing monetary policy to achieve price stability. They also serve a critical role in ensuring economic and financial stability.

One core area within financial stability is the ability to provide efficient, resilient, and accessible ways for households and businesses to make payments. It has been well-documented that a functioning payment system can support long run economic growth and deepen economic activity.¹⁴ Central banks also play a critical role in providing and operating public payment and market infrastructure, while also acting as “guardians” in maintaining the safety and integrity of these systems. In their roles as payments systems operators, central banks histori-

cally have encouraged private sector innovation to improve payment efficiency, safety, and accessibility. As payment innovation evolves, central banks must continue to evaluate technological innovations that could enhance and improve current systems — while also being mindful of legacy public infrastructure competitiveness.

According to the BIS, the Group of Ten (G-10) central banks have been studying e-money developments and related policy issues since the end of 1995. Although the concept of e-money isn't novel, the scale and reach are now unprecedented, largely thanks to the prevalence of mobile devices around the world. More recently, the emergence of crypto assets and private stablecoins — most notably bitcoin in 2008 and Libra in 2019 — have sparked new speculation that the role of central bank oversight and management of money may undergo a fundamental shift.

As payment systems and financial market infrastructure operators, wrapped in all of this is a growing pressure for central banks to decide how, if at all, they should react to some of these trends. At a higher level, many are questioning or are in the process of providing 24/7 payment networks and base level financial services to all.

One area of technological innovation that has interested central banks on this front is the use of central bank digital currency for either retail, and or whole-sale (business) payment applications. Indeed, the research and literature on

the topic of CBDCs has proliferated over the past 5 years — 2020 is on pace to have over 5 times as many unique mentions of 'CBDC' in 2020 academic papers versus 2017, according to Google Scholar.

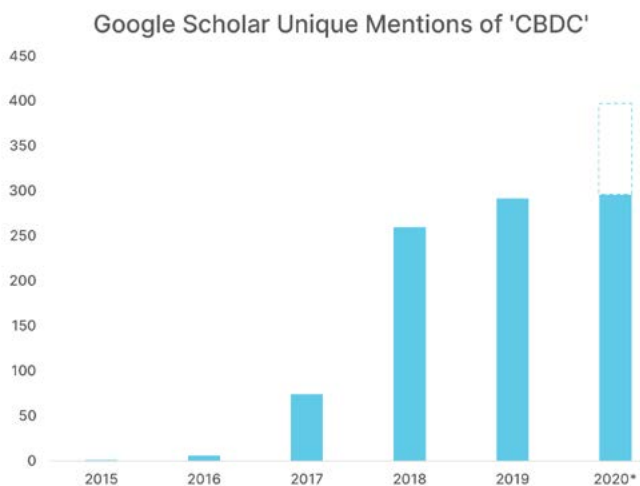
CBDC Taxonomy – Where does it fit compared to “digital dollars” and e-money?

Classifications through a taxonomy can be an instrumental tool to help organize and communicate ideas. As payments innovations continue to expand the form and representation of money, the notion of a taxonomy of digital money continues to evolve as well. But there is still no universally accepted framework to categorize e-money against digital

Figure 2: Change over 2014-2018 and total 2018 level of banknotes and coins in circulation relative to country GDP

Source: The Block, Google Scholar

Note:*



forms of bank money, or the latest developments within crypto assets alongside central banks' exploration of digital currency.

In regards to a taxonomy for money, the IMF has laid out a “Money Tree” framework² which classifies types of money based on a branch-like structure through 4 key attributes of varying means of payments: 1) type, 2) value, 3) backstop, and 4) technology.

The first attribute, type, defines a means of payment as either a claim or an object. A claim can be the traditional “account-based” payment systems, whereas an object is more closely aligned to “token-based” payment systems. The reason the International Monetary Fund (IMF) and a growing list of research (see footnotes) prefers to distinguish further from account vs token based payment is due to the fact that a “token” tends to be coupled with the technology used (in the case of discussing CBDC – blockchain or DLT). There is a building debate that blockchain-based payment systems are more suited to be labeled as account-based since it verifies ownership of an asset via addresses associated with a ledger. Whether that ledger is distributed, or centrally managed, shouldn't impact whether a system is account or token based.

Object-based payments systems settle near instantly and don't require any exchange of information to complete the transaction — the most common example of object-based payments are cash. Claim-based payments, however, offer a way to scale and simplify transactions, at the cost of a need for intermediaries and more complex infrastructure (and counterparties) to complete the transaction. Today, most payments are done through claim-based systems.

The second attribute of payment is how value is redeemed: If a payment system is claims-based, value can be redeemed by either a pre-established fixed redemption (sending someone \$1 via Venmo is redeemable for \$1) or a variable value redemption which implies the money used for payment has a fluctuating market rate redemption value (the price of bitcoin redeemed for dollars is constantly changing).

The third attribute, which only applies to claim-based payment systems, determines how the claim redemption value is guaranteed or protected. Two examples are either 1) directly through the government (commercial bank money) or 2) through the private market which uses various legal and operational structures to provide varying levels of assurances.

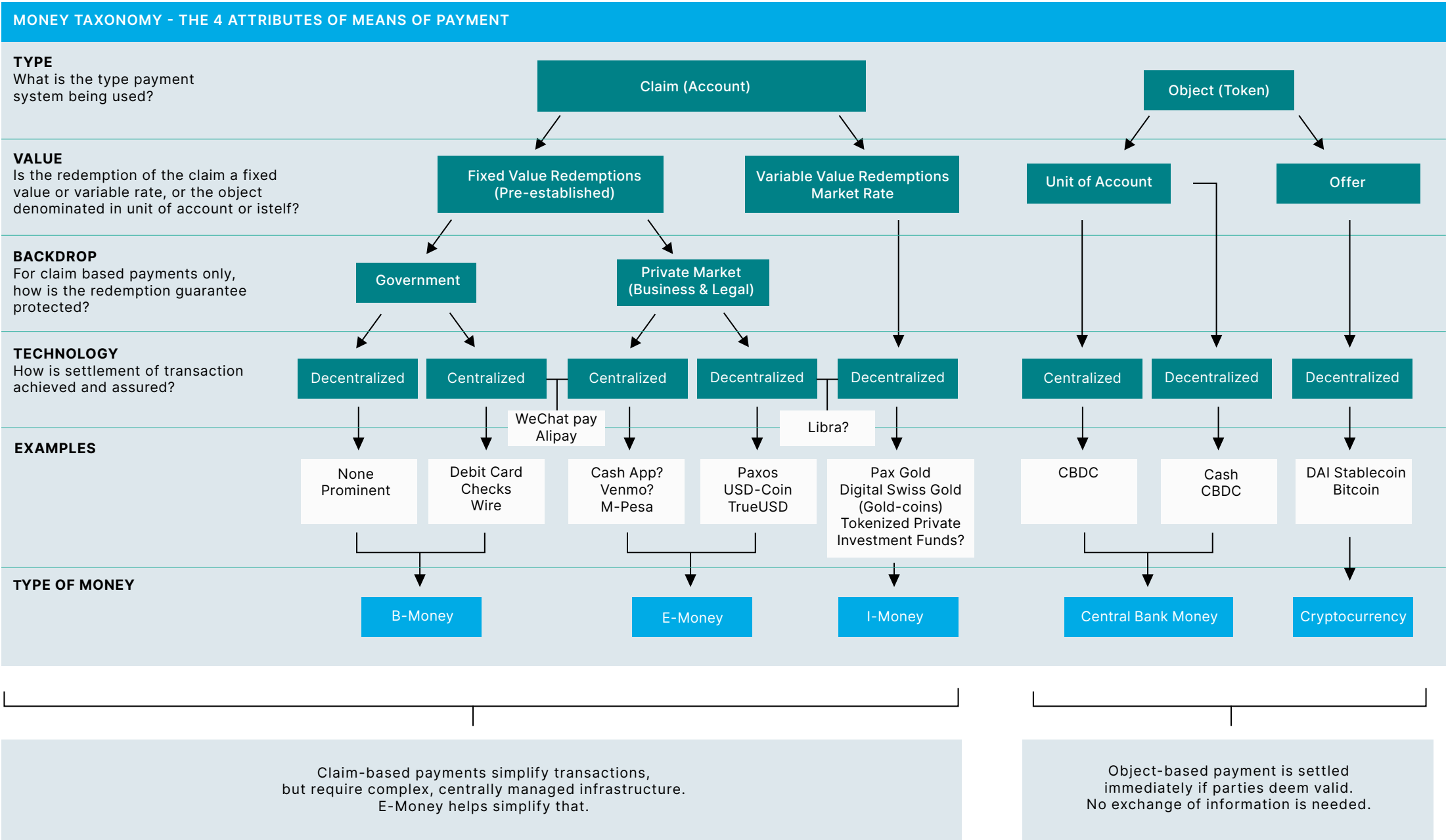


Figure 4: The Money Tree Taxonomy
Source: The Block, IMF

“A Central Bank Digital Currency (CBDC) would be an electronic form of central bank money that could be used by households and businesses to make payments. The key differentiation between reserves (which have been electronic and central bank issued for decades) is that they are universally accepted to all households. And unlike bank-notes, would be fully-digital.”

The final attribute in the IMF’s Money Tree is the technology of the payment settlement. Is the transaction settled through a centralized intermediary, or does it make use of distributed-technologies or blockchain?

Together, these attributes help to define what different types of money look like. After following the decision tree logic, payments are grouped into five different types of money, including (1) b-money, which banks issue currently, (2) e-money, (3) investment money (i-money), (4) central bank money, and (5) cryptocurrency, which is presented in the flow chart on the left.

On the surface this taxonomy feels adequate, but closer inspection of new payment innovations and proposals of central bank digital currencies (CBDCs) pose thorny questions.

As some countries move to push e-money providers to secure deposits at the central bank level, like China’s Alipay and WeChat Pay securing deposits at the PBOC, or the proposal of a tokenized basket of currencies via Libra (which originally looked more akin to a tokenized SDR basket), some of these examples don’t fit neatly within a framework built around 4 attributes of payment.

In the US, would one consider Zelle or Venmo b-money or e-money?

In the case of Zelle, while the initial form of money sits within users’ bank deposits, and thus backstopped by government-insured deposits, the process of payment actually pushes the backstop to the private market as Zelle payments in movement aren’t FDIC insured, and if they are sent to the wrong recipient they aren’t protected on being

returned.¹⁵ These are just a couple examples that highlight expanding gray areas when building commonly accepted taxonomies for digital money.

For the purposes of defining Central Bank Digital Currencies (CBDC), there are a number of questions that arise when using a framework that only considers 4 core defining attributes:

- What distinguishes CBDC from cash besides being a digital representation of cash?
- Does CBDC require decentralization or DLT-like infrastructure?
- Could forms of CBDC be claim-based or account-based payment systems?
- What about the ability to offer programmability?

The latest IMF working paper on CBDC helps to address some of these gaps from the Money Tree framework through a broader classification of CBDC taxonomy by first defining CBDC as a digital representation of a sovereign currency, issued by a central bank.³

The paper then compares cash to CBDC to broader e-money/business money as well as cryptocurrencies on 6 different dimensions:

- 1) central bank-issued
- 2) fiat-pegged
- 3) legal tender
- 4) backed by deposits at the central bank
- 5) can be used to transact peer-to-peer via electronic forms of payment
- 6) can also be programmable with smart contract functionality

KEY MONEY ATTRIBUTES MATRIX: CBDC VS OTHER FORMS OF MONEY

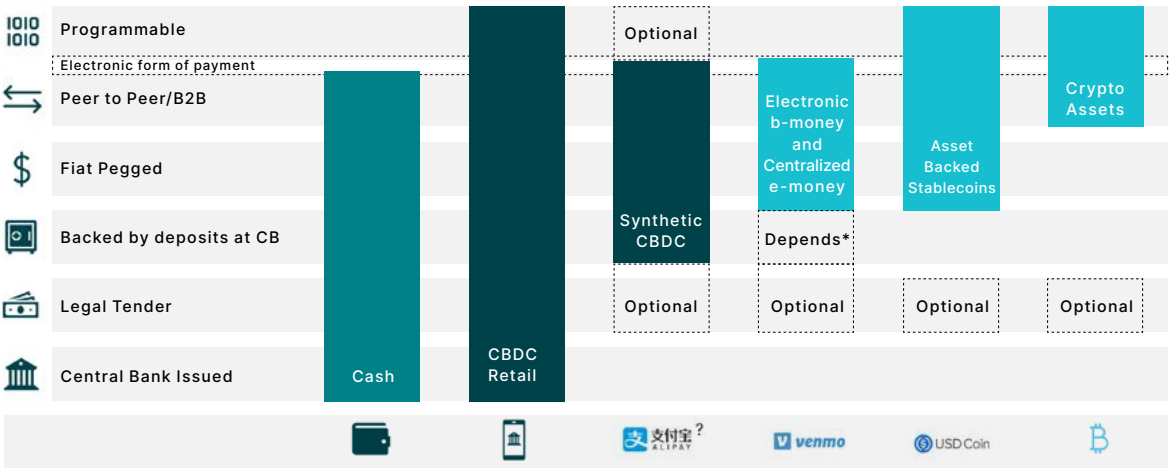


Figure 5: CBDC matrix relative to cash, synthetic CBDC, e-money, stablecoins, cryptoassets
Source: The Block, IMF

From this perspective, the only core difference between cash and a true retail-focused CBDC is the ability to transact with central-bank

issued cash, that is fiat-pegged legal tender, in an electronic and programmable form of payment.

This matrix also allows for a separate kind of CBDC classification, one that is a two-tiered or synthetic CBDC classification (sCBDC). A sCBDC allows consumers and households to hold commercial bank-issued deposits that are backed by deposits stored at the Fed, instead of stored at the commercial bank. This proposal is similar to a narrow banking system, and could involve commercial banks and third parties helping central banks build front-end consumer facing interfaces, as well as manage the accounts and provide customer service & compliance, among other things. sCBDC would still be a claim on central bank liability, but wouldn't be central bank issued, and wouldn't have

to be programmable either. An argument can be made that this type of synthetic CBDC already exists by way of China's Alipay, which is required to be fully reserved with deposits maintained at the PBOC.³

While this updated framework allows for richer differentiation among retail CBDC and synthetic CBDC, there remain edge cases within the matrix that still need tightening in our view. Is programmability and smart contract functionality truly required for a CBDC to offer differentiation among current business and e-money schemes? And where does accessibility and inclusion among all households in an economy fit within this matrix?

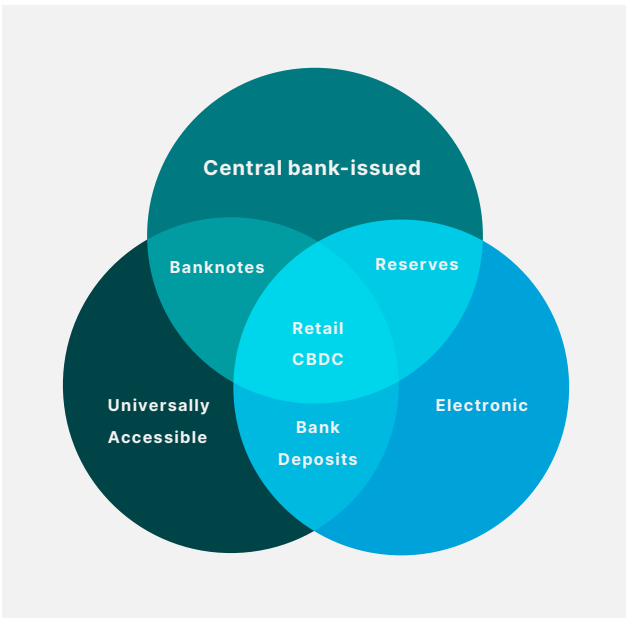


Figure 6: The Bank of England's Retail CBDC Money Flower
Source: Bank of England, The Block

Therefore, for the purpose of this whitepaper, we prefer an even simpler definition of a CBDC: one put forth by the Bank of England earlier this year, which has the longest tenure of publicly published research on the topic (dating back to 2015).

The Bank of England definition of a general-purpose CBDC is: ⁴

“A Central Bank Digital Currency (CBDC) would be an electronic form of central bank money that could be used by households and businesses to make payments. The key differentiation between reserves (which have been electronic and central bank issued for decades) is that they are universally accepted to all households. And unlike banknotes, would be fully-digital.”

How do you think through the taxonomy debate of where to put CBDC within either Account vs Token based payment system classifications?

In terms of the conventional account versus token basis paradigm, account-based payments, they're basically transfers of claims recorded on an account and there's a centralized ledger. But it could also be decentralized. Then the token basis is where the payments involve a transfer, an object like a dollar bill or a coin or something like that, or a digital version of that. But there's a lot of gray zones in there. The reason why we [the IMF] don't like account-based versus token-based is that some economists will put the distributed ledger technology type of system into the token-based category. And yet that's probably a flawed paradigm because even something like Bitcoin which is distributed ledger technology, involving a ledger, it's also an account. It's just the account is managed in a different way. It's managed on a decentralized basis.

So we've preferred actually to go with the different differentiation where we basically have ledger-based versus non-ledger-based platforms. And so within ledger-based, you have a whole bunch of different nuances — ways to differentiate who has the authority to verify and commit transactions to the ledger. So in a traditional centralized ledger where you have a client-server model with no distributed components, transaction processing entails the pair connection to the central ledger keeper initiating funds transfer to the recipient's account. Then there are most of these DLT based CBDC experiments that we've been focusing on and seen in the wild recently are based on private permissions

platforms, which are rather centralized anyways. And so that's the ledger-based world, And there are pros and cons to each of the different flavors of these ledger-based platforms.

Now a ledger-less platform is what we view as the true real token-based platform. So they can conduct all the transactions peer to peer off-line. They're identical to having cash, no tracking of transactions, or anything. And they would typically be mobilized via a stored-value card or in a mobile wallet in which the prepaid values are stored locally. And no one's really looking closely at that yet. Some central banks are kicking the tires on such a token-based platform. And they would probably be most interested in countries where large parts of the population are excluded from the financial sector. Areas, where people can't connect up to bank accounts or they don't have internet access, or very remote areas. But again, in terms of the efficiency of ledger-based versus token-based, there's no one single answer to that. The pros and cons of all of them are here and there, and they depend on the country's specific circumstances.

—
John Kiff
Senior Financial Sector Expert — IMF

Why are central banks interested in CBDC?*

In theory, by offering the ability to program and expand the design landscape of money, central bank-issued programmable digital currency could prove to be more attractive on both the demand side/end-users' need for money, as well as the supply-side central bank's ability to achieve policy and mandate goals.⁵

According to the IMF, the opportunity for CBDC depends solely on its ability to improve upon the three core functions of money:

- 1) a unit of account (ability to measure, ideally same basket of goods overtime),
- 2) means of payment (a widely accessible way to transact across an economy), and
- 3) a store of value (maintain its value overtime and protect against other sources of risks).

From the perspective of end users, the attractiveness of money is maximized across means of payment and store of value functions, where money optimizes private benefit while minimizing costs and risks.⁶ In terms of evaluating the potential for CBDC to improve money, one must also consider other competing forms of money and means of payment that are already available to end-users today, including: cash, traditional commercial bank deposits, new forms of retail-fast payments systems (e.g. India's Unified Payments Interface (UPI), Sweden's Swish system, the upcoming FedNow system, etc.), private e-money, and cryptocurrencies.

Most of these forms of money and payment systems are going through their own evolution to become more attractive to end-users. Things such as "wrapper technology" (Venmo) and real-time payment systems have allowed for faster P2P payments with commercial bank deposits and the ability to transact and settle 24/7, respectively.

In evaluating the potential role for CBDC from a user's perspective, the IMF compares these proposals against core attributes such as: 1) anonymity, 2) scalability, 3) acceptance, 4) settlement assurances, 5) frictionless payments, 6) default risk protections, 7) security, and 8) embedding extra services.⁷

Depending on the design and feature-set embedded into the CBDC, it could in theory offer relative improvements on most of these attributes assuming issues such as scalability, acceptance, and security that comes with DLT-based systems is improved.

*The section largely summarizes work done by the IMF. See footnotes at the end of the introduction.

One area where CBDC could provide noticeable improvement over other forms of digital money, such as traditional bank deposits, is the ability to design in trusted anonymity features that mimic the privacy afforded with cash transactions. Whether governments allow for a new form of digital cash to be designed that allows for privacy assurances is another question entirely.

Plotting out the comparison of these core attributes across various means of money and payment on radar charts highlights the potential maximum value for each attribute, and can provide qualitative comparisons across different forms of money. The further the points lie from the center, the higher the points captured by that attribute; the larger the surface area of the radar chart equates to a more attractive form of money. We present the IMF’s radar charts below, with slight modification based on our own assumptions.

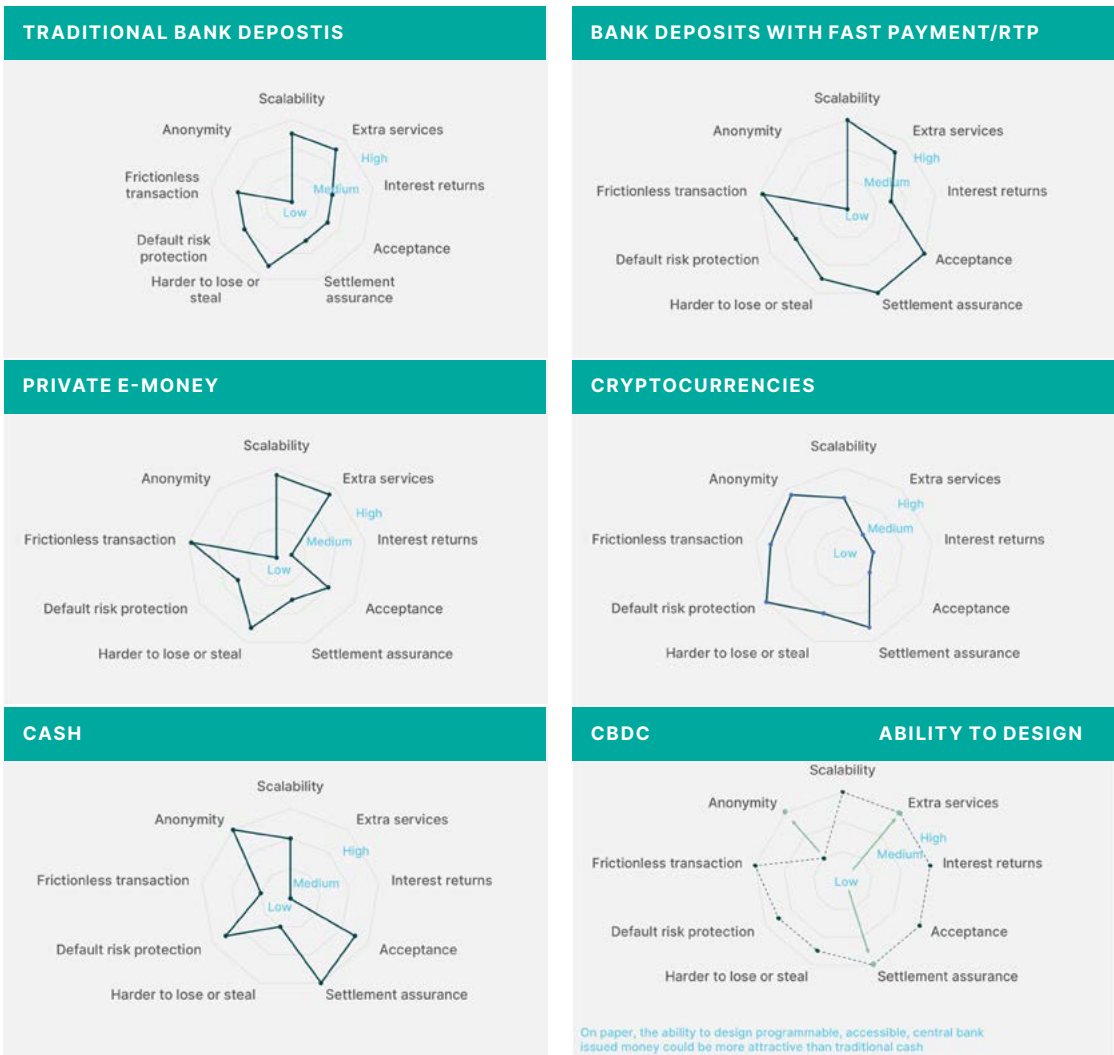
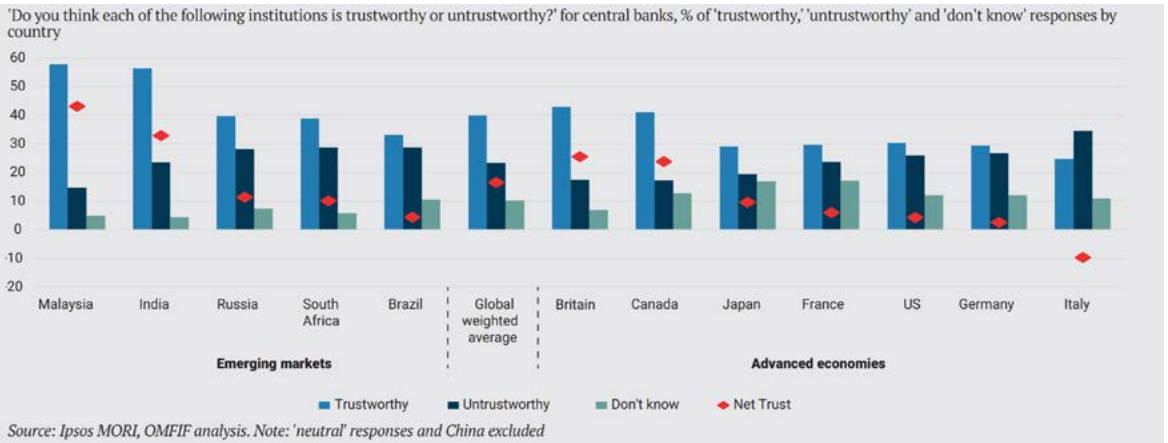


Figure 7: Radar charts depicting the attractiveness of different forms of money and payment systems
Source: The Block, IMF

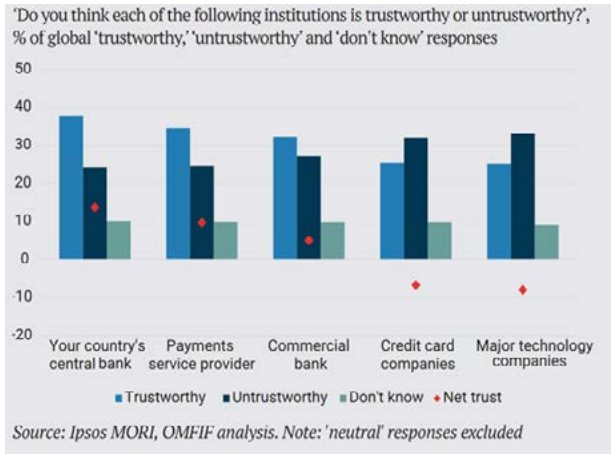
For central banks, attractive money provides a way for central banks to “design the money they issue,” while also meeting the three core functions of money defined above. As proposed today, there has been little evidence that a CBDC could improve the assurance of price stability, or improve the unit of account function of money, nor would they improve a central bank’s respective currencies store of value function.

There is, however, the potential to improve “equal” access to payments for all households and businesses — yet it remains to be seen whether this improved access is more optimal and efficient compared to competing solutions. In other instances, a CBDC may help a central bank remain relevant in a world that continues to shift towards cash-less payments over time.

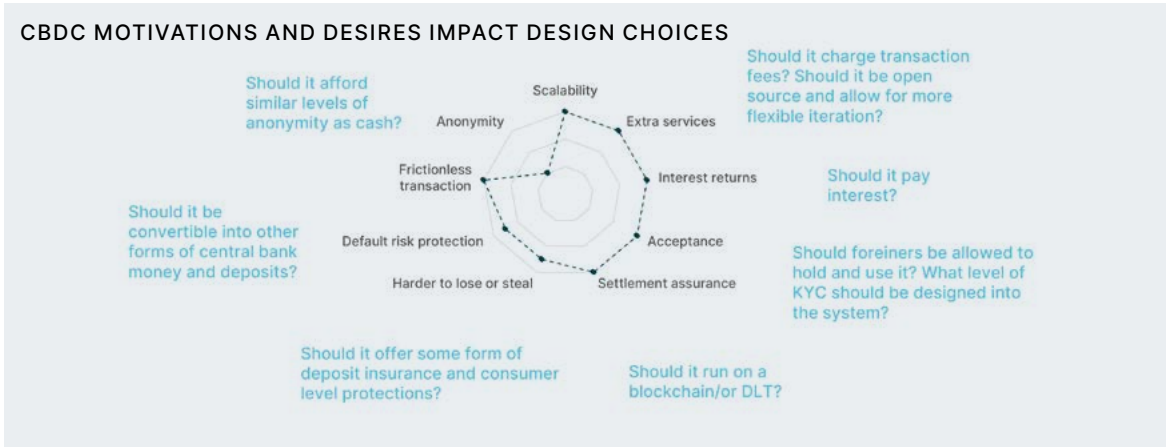
Figure 8:
OMFIF finds that central banks are the most trusted global money service provider, with the highest trust in emerging markets
Source: Ipsos MORI, OMFIF analysis



One thing central banks have going for them relative to competing private money, or e-money solutions, is the trust from end-users for central banks to issue these instruments. According to a poll published in 2020 by the Official Monetary and Financial Institutions Forum (OMFIF), more than half of the people surveyed in 13 countries said they would prefer a digital currency issued by their central bank, while private digital currencies issued by tech companies registered as the least trusted.



A central bank issued digital currency had the highest net trust ratings across payment service providers (PSPs), commercial banks, credit card companies, and tech companies. In some regions across the globe, trust in a central bank issuing a digital currency showed dramatically higher net trust scores relative to other institutions issuing their own form of digital currency.



Given the potential to reimagine central bank issued money and design new possibilities, the next question becomes to what extent central banks should, and what the core motivations behind such moves would be?

Figure 9: Potential motivations for a central bank to explore a CBDC
Source: The Block, BIS, IMF, World Economic Forum

POTENTIAL MOTIVATIONS FOR A CENTRAL BANK TO EXPLORE CBDC	
CBDC could enhance payment system competition. In the face of rising competition from non-banks/big-tech, payment service providers (PSPs), new forms of e-money (stablecoins) and private digital currency, CBDC could help improve payment contestability and lower barriers to entry while improving efficiency and resiliency amid increasing concentration in the hands of few very large companies	
CBDC could support financial digitization and improve financial inclusion. A CBDC could offer access to digital payments at minimum or zero cost by way of a new accessible general purpose electronic payment medium. In economies where cash usage relative to GDP is declining, it could also maintain central bank function of providing money in a purely digital economy	
CBDC could expand monetary and fiscal policy tools. An interest-bearing CBDC could enhance the transmission of monetary policy and break the "zero lower bound" on policy rates to the extent cash were made costly. If access was widely distributed, central banks could explore policy tools such as "helicopter money" or potentially improve the ability to disburse fiscal stimulus. The ability to tap more granular payment flow data across an economy could enhance macroeconomic data integrity	
CBDC could improve the global usage of a local currency. In regions that are attempting to reduce dollarization dependency, CBDC could provide a tool to improve the competitiveness of local currency as a means of payment	
CBDC could be used for wholesale payment applications, known as wholesale-CBDC. Central banks are exploring whether W-CBDC could reduce settlement risks, provide 24/7 up-time, widen interoperability with other settlement systems, reduce cross-border payments costs, and more	

Notably, these motivations clearly differ across economies. More importantly, the motivation behind issuing a CBDC will surely impact design choices made, and in turn impact the end-state attractiveness of the respective CBDC proposal.

Ultimately, the question central banks must answer in regards to their own respective economies is: What is the problem a central bank is looking to address and solve with a CBDC?

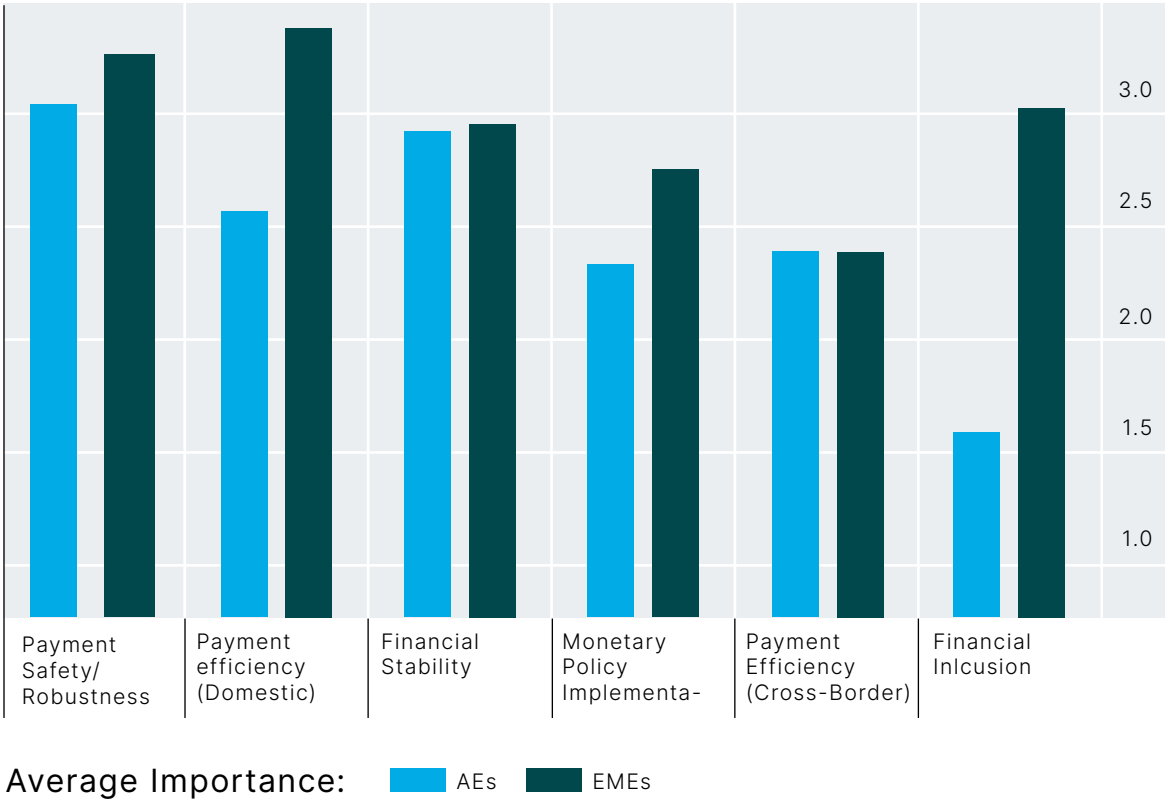


Figure 10: Motivations for issuing a general purpose (retail) CBDC
Source: BIS, The Block | fig.10 Note: *

Who is “exploring” what?

While many are quick to point to Libra and China’s DC/EP as the accelerant behind renewed interest in CBDC, in reality, more than a handful of central banks had already been fully researching and experimenting for years prior to the 2019 development.

The most recent BIS surveys of central banks found that 80% are engaged in CBDC work as of the latest 2019 central bank survey (66 central banks replied representing 90% of world’s economic output).⁸ This has increased from ~70% in 2018, and ~65% in 2017.

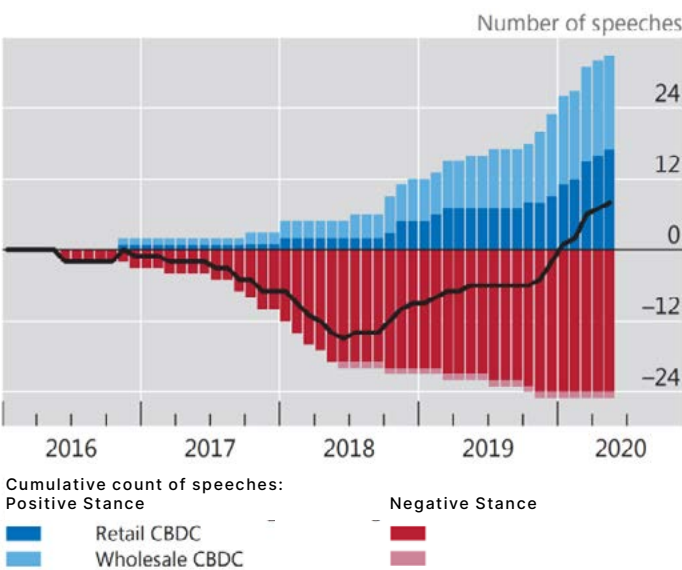


Figure 11: Central bank speeches on CBDC, net positivity stance
Source: BIS, The Block
Note:*

According to another central banking survey (46 respondents, 40% of which come from Europe, 20% from Americas) done at the start of 2020 by Central Banking:¹⁰ 40% of respondents said CBDC would be relevant to the organization in the next 24 months, but currently is not a strategic priority. Meanwhile, ~30% said it would be important, but not in the top 5 priorities at the bank, and ~12.5% said it will be critical or in the top 5 priorities.

% OF TOTAL CENTRAL BANKS ENGAGED WITH CBDC WORK

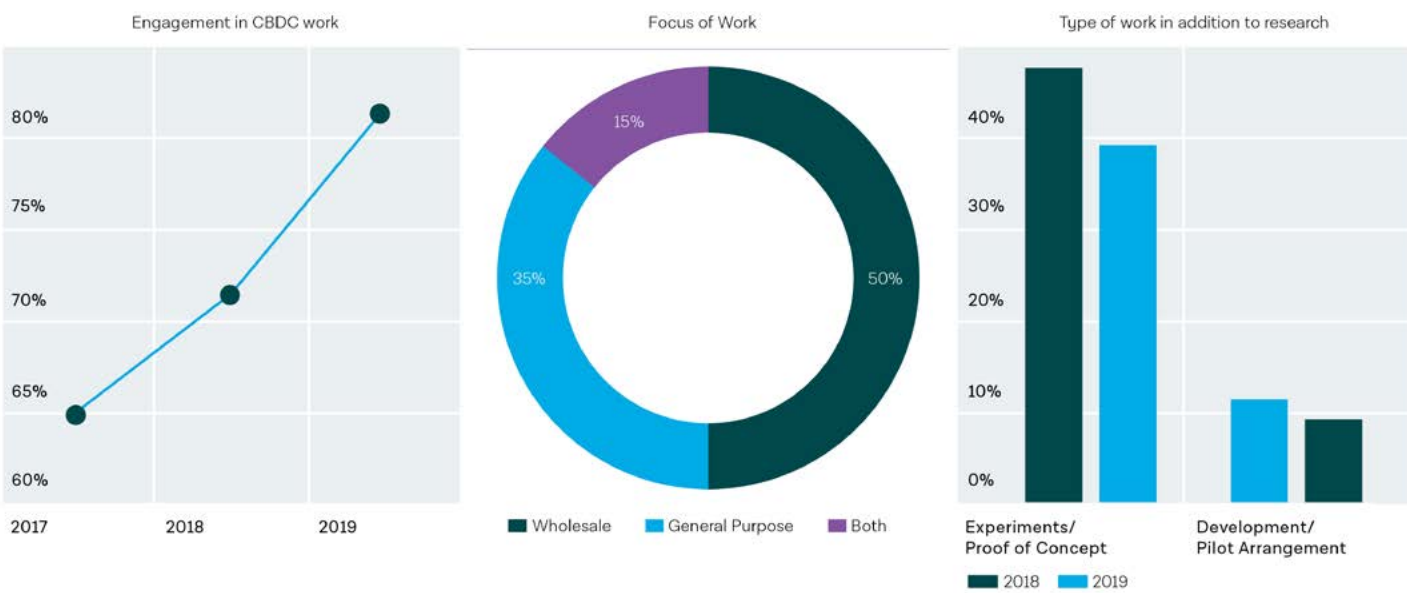


Figure 12: % of Total Central Banks engaged with CBDC work
Source: BIS, The Block

Notably, central bank tone (positive or negative stance on CBDC), specifically on retail CBDC, has shifted recently to being more favorable, according to the BIS.⁹

To be sure, “engaging” with CBDC work is very different from intending to issue a central bank digital currency. The bulk of these respondents are currently doing internal research on the topic, with ~10% of BIS survey respondents last year signaling development and pilot arrangements, and under 50% conducting early stage experiments and proof of concepts.

In total, Central Banking found that 80% of surveyed banks have no plans to issue a CBDC in the short to medium term, while ~20% expect to in the short to intermediate term (1-3 years; 4-6 years).

Figure 13: Central bank survey on what the focus of CBDC research is

Source: The Block, Central Banking

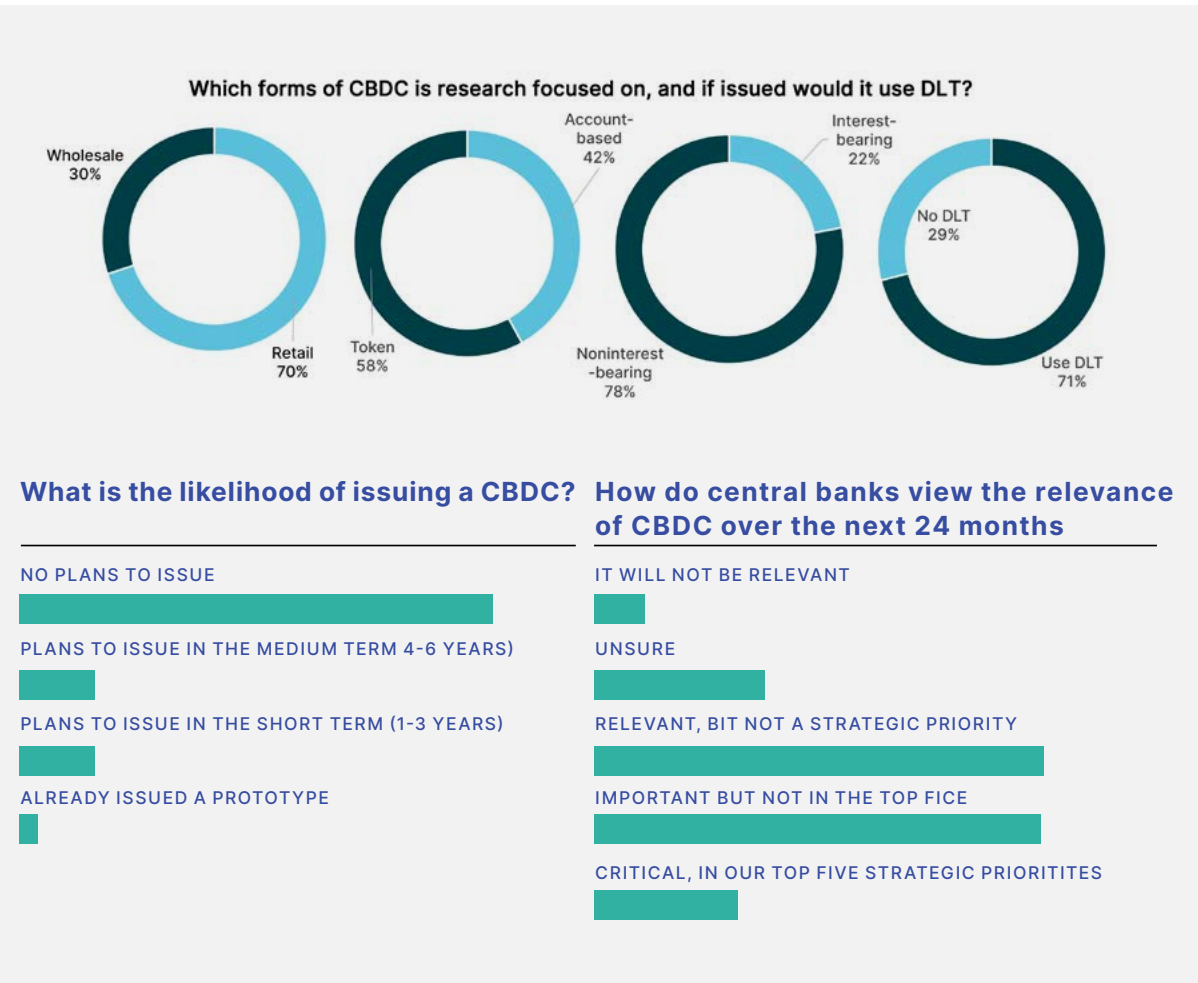
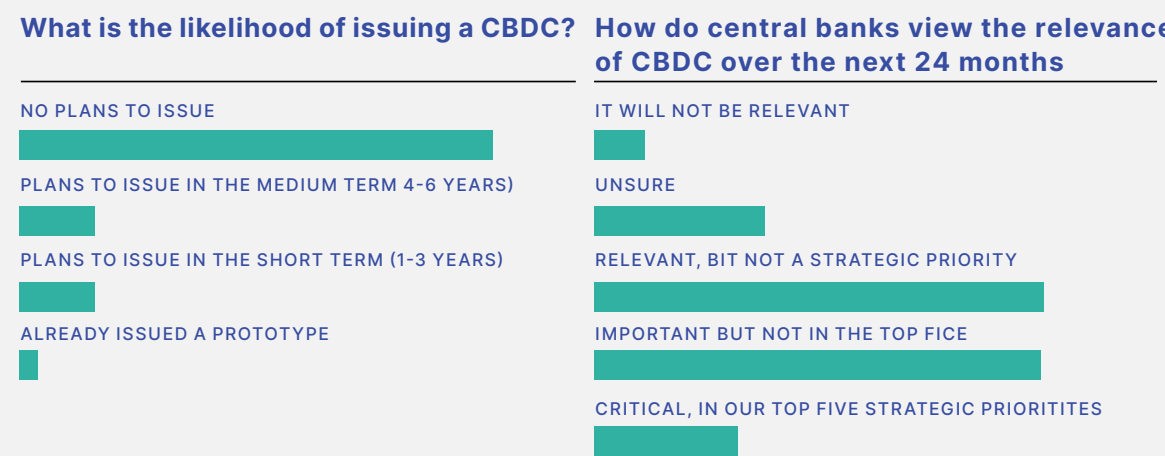


Figure 14: Central Bank CBDC survey data, likelihood and relevance of CBDC proposals

Source: The Block, Central Banking



OTHER INTERESTING STATS FROM THE CENTRAL BANKING SURVEY INCLUDE:

- 1/3 of respondents are considering using DLT
- Most prefer a general issuance model
- Just under 65% of central banks researching CBDCs have a dedicated budget for the project

In terms of a path to implementation, early CBDC pilots have leveraged a handful of DLT-based and other database platforms to explore the potential benefits of various protocols. Many of these pilots have been brought on by tech vendors and other consultancies looking to advise or even provide their own tech stack.

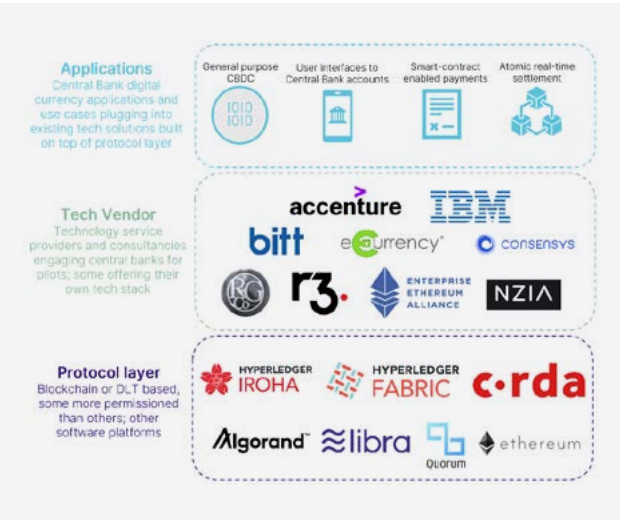


Figure 15: CBDC protocol and tech vendor landscape

Source: The Block

While only a handful of central banks are likely to progress towards full implementation and issue a digital currency in the next 5 years, several more have or are in the process of initiating advanced stages of pilot testing.

A detailed summary sheet of these advanced pilots and early implementations are listed in the figure below.

Implementing a central bank-issued digital currency, whether for retail or wholesale applications, is a multi-dimensional coordination problem that requires input and feedback across various stakeholders.

This whitepaper, written for practitioners and enthusiasts alike, examines the growing body of CBDC literature across central banks and international organizations, such as the BIS and IMF, in conjunction with interviews The Block Research conducted with various stakeholders, to present the global view on central bank digital currencies today: exploring the history, motivations, early technical designs and implementations of the world’s most advanced CBDC proposals.

The paper is broken out across five parts:

- Part 1**
Explores the lessons learned from the first completed retail CBDC pilots
- Part 2**
Examines current retail CBDC pilots in the Bahamas and the Caribbean, focusing on the paths to implementation
- Part 3**
Provides a historical summary of the largest public wholesale CBDC pilots, and the potential opportunities within interbank settlement and cross-border payments
- Part 4**
Gives a current perspective on China’s Digital Currency Electronic Payment system
- Part 5**
Offers a brief look at other CBDC developments within advanced economies

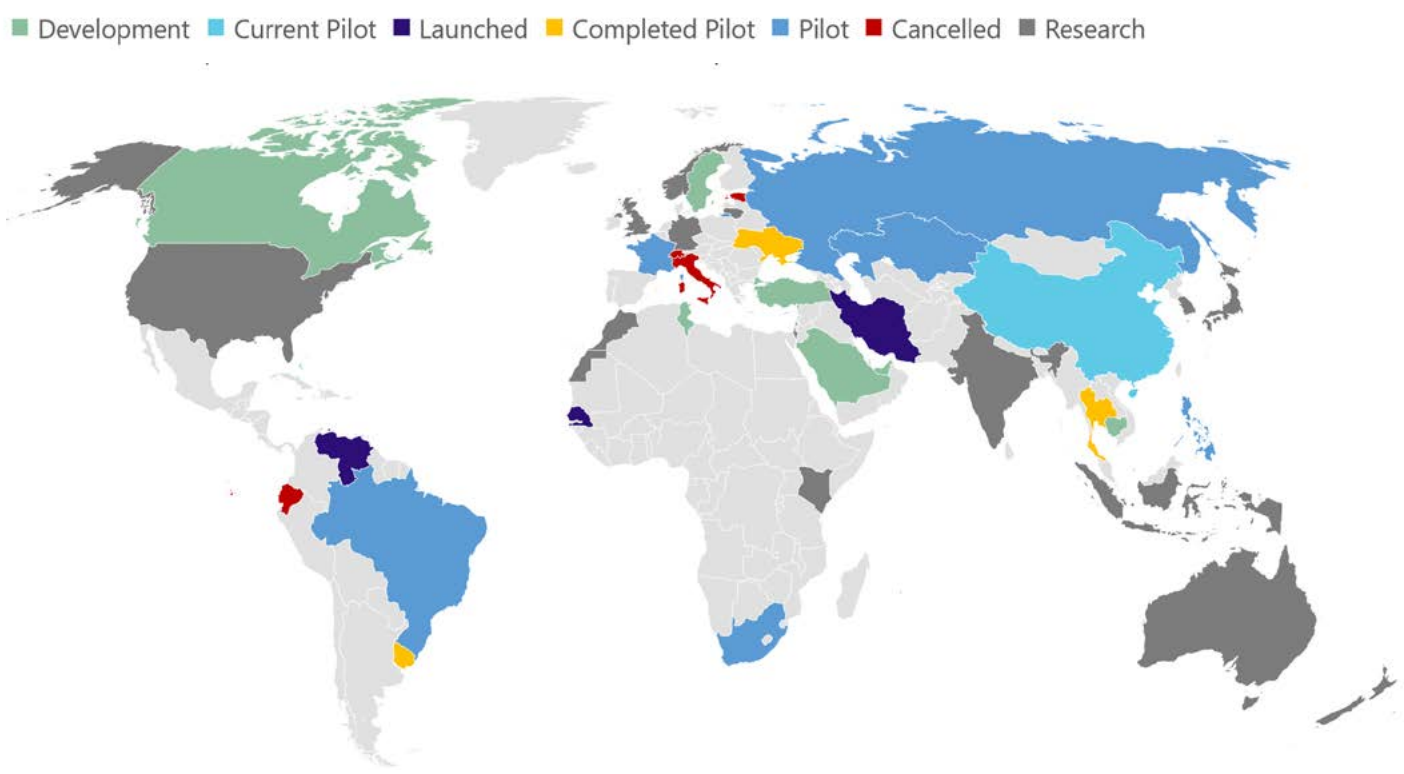


Figure 16: Map of all countries with forms of CBDC engagement
Source:CBDC Tracker, The Block

References:

¹For a full list of sources and links to these events, see the Appendix.
² BIS, [Implications for central banks of the development of electronic money](#), (1996)
³IMF, [The Rise of Digital Money](#), pg. 3 (Adrian & Mancini Griffoli 2019)
⁴IMF, [A Survey of Research on Retail Central Bank Digital Currency](#), (2020)
⁵Bank of England, [Central Bank Digital Currency: opportunities, challenges, and design](#), (2020)
⁶IMF, [Casting Light on Central Bank Digital Currencies](#), (2018)
⁷OMFIF, [Digital Currencies, a question of trust](#), (2020)
⁸BIS, [Impending arrival – a sequel to the survey on central bank digital currency](#), (2020)
⁹Central Banking, [The Central Bank Digital Currency Survey 2020 – debunking some myths](#), (2020)
¹⁰BIS, [Central banks and payments in the digital era](#), (2020)
¹¹ CBDCtracker.org
any books or speeches, as well as hits that including papers on unrelated “CBDC” acronym topics such a Chronic bullous disease of childhood, or Congenital bile duct cysts.
FIG.10 Motivation scores are as follows: 1 equals not so important; 2 equals somewhat important, 3 equals important, 4 equals very important
FIG.11 The score takes a value of negative 1 if the speech stance was clearly negative, it takes a value of plus one if the speech stance was clearly positive, all other speeches have been classified as neutral or no score.

Figure 17: CBDC Advanced Proposals Summary Sheet
Source: The Block

USE CASE						
Most advanced stages of retail CBDC exploration	Central Banks	Digital Currency	Date Announced	Status	Retail	Wholesale
	People's Bank of China	DC/EP	2017*	Active Pilot	☑	
	Sveriges Riksbank	e-Krona	2017	Completed Pilot	☑	
	Central Bank of Uruguay	e-Peso	2017	Completed Pilot	☑	
	National Bank of Ukraine	e-Hryvnia	2017	Completed Pilot	☑	
	Central Bank of the Bahamas	Sand Dollar	2018	Active Pilot	☑	
	Eastern Caribbean Central Bank	DXCD	2019	Active Pilot	☑	
	Project Name					
Most advanced stages of wholesale CBDC	Monetary Authority of Singapore	Ubin	2016	Completed		☑
	Bank of Canada	Jasper	2017	TBD		☑
	European Central Bank/ Bank of Japan	Stella	2017	TBD		☑
	Bank of Thailand/ Hong Kong Monetary Authority	Inthanon/ LionRock		TBD		☑

Other Notes

People's Bank of China
PBOC governor Yi said the central bank does not yet have a timetable for official launch, but confirmed it may be piloted at 2022 Beijing Winter Olympics

Sveriges Riksbank
Currently on Phase 3, working with Accenture on pilot

Central Bank of Uruguay
Provided anonymity of p2p transactions, offline capabilities, and instantaneous settlement

National Bank of Ukraine
Provides in depth technical specification of project

Central Bank of the Bahamas
The Sand Dollar is now an official line item on CBOB balance sheet

Eastern Caribbean Central Bank
DXCD is set for live deployment activities in Q3 2020

Monetary Authority of Singapore
Ubin completed its 5 phases, and has proven commercial viability of DLT-based payment networks for multi-currency cross border payments with Quroum

Bank of Canada
Worked with Project Ubin to prove cross-digital currency (W-CBDC), cross-platform, atomic cross border transaction

**European Central Bank/
Bank of Japan**
4 phases testing DLT for payment processing, securities settlement, cross-border payment, and confidentiality/auditability

Bank of Thailand/ Hong Kong Monetary Authority
The project explored various models of cross-border payment with W-CBDC

CORE MOTIVATIONS				BLOCKCHAIN	
Payment Competitiveness/ Diminishing Cash	Cost Efficiency	Financial Inclusion	DLT Based	Tech Provider/ Protocols	
×			Potentially hybrid	?	
×			Exploring DLT	R3 Corda, Accenture	
	×	×	No	Antel telecomm, RGC system provider, IBM storage	
×	×	×	Exploring DLT	Attic Lab, pilot used Stellar	
	×	×	?	NZIA	
	×	×	Agnostic	Bitt	
×	×		Tested DLT	Hyperledger Fabric, Quorum, Chain	
×	×		Tested DLT	R3 Corda	
×	×		Tested DLT	Hyperledger Fabric, R3 Corda	
×	×		Tested DLT	R3 Corda	

What is the real opportunity for CBDC?

Interview with Neha Narula
Director of MIT Digital Currency Initiative

We have the unique opportunity to design something that is like cash, for a digital context. Bitcoin kicked all of this off, which inspired the Bank of England to do some interesting writing on this. The idea of digital currency and e-money has been floating around for a while, but Bitcoin accelerated that conversation. Now we have an opportunity to decide what [digital cash] could look like — but there are a lot of different stakeholders with different views and wants. We don't yet know how this will turn out. We [MIT Digital Currency Initiative] have opinions on what a CBDC should like, but we are still in the middle of designing the concrete architecture.

A lot of work remains to be done on the design, and this presents the opportunity for a completely new way to achieve our high-level policy goals. For example, compliance is currently done by banks via AML and KYC with one high-level goal being preventing terrorism financing. Could we achieve this, and other higher-level policy goals, in a different way by regulating at a different layer of the system?

Redesigning digital cash is a huge opportunity, but it remains to be seen what the appetite is for change, and because of that we're going to move step by step and try different things and evolve slowly. I think ultimately we need the TCP/IP for money, a protocol for the transfer of value. Once we have that we can re-architect on top of it. The crypto world is a laboratory to experiment with these ideas, but it's still small. The real win is bringing this technology into the real world and seeing what the interfaces look like.

Part I

Lessons From the First Ever Retail CBDC Pilots

<u>46</u>	Sweden: e-Krona
<u>54</u>	Uruguay: e-Peso
<u>58</u>	Ukraine: e-Hryvnia

COMMISSIONED BY  

Key Takeaways:

- Sweden’s central bank, Sveriges Riksbank or the Riksbank, started exploring CBDC in response to a secular decline in cash usage; only ~5% of household purchases were made with cash in 2018 vs ~60% done with cards.
- The e-Krona project was initiated in Q1 2017, when the project group developed a three phase action plan. Phase 1 drafted a general CBDC proposal, while phase 2 created a governance and management structure for an e-Krona system.
- Phase 3 is currently underway; after three years of CBDC research, the Riksbank launched an e-Krona pilot. Working with Accenture, the Riksbank is testing payment, deposit and transfer capabilities for a digital version of the Swedish Krona, along with other features in a distributed ledger technology (DLT) environment using R3’s Corda.

History & Motivation

Sweden’s CBDC efforts are more developed than most European nations. The country’s central bank, Sveriges Riksbank (the Riksbank), is working with Accenture to test payment, deposit, and transfer capabilities for a digital version of the Swedish Krona (e-Krona), along with other features in a distributed ledger technology (DLT) environment. The Riksbank conducted 3 years of CBDC research before launching its e-Krona pilot in February 2020.

The concept of an e-Krona was first openly discussed by a Riksbank official in late 2016. Then-Deputy Governor Cecilia Skingsley discussed whether the Riksbank should issue electronic payments¹², as “cash is no longer as easily accessible” in Sweden.

Indeed, cash as a percentage of GDP in Sweden has fallen from 4% in 2004 to about 1% in 2018, while the percentage of total number of household payments in Sweden done in cash is now about 5%, according to a recent Riksbank payment study.¹³

“In terms of number of payments, card payments are totally dominant in Sweden. In total, about six billion payments were made in 2018, which is the equivalent of two payments per person per day. In most cases, payments were made by card, about 60 per cent of the total (estimate), while Swish, credit transfers and direct debit together made up just over 35 per cent (estimate). The Riksbank estimate is that the number of cash payments constitute just above 5 per cent of the total number of payments.” —Riksbank

% OF TOTAL NUMBER OF PAYMENTS IN SWEDEN IN 2018

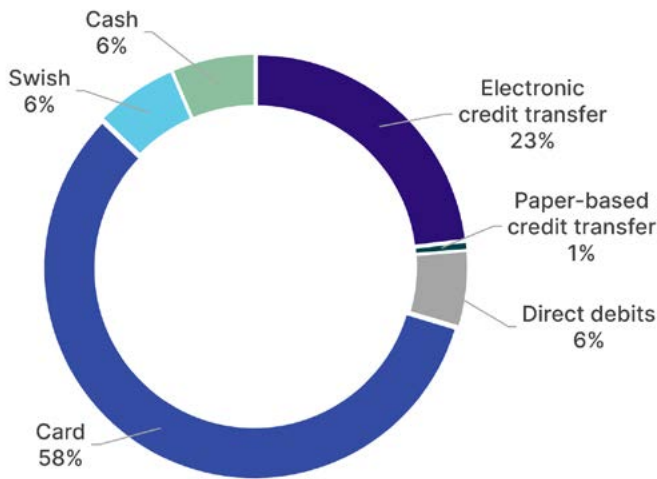


Figure 18: % mix of total number of payments in Sweden in 2018
Source: The Riksbank, The Block

Deputy Governor Skingsley then called for the Riksbank to research a potential e-Krona– the resulting investigation proved comprehensive, consisting of three project phases to date.

Phase 1 was initiated in Q1 2017, when the project group developed an e-Krona action plan. The Phase 1 plan aimed to assess options for electronic payment systems, develop proposals for the resulting system, and analyze the benefits &

challenges associated with a potential e-Krona payment system.¹⁴ The Executive Board reviewed each CBDC proposal, deciding which submission would advance to Phase 2 for further investigation.

The project group released an interim report in September 2017 outlining two feasible e-Krona models:

- A register-based model, where a central database would house e-Krona accounts.
- A value-based model, where e-Krona would be held locally (in an app or on a card), like how cash is held now.¹⁵

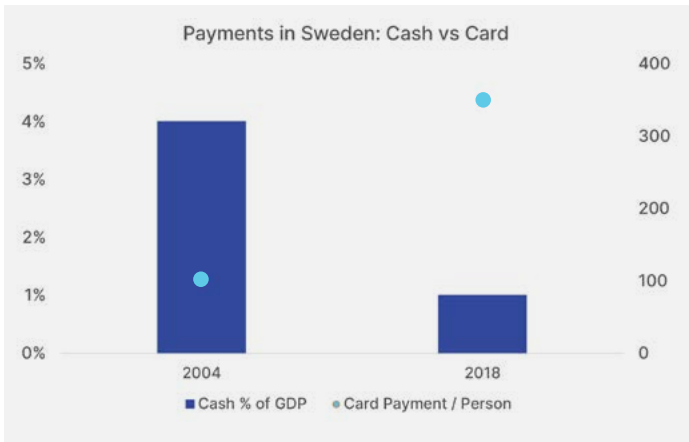
Both conceptual CBDC designs were approved by the Executive Board for the Phase 2 study.

This report also noted payment trends that could hinder the Riksbank’s ability to promote a “safe and efficient payment system” – a secular shift toward electronic payment methods is causing the market to consolidate among “a few private participants and payment services.” Firms like Klarna, iZettle, and Trustly offer unique payment services and synergies, rapidly achieving economies of scale through network effects.

According to the Riksbank, the introduction of an e-Krona could counteract possible problems that may arise from this payment consolidation by establishing a platform where other payment services can build independently of the commercially owned infrastructure of private banks. The successful launch of a e-Krona would therefore be “better able to withstand technological disruptions and situations of financial unease.”¹⁶

Figure 19: Payments in Sweden: Cash as a % of GDP and # of card payments per person

Source: The Riksbank, The Block



In December 2017, the Riksbank kicked off Phase 2 of the e-Krona concept. Using the Phase 1 interim report as a foundation, the project aimed to create a governance and management structure for an e-Krona system.

In October 2018, the Riksbank published its second interim e-Krona project report, discussing the requirements for the potential CBDC design.¹⁷ Specifically, the

report further analyzes Sweden’s shift toward electronic payments, defines the e-Krona conceptual framework, explores potential monetary policy & financial stability repercussions, considers CBDC legal questions, and shares technical solutions discussed with service providers. The project team recommended initiation of development work with information technology infrastructure experts.

Swish and the rise of retail fast-payments
From Riksbank and BIS

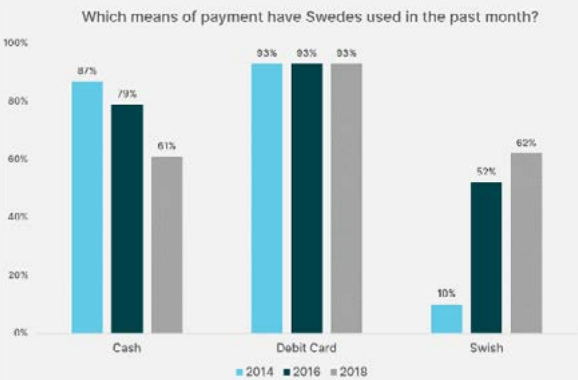
Swish is a mobile payment service introduced in Sweden in 2012 that allows for instant payments where users can send money in seconds from one bank account to another (including business accounts) in seconds – 24/7 and 365 days a year (similar to Zelle in the U.S.). Currently, the system works only between Swedish banks, however Swish is working with other European companies to offer the payment service with instant payment capabilities across regions of Europe.

According to The Riksbank, the use of Swish has increased rapidly over the past 6 years. In 2014 only 10% of Swedish survey respondents had used Swish within a month, however, in 2018 that number jumped to more than 61%. Comparatively, only 60% of Swedes reported using cash once in a month span in 2018. There were close to 400 million Swish transactions in 2018, up more than 130% since 2016.

Swish is a privately owned special purpose institution that uses commercial bank money for settlement, fully-backed by funding in central bank money, that allows for real-time settlement of fast payments even when central bank settlement systems are closed.

Swish is an example of a “fast-retail payment” system (FSPs), a system which allows for the transmission of a payment message and final funds to occur in real time on a 24/7 basis. According to the BIS, FSP systems are now currently in over 55 jurisdictions in the world, and “projected to rise to 65 in the near future.”

Source: The Riksbank, BIS



The report also included a proposal for the Riksbank to begin an e-Krona pilot program that would ready the system for a potential launch if the central bank decided to roll out the CBDC. According to the proposal, “the initial focus will be on an e-krona that constitutes a prepaid value (electronic money) without interest and with traceable transactions.”¹⁸

In June 2019, the Riksbank announced that it was procuring suppliers for the e-Krona pilot, expecting the process to last until the fall of

2019. In 2020, the Riksbank would work with the supplier to develop and test “a technical platform for e-krona payments, as well as a small number of different forms of means of payment for the e-krona ... After this, the Riksbank will decide on whether the agreement will be extended and whether more use cases and functionalities will be developed.”¹⁹

In December 2019, after evaluating 11 requests to participate, the Riksbank declared its intention to sign an agreement with consulting firm Accenture to help develop the e-Krona pilot program.²⁰

In February 2020, the Riksbank published a joint report with Accenture detailing the pilot goals, processes, and technical solution. The e-Krona pilot is scheduled to run until February 2021, but there is an option to extend the assignment for up to seven years, pending results. However, when The Block reached out to the Riksbank, a representative told us that the e-Krona testing environment is not expected to be up and running until the “beginning of 2021,” also adding “what we have right now is a concept for the architecture.”

Design & Implementation

As mentioned in the previous section, the Riksbank is working with Accenture to create a technical platform for the e-Krona pilot project. The e-Krona will be housed on a DLT network as digital tokens (e-Kronor) to facilitate peer-to-peer (P2P) payments; e-Kronor tokens can only be issued and redeemed by the central bank.

According to the Riksbank’s e-krona pilot white paper, the pilot aims to test an electronic payments system that is user-friendly, simple, functional, and secure, with functions including:

- User-friendly and inclusive technology.
- Instant payments available at all times.
- Test users can hold the currency in a digital wallet.
- Users can deposit & transfer money and make & receive payments from the digital wallet via a mobile app.
- Users can make payments on wearable tech like smart watches and cards.

The pilot will also investigate tech enabling offline payments for the digital currency.

Pilot users will interact with current financial market infrastructure and settlement systems via simulation in the e-Krona test environment. However, the e-Krona network is a stand-alone system and all transactions happen apart from existing payment services.

Similar to the existing two-tier financial system, the test environment consists of two levels. The Riksbank will first issue e-Kronor to trusted financial intermediaries like banks by way of participant nodes – new participants can only be approved and added to the network by the Riksbank. E-Kronor will then be distributed to end user digital wallets by participant nodes at the second tier.

The conceptual architecture for e-Krona’s two-tier structure is below :²¹

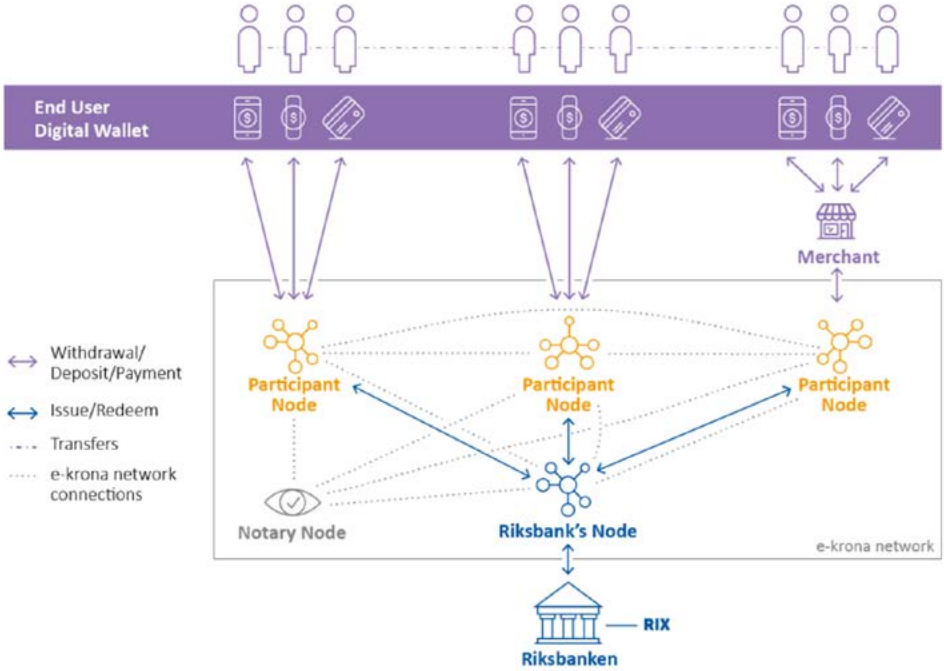


Figure 20: Conceptual architecture of e-Krona two-tier system
Source: Accenture, The Riksbank

When pilot network participants acquire/redeem an e-Kronor, the participant nodes will debit or credit against their reserves. Alternatively, a representative of the Riksbank’s settlement system (RIX) can record the transfer. According to the white paper, “the e-Krona network will be supplied with liquidity by the participants, either as direct participants or as representatives for indirect participants, paying in reserves in RIX in exchange for the Riksbank providing the participant’s node with the same amount of e-Kronor.”²²

Once network participants deliver e-Kronor to end user wallets, the user has multiple payment options. Wallets are digitally installed via applications on consumer smart devices or merchant terminals; e-Kronor wallets must initially be authorized by a network participant before the payment feature is activated. Test users can then use the currency to pay a retailer, transfer to/from their bank account to their digital wallet, receive payments from another user, and more.

Accenture chose to leverage R3’s Corda platform for the e-Krona network. The Riksbank found Corda’s scalability and flexibility attractive, as well as its low energy consumption from only running a few nodes.

According to the Riksbank’s e-krona pilot white paper, the following components are included in the e-Krona technical solution:²³

- The e-Krona network and its governance – the Riksbank controls this network, as described above.
- Participant nodes, their databases, and the e-krona contracts & flows.
- The contracts and flows (sometimes called Corda-distributed application) enforce the regulatory framework set by the Riksbank for the e-Krona via both technical and legal rules.
- Examples of rules include who has the right to distribute e-Kronor, definition of the transaction flow between nodes, signing of transactions, and storage of e-Krona transactions.
- An integration layer Application Programming Interface(APIs) for interacting with existing systems such as RIX and core banking systems.
- Digital wallets in all their forms (smart mobile apps, wearables, cards, and terminals).
- Simulated existing systems, such as banking systems and RIX.

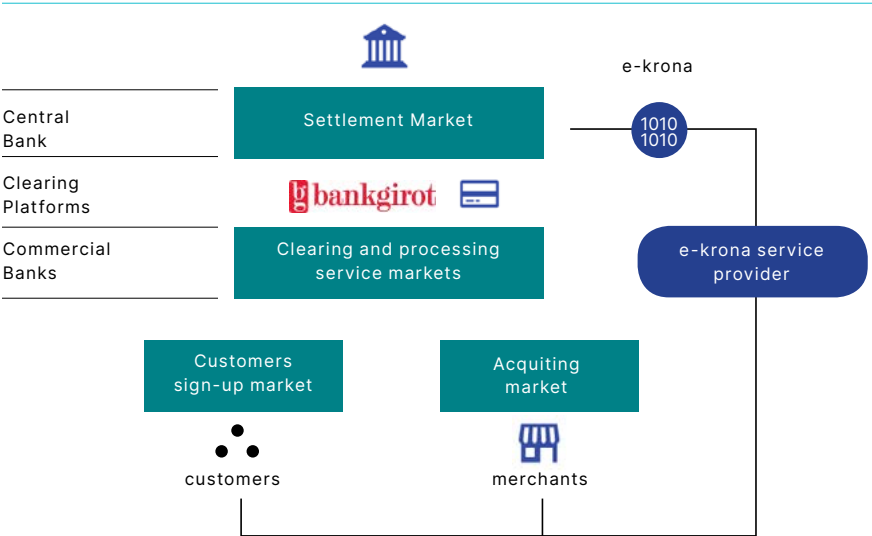
Sweden's well-developed financial market infrastructure and the growing adoption of Swish, a fast-retail payment system, provides a unique landscape to observe potential impacts to payment markets should the e-Krona become implemented.

Currently, transactions made through the Swedish bank-owned mobile payment service Swish must go through bank-owned systems – instant payments are settled through a bank-owned system called Bankgirot (BG), while credit transfers/money orders and checks are processed by Dataclearingen (DCL – owned by Swedish Banker’s Asso-

ciation). Should the e-Krona be built upon distributed ledger technology, and the Riksbank offers an open API at the wholesale level, new payment service providers could enter this system and offer services that wouldn’t rely on the current legacy settlement infrastructure and incumbent banks.

Figure 21:
Illustration of e-krona
among Sweden pay-
ment market

Source: The Block, The
Riksbank



In this scenario, new e-Krona payment providers could enter the market and not be dependent on accounts held at BG or other clearinghouses or on the other services these clearing platforms provide. However, from a retail perspective, access to e-Krona accounts through APIs could potentially be bundled and provided by incumbent banks as a general banking service. In such a scenario, the abil-

ity to bypass legacy clearing and processing markets and the potential to lower barriers of entry for new e-Krona payment service providers could provide new forms of payment market competition.

Payment markets inherently exhibit strong network effects — people and merchants will only use and invest in technology to accept payments if it is widely accepted, also known as “the chicken and egg problem” — which has led to heavy market concentration across the global payment landscape (e.g. Visa, Mastercard, Alipay, etc.).²⁴ Some central banks are exploring a retail CBDC to improve and protect payment market competitiveness. On this front, a functional e-Krona could offer a new look at the impact of CBDCs on the competitive landscape of a well-developed payments market.

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²² Sveriges Riksbank, [Should the Riksbank issue e-krona?](#) (Skingsley 2016)

¹³ Sveriges Riksbank, [The Payment Market is Being Decentralized](#) (2019)

¹⁴ Sveriges Riksbank, [Riksbankens e-krona 14 March 17 Project plan](#) (2017)

¹⁵ Sveriges Riksbank, [The Riksbank's e-krona project Action plan for 2018](#) (2017)

¹⁶ Sveriges Riksbank, [The Riksbank's e-krona project Action plan for 2018](#) (2017)

¹⁷ Sveriges Riksbank, [The Riksbank's e-krona project Report 2](#) (2018) pg 39

¹⁸ Sveriges Riksbank, [The Riksbank's e-krona project Report 2](#) (2018) pg 39

¹⁹ Sveriges Riksbank, [The Riksbank is procuring suppliers to develop proposals for an e-krona](#) (2019)

²⁰ Sveriges Riksbank, [Riksbank develops an e-krona in a test environment](#) (2019)

²¹ Sveriges Riksbank, [The Riksbank's e-krona pilot](#) (2020)

²² Sveriges Riksbank, [The Riksbank's e-krona pilot](#) (2020)

²³ Sveriges Riksbank, [The Riksbank's e-krona pilot](#) (2020)

²⁴ Sveriges Riksbank, [Second special issue on the e-krona](#). (2020)

Key Takeaways:

- Known as the e-Peso, Uruguay’s CBDC pilot ran from September 2017 to April 2018 and tested the issuance and distribution of digital banknotes for use in P2P, B2B, and B2C payment use cases. The pilot did not use DLT, instead opting for digital wallets that operated through state-owned telecommunications provider Antel.
- Key features of the system included: anonymity of P2P transactions, instantaneous settlement, offline transactions or on a device without internet capabilities, and each e-Peso bill had a unique cryptographic signature with a specific denomination.
- Considered a successful pilot by the IMF and BIS, the BCU is reportedly moving into an evaluation phase of broader questions surrounding the initiative, including: anonymity features, interest-bearing features, and the broader impacts to Uruguayan economy.

History & Motivations

Like Sweden, Uruguay has seen a significant decline in both the use and circulation of cash. The Banco Central del Uruguay (BCU) also piloted one of the first general purpose retail-focused CBDCs.

Uruguay’s pilot ran from September 2017 through April 2018 and was considered a part of a wider governmental push around financial inclusion under the 2014 Financial Inclusion Law, which introduced free bank accounts and debit cards to low-income households & small businesses and enacted a broader effort to promote electronic transactions and banking competition. Notably, since the introduction of the Financial Inclusion Law, the availability of ATM and cash dispensing mechanisms has expanded by 4x, while cash withdrawals have plateaued and cash in circulation has continued to contract.

Beyond cashless trends, Uruguay also has room to reduce transaction costs across the payment chain – costs from producing notes and coins, safely securing & transporting physical currency, as well as the costs consumers incur with transactional fees such as ATM withdrawal fees.

According the BCU, estimates in 2018 show that “the cost of using cash in Uruguay is ~0.60% of GDP. While this number is largely inline with other economies, 98% of this cost is passed onto the private sector.”²⁵

According to this study by the BCU, replacing paper cash and checks with electronic methods would imply transactional cost reductions for the private sector of up to 0.65% of Uruguay’s GDP.

Prior to the start of the CBDC pilot phase, early preparation for a legal tender digital peso was first brought to light in 2014 when the BCU was approached by The Roberto Girori Company (a firm specializing in money security systems) with a preliminary proposal for the idea.²⁶ At the time, the BCU determined that its currency legal framework under its Central Bank Charter^v allowed for the BCU to issue digital notes (since Article 7 of its charter did not specify or forbid a specific form or medium of currency) as long as adequate security standards were met.

Design & Implementation

Known as the e-Peso, the pilot tested the issuance and distribution of digital banknotes for use in P2P, B2B, and B2C payment use cases.

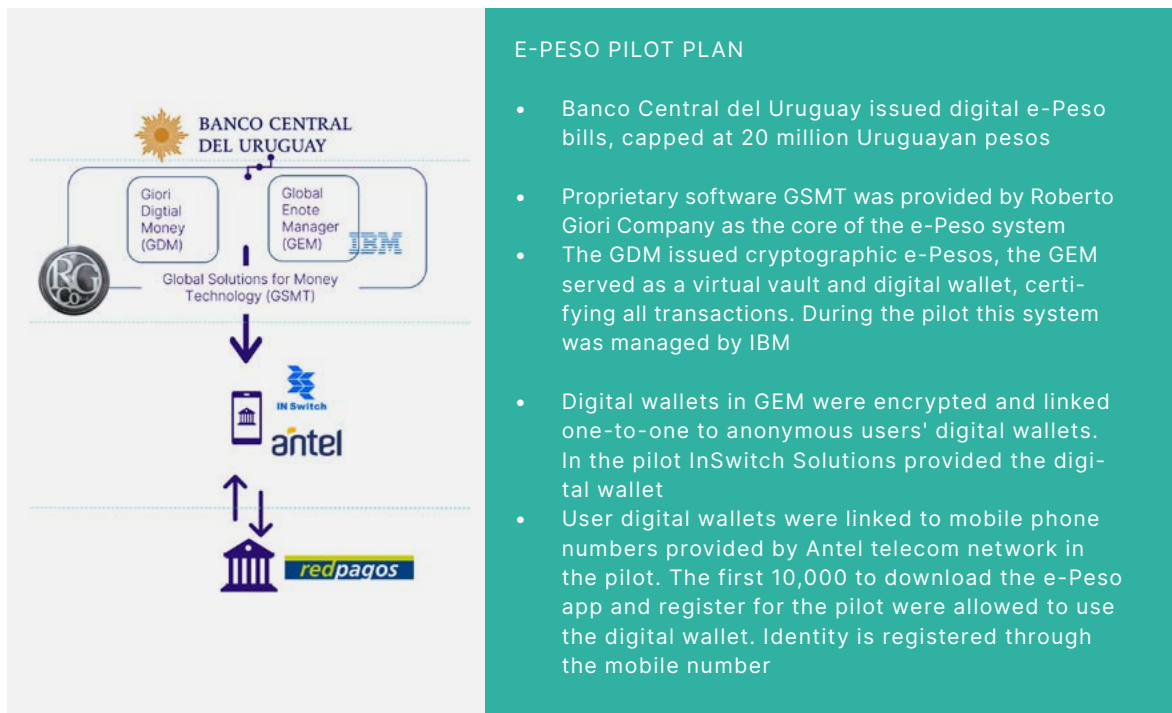
The pilot did not use DLT, instead opting for digital wallets that operated through state-owned telecommunications provider Antel. This design mechanism allowed for offline payments and did not require an internet connection. Other participants included RGC (system provider), IBM (storage, circulation, and control support), IN Switch (user management and transfers), and RedPagos (ticket loading). There was no banking representation in this first pilot.

The pilot issued 20 million e-Pesos (~\$468,000 USD based on USD/UYU FX rate Dec 31st 2017), considered legal tender by the BCU, with 7 million distributed by third-party payment service provider IN Switch. The total value allowed to be held per wallet was capped at about \$1,000 per individual, and around \$7,000 per business wallet.

Key descriptions of the system, including pilot players, are listed in the diagram below:

Figure 22:
The Uruguay e-peso
pilot model and distribution model

Source: The Banco Central Del Uruguay, The Block



Key features of the system included:

- Anonymity of P2P transactions
- Instantaneous settlement
- Dual communications network – authentication used internet-communication with the second layer offering a telecommunication protocol called USSD (Unstructured Supplementary Service

- Data) – similar to SMS messaging. USSD confirms that a mobile phone was used in the transaction, with a valid SIM card, and the phone company validates that it exists and is operational.
- This dual layer allowed for offline transactions or on a device without internet capabilities.
- The system was secured at the GEM component of the mobile phone, similar to how users can port over contacts should they lose a mobile phone. This GEM component stored the transactional data assigned to anonymous (encrypted) digital wallet accounts. This feature allows authorities to access transactional information tied to the identity of the account, and should a judge or legal authority require access would allow the data to be decrypted.
- Each e-Peso bill had a unique cryptographic signature and a specific denomination. There was no fractionalization of digital coins.

Since the pilot lasted 6 months, the BCU wanted to implement an incentive system to encourage use. As such, all costs were covered by The Roberto Giori Company, 500 e-Pesos were credited in the digital wallets for the first 1,000 users that cash into the system, and the most active users and retail businesses (users that made at least 10 transactions in the previous month) accessed lotteries with randomized monthly prizes of ~2000 UYU. By the end of the trial, about 80% of all transactions were P2P, with remaining transactions used for payment of services or products at stores that were part of the pilot phase.

Considered a successful pilot by the IMF and BIS, the BCU is reportedly moving into an evaluation phase of broader questions surrounding the initiative, including: anonymity features, interest-bearing features, and the broader impacts to Uruguayan economy.

Looking ahead, the core outstanding questions that remain from this first pilot included:

- No banks participated in this pilot, even though several expressed interest in participating once the pilot began. Thus, questions of financial stability and impacts to the banking system were not answered.
- No pilots around monetary policy opportunities were conducted. This is an area of interest for future pilots by the BCU.

References:

²⁵ <https://www.bcu.gub.uy/Estadisticas-e-Indicadores/Documentos%20de%20Trabajo/4.2019.pdf>

²⁶ SUIERF, *Do We Need Central Bank Digital Currency*, (2018)

²⁷ Banco Central Del Uruguay, *Organic Charter Ordered Text*, (1995)

Key Take-Aways:

- **Ukraine has made meaningful progress with retail CBDC, and arguably provides the most detailed technical specifications among European nations. The National Bank of Ukraine (NBU) successfully tested an electronic form of its hryvnia currency, the e-hryvnia, during a four-month pilot operation period in 2018.**
- **Throughout 2018, the e-hryvnia pilot was implemented in three phases. Phase 1 consisted of preparatory work, laying the ‘Electronic Hryvnia’ platform foundation; Phase 2, the practical stage, involved e-hryvnia issuance and transaction execution; and Phase 3 comprised data processing and analysis of the pilot outcomes.**
- **E-hryvnia pilot results were formally released in June 2019 as part of the NBU’s Analytical Report on the E-hryvnia Pilot Project.**
- **Most recently, in February 2020, the NBU shared its CBDC vision and e-hryvnia project findings with global central bank representatives at the ‘Central Bank Digital Currencies: New Payment Opportunities’ international conference in the city of Kiev.**

History & Motivations

The National Bank of Ukraine (NBU) successfully tested an electronic form of its hryvnia currency, the e-hryvnia, during a four-month pilot implementation in 2018. E-hryvnia pilot project results were recently presented at the “Central Bank Digital Currencies: New Payment Opportunities” international conference in Kiev.

The NBU started exploring blockchain technology for its “Cashless Economy” project in 2016. In November 2016, the NBU Board unveiled the Cashless Economy roadmap – according to the roadmap presentation, “there will be an ‘evolution of e-money’ as a non-cash payment instrument, the issuer of which will be the National Bank. The regulator plans to issue electronic money on the blockchain in order to optimize acquiring and create an alternative to card payments.”²⁸

In late 2017, it was reported that the NBU expanded its blockchain group. According to an email sent by then-NBU Governor, Yakiv Smolii, the project aimed to study the feasibility of an operational CBDC that would be user-friendly and available 24/7. Smolii also wrote that the NBU saw blockchain technology as the basis for the e-hryvnia, and that they “consider blockchain as the next step in [the] evolution of transactions technologies, which will become more popular and widespread during the next decades.”²⁹ Information technology firm Distribute Lab started working with the NBU to better understand distributed ledger technology (DLT) architecture and security.

The NBU implemented its e-hryvnia pilot in three phases over 2018. From February to August 2018, the central bank performed preparatory work, laying the foundation for its platform. Practical implementation took place between September and December 2018, when the NBU issued e-hryvnia and tested transactions in a live environment. Lastly, the pilot’s statistical data was processed and analyzed in November and December 2018.³⁰

E-hryvnia pilot results were compiled into the NBU’s “Analytical Report on the E-hryvnia Pilot Project” — released in June 2019, the report summarizes Ukraine’s digital currency and blockchain studies since 2016. Further details from this report are highlighted in the next section, but it is recommended that those interested in better understanding CBDC pilots review the paper in its entirety.

Most recently, in February 2020, Ukraine hosted the “Central Bank Digi-

tal Currencies: New Payment Opportunities” international conference in Kiev. The event included participants from research organizations, financial markets firms, and representatives from 15 central banks across the globe, including Sweden, Japan, Uruguay, and Turkey. Members of the NBU shared Ukraine’s CBDC vision and presented the e-hryvnia project findings for conference attendees.³¹

Design & Implementation

In 2016, at the onset of its exploration on the topic, Ukrainian officials saw CBDC as a sovereign-controlled alternative to existing private payment instruments, such as money orders, credit cards, and rapidly growing forms of electronic money (e-money). From its research, the NBU set the following preconditions for any future electronic hryvnia or e-hryvnia issuance:³²

- The e-hryvnia is regarded as a digital currency issued by the NBU.
- It may be characterized as a national digital currency representing a fiat currency.
- E-hryvnia must be convertible into cash or cashless money without limitations at the rate of 1:1.
- The currency is not a yield-bearing instrument, and therefore, it works as a medium of exchange, not as a store of value.
- It could be either an anonymous CBDC or user-identifiable, since both options have their own advantages and disadvantages.
- The e-hryvnia could be launched in Ukraine’s payment market on the basis of one of the following two models (schemes) of interaction between participants: centralized or decentralized.

For the 2018 pilot project, the NBU created two working groups: (1) An internal team composed of employees from the central bank’s subdivisions and (2) An initiative group consisting of volunteers from Ukrainian payment companies.

The internal working group set the following pilot objectives:³³

- 1) Use distributed ledger technology (DLT) as the technological basis for the issuance and circulation of the e-hryvnia.
- 2) Test the NBU’s capability to implement advanced information technology projects.
- 3) Study legal aspects of the e-hryvnia issuance by the NBU.
- 4) Analyze potential macroeconomic effects from the e-hryvnia issuance.

- 5) Work out an optimal business model advantageous for all participants of the e-hryvnia ecosystem.
- 6) Analyze international experience in the issuance of digital currencies by central banks.

The initiative group’s intended contributions were documented as follows:³⁴

- Attic Lab was responsible for creating the system’s core, load testing, financial applications development, integration with involved participants, and technical consulting as part of further technical support to the Platform.
- UAPay served as a settlement agent, servicing e-hryvnia payments at its online domain.
- Finance Company OMP 2013 was originally meant to be the distribution agent, providing a network of self-service devices for purchasing e-hryvnia. However, the company took no part in the pilot project implementation due to the revocation of its license from the TYME payment system.

The e-hryvnia pilot project was carried out in three phases. The preparation phase “comprised drafting and approving regulatory and technological documents, taking measures to install and configure system and application software at main servers (the Platform’s core), configuring technological processes, settling information security and organizational issues, configuring the systems and software of the NBU and other participants of the Pilot Project, as well as considering matters of accounting and financial interaction with external participants of the Pilot Project.”³⁵ As part of this stage, the project team gained approval from the NBU Change Management Committee in February 2018.

The operational phase lasted four months, from September to December 2018; it was officially launched in September 2018. Phase 2 consisted of “e-hryvnia issuance, opening of e-wallets, and execution of e-hryvnia transactions by users in accordance with the project’s target KPIs.”³⁶

Specific operations and descriptions executed on the e-hryvnia platform are listed in fig. 23 below.

A total of 5,443 e-Hryvnia were issued by the NBU for the pilot (~\$200 based on UAH/USD FX Rate, Dec 31, 2018); participants registered 121 e-wallets, but only 79 were activated. Working group members executed the following steps over the operational period:⁴⁴

- 1) Creation of personal e-wallets
- 2) Installation of the e-wallet mobile application on personal devices with the Android or iOS operating system
- 3) Refilling of e-wallets in a cashless way using the NPS PROSTIR card via a specialized virtual terminal integrated with the Platform
- 4) E-hryvnia transfers between e-wallets (P2P transfers)
- 5) Merchant transactions (topping-up e-hryvnia to mobile phone balances, LifeCell operator)
- 6) Charitable contributions to help soldiers of the Joint Forces Operation
- 7) Exchange of e-hryvnia for non-cash funds using an NPS PROSTIR card

Figure 23: Main operations performed on the e-hryvnia platform with descriptions

Source: NBU

Main operations performed on the Platform		
Operation	Brief description	
1. setting the maximum amount of e-hryvnia circulation	a transfer of an e-hryvnia amount from the base e-wallet for which this amount will be subsequently shown with the negative value to the issuer's e-wallet where the balance of issuable e-hryvnia is accounted for	
2. e-hryvnia issue	provision of the e-hryvnia by the issuer to users and distribution agents in exchange for cashless funds (i.e., recording the successful exchange of the national currency, the hryvnia into the e-hryvnia at the rate of 1:1)	
3. e-hryvnia distribution (refilling e-wallets of Platform users):	a transfer of an e-hryvnia amount from the distribution agent's e-wallet to the Platform user's e-wallet in exchange for cash or cashless funds	
4. e-hryvnia transfers between Platform users	a transfer of an e-hryvnia amount from the e-wallet of one Platform user to the e-wallet of another Platform user	
5. e-hryvnia payments for purchases	a transfer of an e-hryvnia amount from the Platform user's e-wallet to the merchant's e-wallet	
6. cashback of e-hryvnia payments for purchases	a transfer of an e-hryvnia amount from the merchant's e-wallet to the Platform user's e-wallet involved in the e-hryvnia payment for purchases transaction in the amount not exceeding the amount of the said transaction	
7. e-hryvnia exchange into cash or cashless funds	a transfer of an e-hryvnia amount from the e-wallet of a Platform user/merchant to the e-wallet of a settlement agent	
8. e-hryvnia repayment	withdrawal of the e-hryvnia from circulation with the subsequent provision of cashless funds to settlement agents	

The final pilot phase involved aggregating, processing and analyzing all of the transaction data from the aforementioned operational procedures. Luckily, the ‘Electronic Hryvnia’ platform was DLT-based, ensuring accurate and secure recording keeping. Furthermore, “synthetic recordkeeping of e-hryvnia transactions on the issuer’s accounts was performed via the NBU’s banking automation system solely in hryvnia. The issuer’s liabilities under the issued e-hryvnia were recorded on a separate consolidated account. Depending on the essence of accounting entries, the

files with such accounting entries were prepared by different systems of the NBU: the Platform, the Central Switching Center and the Settlement and Clearing Center, or the Processing Center.”³⁹

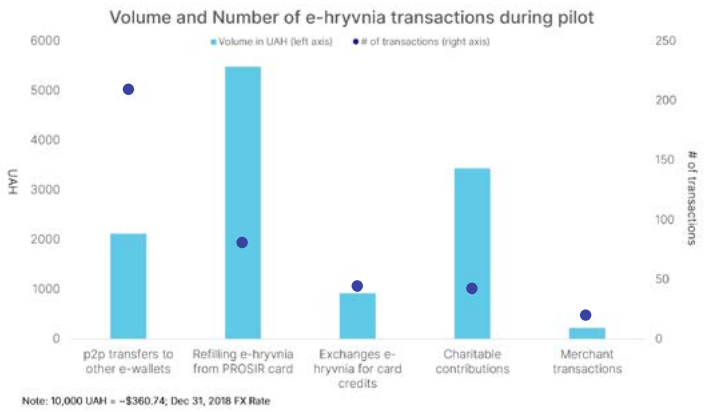


Figure 24: e-Hryvnia pilot volume and number of transactions
Source: NBU, The Block

From a technical perspective, the NBU selected a private version of the blockchain protocol Stellar to serve as foundation for the ‘Electronic Hryvnia’ pilot platform. Specifically, the application software was built on “the SDK Stellar network with Stellar Core Horizon API.” Stellar was chosen “after one of the project’s participants suggested to provide free-of-charge a ready-made basic solution of such a system to be used in the project on the Platform’s implementation

with an option to finalize that basic solution in line with the requirements that would be established at the preparation phase of the Platform’s implementation.”⁴⁰

However, one of the major technical conclusions from the Analytical Report on the E-hryvnia Pilot Project was that the Stellar version used would not be proper for a national-scale system. The NBU felt it was “practically impossible to update it following the development of the basic Stellar blockchain protocol. Instead, the national-scale system can be designed on the basis of one of the public versions of modern powerful blockchain protocols.”⁴¹

A centralized issuance model⁴² was chosen for the pilot due to its simplicity and transparency. The NBU had sole control over the centralized registry which accounted for the e-wallets; transaction validations were based on the NBU’s information resources. Similar to the existing dual banking system, the e-hryvnia pilot ecosystem had a two-level structure.

Level one was reserved for the central bank, while financial intermediaries served as agents to consumers and merchants at level two. According to the two-level architecture, “banks and non-bank financial institutions in accordance with this scheme are agents for the settlements and distribution of e-hryvnia, provide users with access to the Platform through their Internet resources, provide customers with other services: secure key storage, applications for mobile devices, user-friendly presentation of information on customer transactions, etc.”⁴³

The NBU is open to exploring both a centralized and decentralized model for any future e-hryvnia system. When giving the opening remarks for the ‘Central Bank Digital Currencies: New Payment Opportunities’ conference, Yakiv Smolii stated “we continue to look into the chance of issuing the e-hryvnia, and we will be ready to return to this matter when we are convinced that not only can it be technologically feasible, but also that it will not interfere with the pursuit of our mandate as a central bank, which is to ensure price and financial stability.”⁴⁴ CBDC enthusiasts will certainly be on the lookout for further e-hryvnia developments by the NBU.

The NBU provided summary tables of the advantages and disadvantages of both decentralized and centralized models of issuance and circulation of the e-hryvnia, which we have repurposed below:

ADVANTAGES AND DISADVANTAGES OF A CENTRALIZED MODEL OF ISSUANCE AND CIRCULATION OF E-HRYVNIA			
- DISDVANTAGES (OPEN ISSUES)		0	ADVANTAGES+
NBU			
<ul style="list-style-type: none">• Servicing individuals, the NBU will perform a noncore function (including dispute resolution).• The NBU will need to allocate resources for creating and maintaining the Platform, as well as for the promotion of this instrument.• Legal framework is needed.		<ul style="list-style-type: none">• The scheme is transparent in terms of its control and regulation.• The share of cash in circulation will decrease.	
Users			
<ul style="list-style-type: none">• If wallets are anonymous, the limits will be applied		<ul style="list-style-type: none">• The central bank will provide a guaranteed payment instrument.• If wallets are anonymous, the bank identification is not needed.	
Banks and nonbank financial institutions			
<ul style="list-style-type: none">• There is a risk that liquidity will be flowing to the central bank rather than staying with participants of the banking system.• The attractiveness of the business model is questionable		<ul style="list-style-type: none">• When using the blockchain platform, the cost of the required infrastructure is potentially lower compared with the card payment schemes.	

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²⁸ Forklog.com, [The National Bank of Ukraine will issue electronic money on the Blockchain](#) (Asmakov 2016)

²⁹Coindesk.com, [The Ukrainian Central Bank is Expanding Its Blockchain Team](#) (del Castillo 2017)

³⁰ National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) (2019)

³¹National Bank of Ukraine, [Report on the results of the conference](#), pg. 2 (2020)

³² National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg 5. (2019)

³³ National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg 6. (2019)

³⁴ National Bank of Ukraine, [Analytical](#)

[Report on the E-hryvnia Pilot Project](#) pg 23 (2019)

³⁵ National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg 23-24 (2019)

³⁶ National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg 24 (2019)

³⁷National Bank of Ukraine, [Analytical](#)

ADVANTAGES AND DISADVANTAGES OF A DECENTRALIZED MODEL OF ISSUANCE AND CIRCULATION OF E-HRYVNIA			
- DISDVANTAGES (OPEN ISSUES)		0	ADVANTAGES+
NBU			
<ul style="list-style-type: none">• To resolve a number of issues, including building up guarantee deposits and establishing an institution similar to the DGF.• To draft admission criteria and a permit/licensing procedure for banks and non-bank financial institutions that wish to issue e-hryvnia.		<ul style="list-style-type: none">• Fee and commissions income for servicing operations of various issuers.• Reduced share of cash.	
Users			
<ul style="list-style-type: none">• If wallets are anonymous, the limits will be applied.		<ul style="list-style-type: none">• If wallets are anonymous, the bank identification is not needed.	
Bank			
<ul style="list-style-type: none">• The Platform, if joined by the bank, can absorb existing electronic money services of the bank.• Significant investments have already been made to build banks' own customer services.		<ul style="list-style-type: none">• The model eliminates the risk of liquidity flowing from in the banking system participants to the central bank.	
Nonbank financial Institutions			
<ul style="list-style-type: none">• The Platform, if joined by the NBFi, can absorb existing electronic money services of the NBFi.• New investments are needed for building a new payment infrastructure (significant investments have already been spent on building NBFIs' own customer services).		<ul style="list-style-type: none">• The model provides an opportunity to loosen limits for operations with e-hryvnia in comparison with the limits on operations using electronic money, established by the current NBU's regulations, provided identification is done of users of e-hryvnia.• The model provides interoperability of different issuers (as opposed to the incompatible systems of electronic money that operate today in the payment market of Ukraine).	

Source: NBU, The Block

[Report on the E-hryvnia Pilot Project](#) pg 42 (2019)

³⁸National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg. 29 (2019)

³⁹National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg 27 (2019)

⁴⁰National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg

28 (2019)

⁴¹National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg 33 (2019)

⁴² An illustration of the centralized e-hryvnia pilot model can be found on slide 6 of Roman Hartinger’s presentation for the ‘Central Bank Digital Currencies: New Payment Opportunities’ conference. Roman serves as Head of the NBU’s

Innovative Projects Unit, and was interviewed by the Block’s research team for this report.

⁴³National Bank of Ukraine, [Analytical Report on the E-hryvnia Pilot Project](#) pg 27 (2019)

⁴⁴National Bank of Ukraine, [Report on the results of the conference](#), pg. 2 (2020)

What was a key lesson from the E-hryvnia pilot project in working with the private sector?

During the pilot project on E-hryvnia, we focused on two models of cooperation between the central bank and the market. For the pilot we applied a more transparent and simple model, in which the central bank owns and controls the Blockchain platform. Also, in this model, the central bank is the only issuer of the digital currency. At the same time several volunteering companies from the Ukrainian market were acting as payment agents there.

We are sure that in order to scale the project we need to enroll the second layer of CBDC ecosystem from the side of commercial banks and fin-techs in order not to forget about innovation and competition issues.

Central Bank is the bank for banks. It's not the bank for consumers. In the market we have commercial banks and non-bank financial institutions which used to work with consumers directly. The ecosystem of CBDC should include the participation of those private market players to set interaction between the central bank and end consumers. This will be an effective tool to compete and to innovate the services.

It is true in any model for CBDC. The only exception might be small countries or countries which do not have a well-developed private market where a central bank can issue CBDC, and also be the one to interact with consumers. But if you want CBDC to be perceived as competitive and innovative, you have to involve the private markets where possible.

Part II

Pilots of the Caribbean: Emerging Market retail CBDC implementations

70	The Bahamas: Project Sand Dollar
84	DXCD Caribe Network: The Digital Eastern Caribbean Dollar

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The Bahamas: Project Sand Dollar

Key Takeaways:

- **Project Sand Dollar is now live in both Exuma and The Abacos Islands; pilot data will assist with the national Sand Dollar rollout, which is expected by Q4 2020.**
- **Sand Dollar activity falls under the Bahamian Payments System Modernization Initiative; regulatory reforms have cut through red tape, clearing a path for CBDC implementation.**
- **As the preferred technology services provider, NZIA Limited is working closely with The Central Bank of the Bahamas (CBOB) to design and implement the Sand Dollar ecosystem.**
- **The central bank is responsible for issuing Sand Dollars, monitoring holdings, sponsoring KYC infrastructure, and maintaining a ledger of all CBDC in circulation.**
- **Licensed financial intermediaries sponsor the mobile payment wallets, including credit unions, money transmitter businesses (MTBs), banks and PSPs.**
- **"Sand Dollar in circulation" is now an official line item on the CBOB balance sheet and statement of cash flows.**

History & Motivation

The Central Bank of the Bahamas (CBOB) applies monetary policy, supervises the financial sector of the Bahamas, and maintains the Bahamian dollar's value. With Project Sand Dollar, the central bank is introducing a digital version of the Bahamian dollar, the "Sand Dollar." The Bahamas CBDC implementation efforts are underway, thanks to recent financial infrastructure regulatory reforms.

"Central banks and other financial sector authorities worldwide are giving increased attention to innovative payment instruments such as mobile payments, stored-value cards, other forms of electronic money (e-money), and the features of the payment services being provided through these and other payment instruments. This has been driven by technological innovation and concerns about the safety and efficiency of such instruments and access channels, and the entrance of non-bank and even non-financial institutions into the payments market."⁴⁵

In the early 2000s, the Bahamian government sought to modernize its domestic payment systems through the Bahamian Payments System Modernization Initiative (PSMI). This led to the creation of a real-time gross settlement (RTGS) system for wholesale payments between banks in 2004. Retail payment infrastructure was later upgraded in 2010 with the Bahamas Automated Clearing House (BACH). These technological advancements increased the efficiency and speed of domestic payments, particularly those conducted electronically.

With the passage of the Payments Systems Act (PSA) in 2012, non-bank companies were incentivized to create electronic payment solutions. These companies were allowed to apply for licenses as payment services providers (PSPs) under the Payments Instru-

ments Oversight Regulations of 2017, opening the door to markets for stored-value products, such as digital assets. By intentionally leaving the electronic money (e-money) regulations open to interpretation, the Bahamas set up a flexible legal framework for the future creation of a CBDC.

Public documents released by the Central Bank of The Bahamas during 2017 make clear that the regulatory foundation for a CBDC was being laid. In May of 2017, the payments unit research department released a consultation paper inviting the public to comment on the upcoming payments instrument (oversight) regulations. This paper noted the concerns around innovations in retail payments, stating:

"Central banks and other financial sector authorities worldwide are giving increased attention to innovative payment instruments



such as mobile payments, stored-value cards, other forms of electronic money (e-money), and the features of the payment services being provided through these and other payment instruments. This has been driven by technological innovation and concerns about the safety and efficiency of such instruments and access channels, and the entrance of non-bank and even non-financial institutions into the payments market."⁴⁵

The Central Bank of The Bahamas later asserted its authority over e-money products when it released application guidelines for e-money PSPs in July of 2017. Operational requirements made it clear that "the Central Bank reserves the right to impose on Payment Service Providers any relevant standards to ensure a safe and reliable issuance and management of an instrument. More specifically, the Central Bank reserves the right to impose on Electronic Money Issuers such conditions and limits on the nature of e-money products that may be offered, the quantity of e-money products that may be issued over a particular period and limits on the monetary values that may be transferred or funded to particular e-money products."⁴⁶

These e-money quantity limits would later prove to be important in the Sand Dollar rollout, as would simplified customer due diligence for low denominations of e-money. Both processes were part of a financial inclusion initiative announced by Governor John A. Rolle in August 2017.

The payment system regulations and infrastructure implementations served as an essential precursor to the 2018 CBDC announcement. In a March 2018 speech, Gov. Rolle envisioned an acceleration in electronic transaction use and a decrease in cash payments, driven in part by a digital Bahamian dollar.⁴⁷

The CBOB set a goal to launch a CBDC pilot within 24 to 30 months and began the process of identifying the pilot communities for the digital currency circulation. As such, The Central Bank of The Bahamas sought technology service providers to help them achieve this CBDC vision.

After reviewing thirty proposals, The CBOB selected NZIA Limited as the preferred tech solutions provider charged with designing and implementing the digital currency, now designated "Project Sand Dollar." In June 2019, it was announced that Exuma Island would be the first location for the CBDC pilot.

On the value of using a sandbox as a starting point to full implementation

**Interview with Carmelle Cadet
EMTECH**

The idea of a sandbox for us came from our conversations with various central banks. We hit the road around this time last year to talk to central banks. We would say central bank digital currency?. They'd say sandbox? We'd say again "central bank digital currency?" And they would say sandbox? I said, what is this and took it back to the team as market feedback.

When we started looking into it, we realized there is a shift that needs to happen for a lot of central banks before they can really get to central bank digital currency.

So the sandbox idea became not only about asking fin-techs and innovators to come get regulatory approvals, but it can be designed to be a robust mechanism for regulators to introduce innovation as well, such as a CBDC, to the market in a controlled manner.

There are national priorities and challenges the central banks are trying to solve for. They technically are on the hook to solve for faster payments for example, but they don't have the mechanism or the infrastructure to execute fast enough or effectively enough. Innovation in the private sector is moving much faster.

Therefore, if a central bank wants to test its CBDC solution before launch, we believe via regulatory and innovation sandbox is the way to do it. It can be controlled and digital. It can be multi-agency and regionally harmonized (think Federal vs 50 states or Ghana vs West Africa, UK vs EU). Innovators from banks and non-banks can participate via test environments and collaborate in real time. Regulators can learn, assess risks and provide guidance faster.

Indeed, we believe every central bank that plans to introduce a CBDC should have a regulatory and innovation sandbox.

—
Carmelle Cadet
EMTECH

Design & Implementation

Exuma was chosen for the CBDC pilot launch because of the island's high cell phone adoption rate — a 2019 baseline survey revealed that 96% of respondents owned mobile devices. Exuma residents were also open to utilizing digital financial services, as more than half of the people surveyed were willing to receive payments through digital platforms. Residents were likely receptive due to the previous success of other PSMIs, such as ACH and RTGS implementations, which vastly improved the capabilities of domestic payment systems.⁴⁸

Money and payment system improvements over the past two decades have set the stage for Project Sand Dollar. The goal is "that all residents in The Bahamas would have use of a central bank digital currency, on a modernized technology platform, with an experience and convenience—legally and otherwise—that resembles cash. It is expected that this will allow for reduced service delivery costs, increased transactional efficiency, and an improved overall level of financial inclusion."⁴⁹

Although Sand Dollars will not provide complete anonymity to users, the related infrastructure will strictly protect data and confidentiality, as security is a top priority for the CBOB.

NZIA Limited was chosen as tech service provider for offering the following solutions, according to the project's white paper :⁵⁰

- Interoperability among existing and new channels for the provision of payments services.
- Offline functionality support for wallets.
- Near-instantaneous validation of transactions/real-time processing.
- Point of sale support through credit and debit card machines or mobile phone apps.
- Fully auditable transactions trail (non-anonymous).
- Fraud detection monitoring.
- Restriction of the Bahamian CBDC to domestic use only.
- Multi-factor authentication for wallet users.
- Digital ID solution (using KYC and identity features incorporated in the system design).

Emtech (Emtech Services, LLC) is also providing Sand Dollar pilot support as a service provider and technological adviser to the CBOB. The Sand Dollar is interoperable with both retail and wholesale payment applications.

Like clearing house operations, wholesale CBDC transactions are restricted at the inter-bank level. Each retail CBDC is a direct claim on The Central Bank of The Bahamas, meaning holders have the legal equivalent of an account with the bank.

To mitigate risks, several policy controls have been built into the Sand Dollar design. Limits are placed on the amount of Sand Dollars that individuals and non-bank businesses can hold to prevent them from becoming a substitute for traditional bank deposits. Furthermore, each individual's digital wallet is linked to their domestic bank account, with all excess Sand Dollars being transferred when necessary; those without a bank account can still have a mobile wallet, but functionality is limited. All business wallets must be linked to a corporate bank account.

The central bank-imposed Sand Dollar ceilings are determined by the user category and the amount of due diligence required. Per the white paper, initial Sand Dollar limits and terms for each category are as follows:

Business Wallets

- Permitted to hold total balances which are the greater of \$8,000 or 1/20th of their annual sales receipts, subject to a maximum ceiling of \$1 million.
- Monthly transaction limits would also apply: proposed at 1/8th of annual sales or \$20,000, whichever is greater.

Individual Wallets

- Those established with basic due-diligence, would be capped at a maximum holding capacity of \$500 and subjected to monthly transactions totals against either payments or receipts of \$1,500.
- Personal accounts, which undergo more enhanced due diligence around identification, verification of contact, would be enabled to operate within a maximum holding amount of \$5,000 and subject to an annual transactions limit of \$100,000 (or \$10,000 per month).
- Personal wallets, once connected to deposit accounts at financial institutions, would be enabled to undertake higher total transactions value, on the condition that the transactions flow through deposit accounts, since the maximum amount of digital currency holdings would remain capped.

To avert potential financial instability issues — such as bank runs —

the Sand Dollar will not pay any interest. As a preventative measure, the related infrastructure will monitor individual bank liquidity with real-time consolidated transactions. Circuit breakers will also be deployed if interruptions occur to systemically important payment systems including ACH, RTGS, and all related Sand Dollar infrastructure.

By design, the Central Bank of The Bahamas is responsible for issuing Sand Dollars, monitoring holdings, sponsoring KYC infrastructure, and maintaining a ledger of all Sand Dollars in circulation. Initially, the central bank will support a centralized identity register with user profile data to identify those without bank accounts or other licensed intermediaries. The registry adheres to all AML/CFT standards, i.e. monitoring all accounts maintained by financial institutions and verifying income/wealth sources of those deemed high risk. These procedures allow supervised financial entities to develop other monetary relationships with users.

Licensed financial intermediaries are mobile payment wallet sponsors within the Sand Dollar ecosystem. These include credit unions, money transmitter businesses (MTBs), banks, and PSPs. PSPs and MTBs currently have the technology necessary to offer Sand Dollar wallets, while banks and credit unions have the option to pursue it.

However, according to the white paper, "banks and credit unions are expected to contribute to the customer due diligence regime; facilitate connectivity of deposit accounts with mobile wallets; and enable foreign exchange transactions. In particular, the Central Bank will promote regulations to permit all PSPs, with the consent of enrolling participants, to rely on KYC documentation already possessed by commercial banks."⁵¹

In all cases, the wallet initiation process requires using pre-established Central Bank account codes. Mobile device users can download the Sand Dollar app and set up the account through a licensed service provider, while non-mobile clients can use a card-based digital wallet, where balances are updated via point-of-sale equipment.

As lead originators, the public sector is a major stakeholder of the digital currency initiative. For example, the Bahamas Government and National Insurance Board (NIB) are the largest digital payments originators. Responsibilities include "equipping both the payments receipt and disbursing systems to conclude transactions in digital currency;

and becoming direct participants in the ACH."⁵² Both the government and NIB possess the largest dataset on private commercial businesses that are interested in digital payment services.

The Sand Dollar Ecosystem is illustrated below:

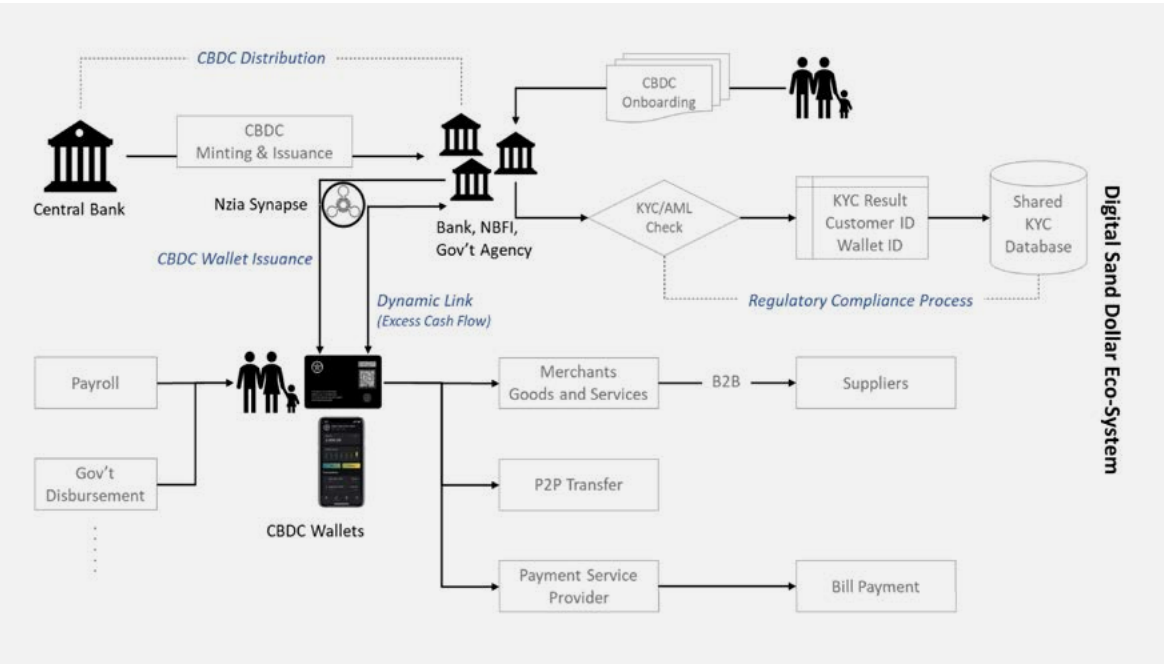


Figure 25: The Sand Dollar ecosystem illustration
Source: The Central Bank of the Bahamas

The Sand Dollar ecosystem is a secure atmosphere for tokenized payments. QR codes are created on the payer's mobile device or their electronic card via the receipt entity's point-of-sale terminal. According to the white paper, in-person payments are then executed in three possible forms:

- 1) A scan of the payee's static QR code, then entering the amount required on the next screen
- 2) A scan of the payee's dynamic QR code with an embedded amount, and then confirming at next screen
- 3) A transmission of payment amount to the payee via their Sand Dollar unique handle, alias, or address

Batch transactions can be processed using PSP platforms and the Sand Dollar infrastructure. This includes high-volume originations from the NIB, government, and private businesses. Such operations are like ACH transactions, but with settlement occurring in the Sand Dollar.

Following months of extensive discussions between NZIA, the central bank, and other related parties, the Exuma pilot launched in December 2019 with users enrolling in the Sand Dollar program through the wallet providers. The Sand Dollar infrastructure currently leverages existing public communication systems for payment message processing, as well as private communications networks created by NZIA.

After a successful rollout in Exuma, the Sand Dollar program expanded to the Abaco Islands in February 2020. Because of extensive damage to the financial system caused by Hurricane Dorian, the Abacos are being used to test emergency wireless communications for Sand Dollar systems. Data is being collected from both the Exuma and Abaco pilots to assist with the national Sand Dollar deployment, which is expected by Q4 2020.⁵³

Upon release of its 2019 Annual Report in May 2020, the CBOB officially recognized the Sand Dollar as a line item on its financial statements. "Sand Dollar in circulation" can be found on the CBOB balance sheet as a demand liability, and the statement of cash flows as an increase in operating liabilities.⁵⁴

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[Pilots in Caribbean](#)

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How have central bank's views around CBDC evolved over the past 5 years; and looking ahead, what's the main hurdle to implementation?

Interview with John Velissarios
Managing Director and Global Blockchain Technology Lead at Accenture

At first central banks were more defensive in their work in trying to look at what this technology can do in response to some early fears around cryptocurrency, and the potential for those to impact central banks and monetary policy.

From there, the early projects were strategic and collaborative, with pilot engagements like Project Jasper trying to understand with broader market stakeholders the implications of the tech and how it can be applied.

Now the attitude towards CBDC is more accepting with countries looking to others as a potential opportunity to collaborate in figuring out how it can be used, and standardized to allow for interoperability.

[In terms of implementation] When you talk to many of the central banks, they will make no firm commitment that they will be tokenizing their money tomorrow because from an implementation perspective there are a lot of things to consider. A lot of the language around pilots is noncommittal. What is the intent, why are they spending the time and money to develop these things? Some of these things are being done in industrial-grade environments because the intent is to implement a CBDC and take it to the next level. Watch some of these projects that are unfolding. [Questions to ask yourself] How focused is it? What is the investment that is going into it? And how big is it on the implementation and central bank side?

Implementation isn't about the technology, it's not that complex technologically speaking. There are some key technical open questions around standardization and interoperability that need to be worked out.

Key Takeaways:

- CBDC activity falls under the purview of the Eastern Caribbean Central Bank (ECCB). The ECCB issues and maintains the Eastern Caribbean dollar (EC dollar) for Eastern Caribbean Currency Union (ECCU) members.
- The ECCB’s Strategic Plan 2017-2021 was drafted to modernize the ECCU financial system, helping clear the way for a digital EC dollar.
- In February 2020, the Monetary Council passed amendments to the Eastern Caribbean Central Bank Agreement to expedite CBDC related processes.
- Barbados-based fintech company, Bitt Inc. is working with the ECCB to issue a digital EC dollar (DXCD).
- According to the ECCB’s 2019-2020 Annual Report, milestones to date include: (i) Design and deployment of the DXCD minting network; (ii) Completion of DXCD issuance test; (iii) Alpha Release of all DXCD Apps; (iv) Drafting of guidance documents for financial institutions and merchants; and (v) Engagements with user focus groups in all four pilot countries.
- After Covid –19 related delays, DXCD is set for live deployment activities at the end of Q3 2020.

The Eastern Caribbean’s Monetary Structure

In 1981, seven Eastern Caribbean countries signed the Treaty of Basseterre, establishing the Organization of Eastern Caribbean States (OECS). The OECS provided a framework for political and economic collaboration between Antigua and Barbuda, Dominica, Grenada, Montserrat, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines. Two years later, the original seven OECS members created the Eastern Caribbean Central Bank (ECCB).

The Organization of Eastern Caribbean States

Associate Member		ECCU Member
State	Joined OECS	
 Antigua and Barbuda	Founder	
 Dominica	Founder	
 Grenada	Founder	
 Montserrat	Founder	
 Saint Kitts and Nevis	Founder	
 Saint Lucia	Founder	
 Saint Vincent and the Grenadines	Founder	
 Anguilla	1995	
 British Virgin Islands	1984	
 Guadeloupe	2019	
 Martinique	2015	

The ECCB serves as monetary authority to 8 of 11 current OECS members; Anguilla, the British Virgin Islands, Guadeloupe, and Martinique joined the OECS as associate members over the past several decades. The main goal of the ECCB is to provide stability to the Eastern Caribbean dollar (EC dollar) and uphold the banking system’s integrity. Under the Eastern Caribbean Currency Union (ECCU), the original seven OECS members and Anguilla use the EC dollar as their common currency. The ECCB has maintained a fixed rate peg of EC\$2.70 to US\$1.00 since 1976.

History & Motivation

Like the Bahamas, the Eastern Caribbean Central Bank has sought to leverage financial technology and public-private initiatives to modernize its financial system. The ECCB’s “Strategic Plan 2017-2021” was drafted to provide a roadmap for ECCU members to undergo a unified socio-economic transformation through digital innovation.⁵⁵ The strategic plan found that above all, the most promising tech innovation for both financial firms and regulators is blockchain technology. Blockchain is viewed as a tool for Caribbean banks and non-bank institutions to merge financial processes, creating a more adaptive and resilient financial system.

In September 2017, ECCB Governor Timothy Antoine further emphasized fintech solutions at Bitt Inc.’s “Central Bank Meets Blockchain”

Figure 26:
The Sand Dollar
ecosystem illustration

Source: The Block

seminar in Barbados. Governor Antoine praised Bitt for pioneering central bank DLT applications – the Barbados-based fintech company had successfully digitized the Barbados dollar in February 2016 – and announced that the ECCB was in talks with the company about a potential digital currency pilot for the ECCU.⁵⁶

“During 2018, over a period of eight months, the ECCB engaged diverse groups of ECCU stakeholders (financial institutions, government institutions, private sector institutions, professional associations, merchants, consumers) as well as regional and international peer central banks, to identify the issues critical to the development of the customer value proposition and the resulting business requirements for the digital EC pilot.”

In March 2018, Bitt and the ECCB signed a Memorandum of Understanding (MOU) around the project. In a press release, Governor Antoine was quoted as saying “this fintech pilot is part of the Bank’s Strategic Plan 2017-2021. The aim of the pilot is to ascertain the suitability of blockchain technology to help boost economic growth and competitiveness in the region consistent with the ECCB’s monetary and financial stability objectives. Furthermore, as the ECCB promotes the safety and soundness of the financial system in the ECCU, it also has a responsibility to encourage and support innovation consistent with

the Bank’s mandate to facilitate the balanced growth and development of member countries. To that end, blockchain technology merits our attention and consideration at this time.”⁵⁷

In June 2018, the ECCB issued an advisory on fintech initiatives taking place in the ECCU. As per the notice, such operations included peer to peer lending, digital wallets, crowdfunding ventures, crypto-assets, and initial coin offerings (ICOs).⁵⁸ The ECCB wanted citizens to be cautious of unregulated fintech activities, but also reiterated its commitment to developing legal financial innovation. The ECCB spent the rest of 2018 planning for its CBDC pilot.⁵⁹

In March 2019, a regional media conference was held at the ECCB headquarters in Saint Kitts to commemorate the ECCB Digital EC Currency (DXCD) pilot launch. Throughout the event, Bitt’s CEO Rawdon Adams and Governor Antoine provided project updates and fielded media questions from representatives of the 8 ECCU member countries.

Governor Antoine emphasized the need for stakeholder engagement, revealing that “during 2018, over a period of eight months, the ECCB engaged diverse groups of ECCU stakeholders (financial institutions, government institutions, private sector institutions, professional asso-

ciations, merchants, consumers) as well as regional and international peer central banks, to identify the issues critical to the development of the customer value proposition and the resulting business requirements for the digital EC pilot.”⁶⁰

The DXCD pilot was reportedly to be carried out in two phases: (1) development/testing, which would take about 12 months and (2) roll-out/implementation for pilot countries, lasting about 6 months. 3 countries were initially selected (a fourth was later added), based on institutional capacity, technology infrastructure, geographic layout, and feedback from ECCU-licensed financial institutions.

Governor Antoine concluded the event with a call for collaborative innovation, asking non-bank financial institutions, telecom service providers, tech companies, and citizens to join the effort to “develop a digital ecosystem from which [the] region can reap huge digital dividends.” The ECCB planned to increase DXCD public education and awareness campaigns across ECCU member countries in 2019, including a DXCD page to its website linking to educational newsletters, FAQs, project updates, and more.

The following payments graphic is from DXCD Times Issue 02, November 2019:⁶¹

In November 2019, the Center for Latin American Monetary Studies (CEMLA) hosted a Regional Payments Week in Willemstad, Curaçao. Francis Fontenelle, Senior Banking Specialist for the ECCB, gave a presentation on DXCD progress for members of CEMLA, the BIS, and the World Bank. The

pilot objectives included increasing payment efficiencies and promoting innovation, business development and increased productivity with a view to advancing inclusive growth, economic resilience & competitiveness, and greater financial inclusion.⁶²

Representatives from the ECCB spent January and February 2020 engaging potential merchants, consumers, and banks on the DXCD pilot features and benefits. They received feedback from stakeholders



Figure 27: Screenshot of ECCB public education campaign around DXCD

Source: ECCB

across Antigua and Barbuda, Grenada, St. Kitts and Nevis, and Saint Lucia. Furthermore, the ECCB hired WEUSTHEM, a Canadian marketing firm, to conduct surveys in March 2020, which reportedly aimed to further investigate consumer preferences for financial services and identify the key communication points to shape the messages around the pilot project.⁶³

On the regulatory side, the ECCB’s Monetary Council passed amendments to the Eastern Caribbean Central Bank Agreement in February to expedite DXCD-related processes. Public-private support for the DXCD pilot has already proven to be successful. According to the ECCB’s 2019-2020 Annual Report, milestones to date include: (1) design and deployment of the DXCD minting network; (2) completion of DXCD issuance test; (3) alpha release of all DXCD apps; (4) drafting of guidance documents for financial institutions and merchants; and (5) engagements with user focus groups in all four pilot countries.⁶⁴

After Covid-19 related delays, DXCD is set for live deployment activities in late Q3 2020.

Design & Implementation

As noted in the previous section, the Barbados-based fintech company Bitt Inc. was chosen to be the primary technology services provider for the ECCB’s DXCD pilot project. Bitt is authorized to host and manage DXCD network technologies on behalf of the ECCB.

As per the ECCB presentation at the Regional Payments Week 2019, Bitt’s key responsibilities include: ⁶⁵

- Overseeing DXCD network performance and maintenance
- Implementing governing rules/protocols for pilot operations as provided by the ECCB
- Securing network APIs so third-party applications can interact with DXCD’s system
- Providing Tier 3 support to financial institutions and the ECCB for their operations on the DXCD network
- Supplying operation applications for all DXCD pilot network participants
- Drafting training and operations guidelines as technology service providers

Pinaka Consulting is also providing DXCD pilot support while serving as blockchain technical adviser to the ECCB. The project is being conducted under the ECCB’s supervision in a controlled sandbox environment. DXCD is a securely minted digital version of the EC dollar issued and redeemable by the ECCB.

Like physical notes and coins, the DXCD units are a liability of the ECCB that co-circulate with traditional cash throughout ECCU economies. The ECCB issues DXCD to banks and approved non-bank financial institutions on a private permissioned blockchain network – financial intermediaries then distribute DXCD network and transaction access to businesses and consumers, as illustrated below.

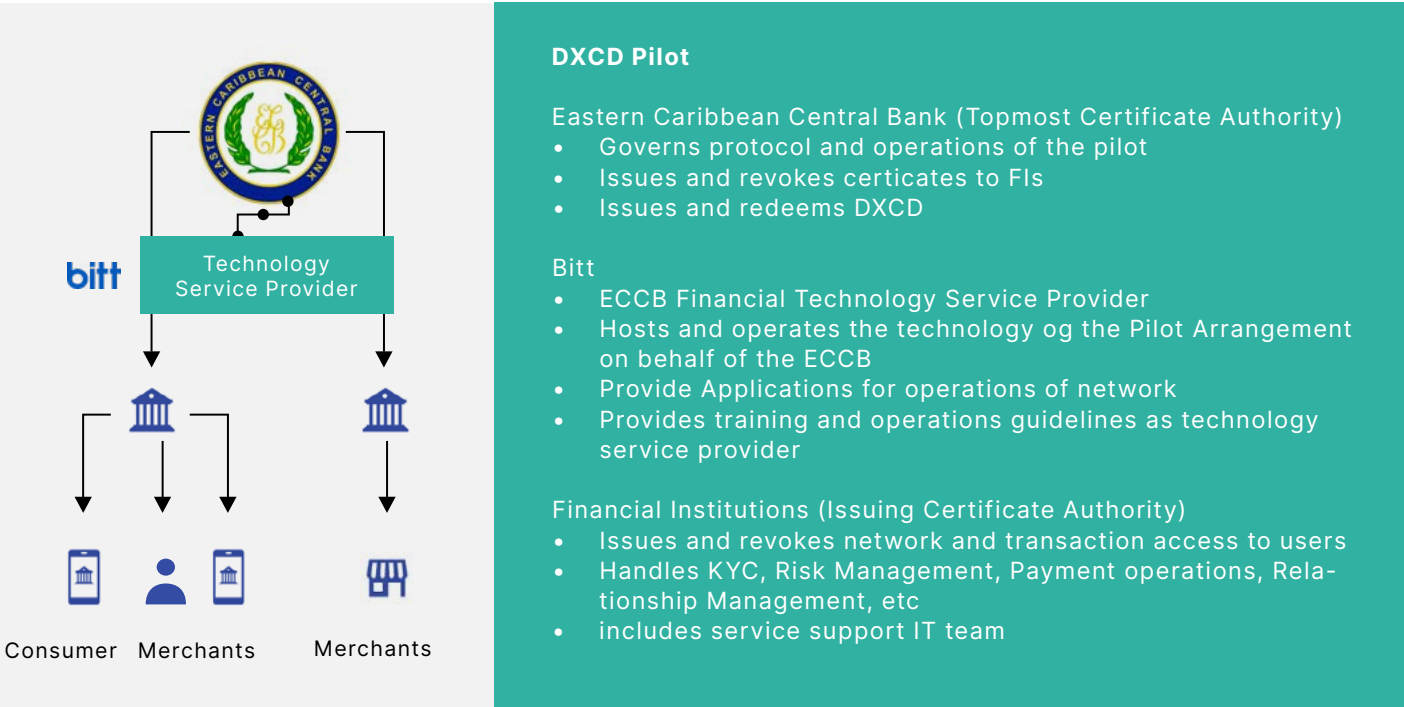


Figure 28: DXCD pilot model and participants
Source: ECCB

IBM Hyperledger Fabric was chosen to be the blockchain platform for the DXCD pilot. The ECCB liked its strong security features as a permissioned blockchain with advanced identity management techniques. An open source architecture also contributes to platform security, versatility, and scalability.

As per an ECCB press release in March 2019, IBM Hyperledger Fabric’s key features include:

- Private permissioned blockchain
- Open source, hosted and managed by Linux Foundation

- Enterprise-grade distributed ledger
- Supports business transactions
- Confidentiality of data through channel architecture
- Privacy in channels through private data feature
- Better performance and scalability through flexible architecture

Using Hyperledger Fabric, the ECCB can allocate network access to all pilot stakeholders, implement governance decisions, onboard financial institutions, issue & redeem DXCD units, and regulate the DXCD network. As part of its fulfillment services, the ECCB is responsible for issuing and revoking financial institution certificates, verifying security of DXCD applications, and establishing the rules & protocols for the pilot operations.

The following graphic from the ECCB’s Regional Payments Week 2019 presentation lists notable DXCD network features:⁶⁶



Figure 29: Notable DXCD network features
Source: ECCB

Financial institutions (FIs) have two primary roles during the DXCD pilot: to facilitate business processes and to support technology services. Key businesses processes include performing KYC/AML compliance, managing risk, and overseeing payment operations. Services support focuses on improving technology systems that assist customer experience representatives, such as IT and Tier 2 DXCD networks. Furthermore, FI employee pilot roles and responsibilities are administered through training programs. Financial institutions are providing relevant process feedback to the ECCB team throughout the project. DXCD is available to both the banked and unbanked population, as two different DXCD models currently exist.

The registered-based model uses a holding account where financial institutions offer custody services for the private keys of account holders. Those with an existing financial institution relationship are eligible for this model and are subject to KYC and AML/CFT monitoring by said FI. The value-based model is meant for those who do not have a bank account and want to engage in low-value transactions. Each

user’s private and public keys are stored on their smart device, removing the need for custodian services. Non-bank licensed financial institutions perform KYC procedures before customers are onboarded to the network. However, users are not subject to consistent monitoring, as there are pre-set wallet limits.⁶⁷

DXCD VALUE BASED (NON CUSTODIAL) WALLET LIMITS		
Limit Period	Limit Calculation	Caps
Monthly	Total value of transactions per calendar month	2000
Weekly	Total calue of transactions per calendar week	500
Daily	Total value of transactions daily	300
P2P Transfers	Total value able to send and receive in a single transaction	500

Figure 30: DXCD pilot wallet limits capped by value | Note*
Source: ECCB



Figure 31:
DXCD application
signup screen

Source: ECCB

From a financial inclusion standpoint, the ECCB wants to make sure that all potential users have access to the necessary devices and can afford to use DXCD. The ECCB and Bitt are working with a large telecommunications company in the ECCU to facilitate DXCD Caribe network transactions – this company is offering DXCD wallet users subsidized and, in some cases, zero-rated data costs. State-of-the-art ID verification and face scanning software assist with remote onboarding in-app.

References:

⁵⁵ Eastern Caribbean Central Bank, [Strategic Plan 2017-2021](#) (2017) – pg.49

⁵⁶ The Barbados Advocate, [Blockchain Technology Provides Enormous Opportunities for Our Region](#) (2017)

⁵⁷ Eastern Caribbean Central Bank, [ECCB to Embark on Blockchain Pilot Initiative With Bitt Inc.](#) (2018)

⁵⁸ Eastern Caribbean Central Bank, [ECCB Advisory on FinTech Operations in the ECCU](#) (2018)

⁵⁹ Eastern Caribbean Central Bank, [Governor Antoine Addresses the ECCU Media on Launch of FinTech Pilot Project](#) (2018)

⁶⁰ Eastern Caribbean Central Bank, [Governor Antoine Addresses the ECCU Media on Launch of FinTech Pilot Project](#) (2018)

⁶¹ Eastern Caribbean Central Bank, [DXCD Times: Towards a Digital Economy](#) (2019) – pg. 2

⁶² Eastern Caribbean Central Bank, [The ECCB Fintech Project: Digital Eastern Caribbean Currency Dollar](#) (2019) – pg. 2

⁶³ Eastern Caribbean Central Bank, [DXCD Times: Towards a Digital Economy](#) (2020)

⁶⁴ Eastern Caribbean Central Bank, [DXCDCaribe Annual Report 2019-2020](#) (2020) – pg. 12

⁶⁵ Eastern Caribbean Central Bank, [The ECCB Fintech Project: Digital Eastern Caribbean Currency Dollar](#) (2019) – pg. 17

⁶⁶ Eastern Caribbean Central Bank, [The ECCB Fintech Project: Digital Eastern Caribbean Currency Dollar](#) (2019) – pg. 18

⁶⁷ Eastern Caribbean Central Bank, [The ECCB Fintech Project: Digital Eastern Caribbean Currency Dollar](#) (2019) – pg. 18

⁶⁸ Eastern Caribbean Central Bank, [DXCD Times: Towards a Digital Economy](#) (2020)

^{FIG.30}[The table reflects ongoing discussions on the limits.]

What's the biggest misconception you hear, or key consideration that gets left out, when discussing CBDC across stakeholders?

There is a misconception that a CBDC necessitates the use of a particular technical back-end or a particular technology. That's actually not true. You can have centralized CBDC or you can have decentralized CBDC that can sit upon either centralized or decentralized technology systems. That doesn't change the issuance of the CBDC. It's just the technological choice that goes into that. But that is not part of the definition of a CBDC. It's merely the implementation mechanism that's chosen with the technology. And there are very good reasons why you might go one way or the other when you're making that choice.

We don't [WEF] have a formal view on the need for programmability within CBDC. We're still in listening mode on this. It's not obvious if you don't use DLT or blockchain now, you're missing out on this. In my mind, the movement to digital currency and e-money, that move is so radical, that the disintermediation component could be too big of a leap to take. There is an idea of using existing infrastructure to take a midstep down the road into blockchain. Is that ideal? No. But I'd rather see these guarded permutations happen, instead of pushing everyone to jump into DLT.

It's not an education issue. It's a risk to assessment. Is this tech stable enough? Is it going to change a lot in next few years to where it's outdated? This is a bank, an economy of a country. They want to feel confident that the tech is stable. It's an ROI question.

At the end of the day, [banks] must ask themselves,

what are the problems, in priority order, that we are trying to solve with CBDC? What problems are addressable within the scope of the project, and what problems fall out of that scope? This is the most challenging part. The build will largely follow, but this is not a situation where the tech should be driving the discussion.

—
Sheila Warren
World Economic Forum
Head of Blockchain, Digital Assets, and Data Policy

Case Study - Bitt

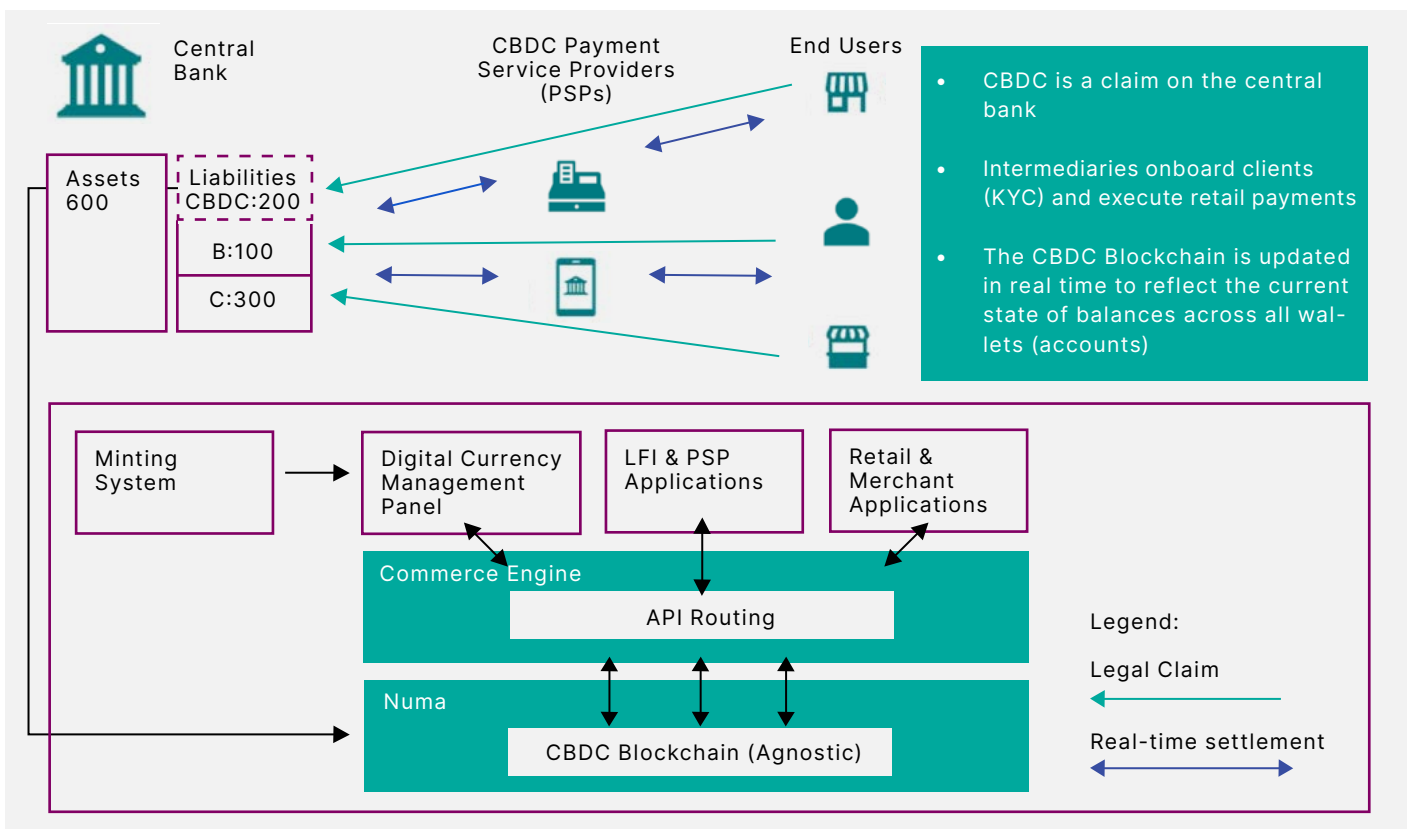


Bitt's mission is to ensure the innovation of distributed ledger technology (DLT) can be effectively leveraged to provide secure, efficient, fast, and reliable payments infrastructure for economies worldwide. DLT can be utilized by Central Banks to better achieve their mandate of regulating the monetary supply and fostering economic growth, and to meaningfully evolve national and international payment systems. As the primary monetary authority, Central Banks have the opportunity to adopt modernized financial technologies for the betterment of their economies, financial systems, and citizens as we continue through the digital age.

Having digitized the Barbados dollar in 2016 with the support of the Central Bank and Finance Ministry, Bitt was the first company to digitize a national currency on a public blockchain. The Digital Barbados Dollar (DBBD) utilized the Colored Coins protocol, an overlay protocol for the Bitcoin network. While public decentralized networks offer innovative solutions for the digitization of currencies and assets, most Central Banks are currently contemplating the use of private distributed networks for Central Bank Digital Currency (CBDC) due to the ability to control access to and the evolution of the network itself. As decentralized blockchains scale in the coming years we may see Central Banks re-consider such networks for the digitization of national currencies.

Bitt's stack, the Digital Currency Management System (DCMS), enables Central Banks to deploy CBDC infrastructure in both the domestic and international financial system, while setting boundaries for access and usage in line with desired policy and legal frameworks. Furthermore, the DCMS enables Central Banks to utilize the blockchain that best suits their needs, which differ from country to country. For example, the DXCD network utilizes a tailored version of Hyperledger Fabric, a permissioned network, built to a technical specification developed by Bitt and the Eastern Caribbean Central Bank (ECCB) to suit the needs of the Eastern Caribbean Currency Union. As a technology services provider for Central Banks, Bitt will continue to maintain and evolve the underlying blockchain network itself while leveraging updates from the open source community. In addition, Bitt continues to evolve our proprietary architecture and all associated user-facing applications that comprise the DCMS on an ongoing basis.

An imperative of the DCMS is ensuring compatibility with international standards for CBDC networks - blockchain and otherwise - especially given that there are significant efficiency gains to be realized in the realm of multilateral exchange and swap transactions executed atomically in payment vs. payment scenarios. While ISO20022 has served to standardize messaging formats for existing payment systems, bodies like the International Telecommunications Union (ITU) and the International Standards Organization (ISO) are now investigating which stan-



dards best apply to blockchain and DLT-based CBDC networks, while seeking to leverage the significant accomplishments of ISO20022 as they pertain to such networks. Bitt continues to contribute to the development of CBDC network standards and best practices to ensure effective collaboration amongst international Central Banks. These standards will also further the efforts of launching the Caribbean Settlement Network (CSN), a multilateral settlement network enabling the direct exchange of CBDCs from the Caribbean basin and beyond. Settlement networks like the CSN offer participating countries increased access to liquidity, lower settlement times, cost savings, and elimination of settlement risk given the atomic nature of exchange and swap transactions, in comparison to traditional platforms.

We envision a future where Bitt enables Central Banks to achieve the roles of operator, catalyst and overseer of their own CBDC networks through public private partnerships utilizing Bitt's DCMS. The DCMS is a production-ready blockchain based CBDC software suite that enables Central Banks to pilot their own digital legal tender out of the box. While customizations may be required to meet the unique needs of each country's economy, and to effectively integrate into the country's existing financial system, the suite has extensive stock features that are applicable to all Central Banks in their role as primary monetary authority. Furthermore the DCMS was designed to be interoperable in order to accommodate and integrate with the multiple mechanisms that make up a financial system.

The DCMS is comprised of a number of elements, namely:

- **Minting system:** provides secure private key storage and signing mechanisms enabling the currency management department and other relevant authorities to action the minting of new currency; a hardware and software solution.
- **Commerce engine:** a routing system with business logic for the Central Bank, Licensed Financial Institutions (LFI), merchant and retail applications, and more.
- **Numa system:** provides secure data handling and monitoring functionality, and APIs for wallet generation, transactions, query, and more. The Numa also holds any currency-specific details such as currency code, country-specific rules, and other elements as required by the Central Bank.
- **The core blockchain protocol:** powers the state changes of wallets and all CBDC in circulation.
- **Digital Currency Management Application:** enables Central Banks to implement a variety of monetary policy actions, as well as extensive monitoring and reporting tools.
- **LFI Applications:** enables commercial banks and payment service providers to interact with the Central Bank and their retail and merchant clients, as well as perform financial operations and AML Compliance functions.
- **Retail & Enterprise Applications:** enables retail and enterprise users to send and receive CBDC, generate reports, and more.

Bitt provides the Digital Currency Management System to Central Banks and assists them in the process of designing, developing, and deploying a CBDC solution that is best suited to their economy and financial system. In a live deployment scenario, the marketplace model is implemented and the Central Bank controls which entities have access to their CBDC network. This introduces variety and competition at the payments services layer for licensed LFIs and PSPs in their provision of retail and enterprise payments applications clients. In a live deployment scenario, all licensed participants (mainly LFIs and PSPs) could engage a technology services provider of their choice for the development and operation of the requisite CBDC software for both their own institution and their clients, or could build their own applications in house.

The image on the prior page has been edited to show how Bitt's DCMS enables the marketplace model, also adapted from 'Central banks and payments in the digital era' by the BIS. The DCMS enables a variety of CBDC scenarios (hybrid, direct, etc.) depending on the requirements of the Central Bank. Similarly, the DCMS enables the Central Bank to choose the blockchain that best suits their requirements; a private chain is shown in the diagram below, which is typically run on multiple nodes within the country and with trusted cloud service providers. A public chain can be used, which would interact with the Numa while being run on distributed nodes worldwide (such as with the decentralized networks Bitcoin, Ethereum, Stellar, and others).

Part III

The Wholesale CBDC Pilots: Interbank settlement and cross-border payment opportunities

<u>106</u>	Project Stella (ECB and Japan)
<u>116</u>	Project Ubin and Jasper (Singapore & Canada)
<u>130</u>	Project Inthanon / LionRock (Hong Kong and Thailand)

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Key Takeaways:

- The latest BIS central bank CBDC survey found that 15% are exclusively focusing on wholesale use cases, and about half of banks surveyed are looking at both retail and wholesale use-cases.
- Some opportunities being explored for wholesale CBDC include: 24/7 settlement availability, new levels of anonymity, ability to do p2p wholesale large value payments without an intermediary, the potential to reduce counterparty risks by settling directly with central bank liabilities, and the a reduction of cross-border transaction costs
- Part III of this paper explores the history and unique findings of some of the most well-known publicly-disclosed wholesale CBDC experiments by central banks to date, including Project Stella, Project Ubin/Jasper, and Project Inthanon/LionRock.
- Looking ahead, for a tokenized version of fiat to be used as a viable and safe settlement asset for wholesale applications, clear legal structures equivalent to the established frameworks set in place for RTGS systems may need to be expanded for wholesale CBDC.
- Wholesale CBDC and DLT-based settlement experiments conducted by central banks to date are still highly exploratory in nature. Previous adoption curves by central banks on implementing RTGS systems, and more recently retail-fast payment systems, suggest that wider adoption of W-CBDC and/or DLT-based settlement systems is still at least over a decade away.

Central bank mandates extend beyond just managing monetary policy to achieve price stability; they also serve a critical role in ensuring economic and financial stability.

One core area within financial stability is the ability to provide efficient, resilient, and accessible ways for households and businesses to make payments. It has been well-documented that a functioning payment system can support long-run economic growth and deepen economic activity.⁶⁹

Central banks also play a critical role in providing and operating public payment and market infrastructure, while acting as “guardians” in maintaining the safety and integrity of these systems.

In their roles as payments systems operators, central banks historically have encouraged private sector innovation to improve payment efficiency, safety, and accessibility. As payment innovation evolves, central banks must continue to evaluate technological innovations that could enhance and improve current systems, while also being mindful of legacy public infrastructure competitiveness.

One area of technological innovation that has interested central banks is the use of central bank digital currency for wholesale payment applications, known as wholesale CBDC (W-CBDC). Central banks are exploring whether W-CBDC could reduce settlement risks, provide 24/7 up-time, widen interoperability with other settlement systems, reduce cross-border payments, and more.

Wholesale digital money is not a new concept as financial institutions have had access to electronic reserves held at central banks for decades. However, the idea of W-CBDC is incremental in that it forces a reevaluation of how legacy settlement and cross-border payments currently works, by way of evaluating whether distributed ledger technology and tokenized fiat issued by a central bank could provide better capabilities.

The latest BIS central banks survey published in January 2020⁷⁰ – surveying 66 banks covering 75% of the world's population and 90% of its economic output – found that [15% are exclusively focusing on wholesale use cases (which hasn't moved since 2018), and about half of banks surveyed are looking at both retail and wholesale use-cases]

Wholesale CBDC Definition and Potential Benefits
From Ubin-Jasper Phase 4 Report

Wholesale CBDC is a limited-access central bank issued legal tender digital currency used for wholesale, interbank payment and settlement transactions. Some benefits they could pose include:

Availability: Currently, the availability for requesting instructions to process CBDC is limited to central bank operating hours traditionally less than 24 hours a day and usually five days a week. CBDCs could be available 24 hours a day and seven days a week or during certain specified times (such as the operating hours of large-value payment systems). CBDCs could be available permanently or for a limited duration; for example, they could be created, issued and redeemed on an intraday basis. On this basis, the use of CBDCs can address the current challenges of service availability across time zones.

Anonymity: CBDCs can, in principle, be designed to provide different degrees of anonymity or privacy similar to private digital tokens. The degree of anonymity or privacy vis-à-vis the central bank needs to be balanced with, among other things, concerns relating to money laundering, financing of terrorism and privacy.

Transfer mechanism: The transfer of cash is conducted on a peer-to-peer basis, while central bank liabilities are transferred through the central bank, which acts as an intermediary. CBDCs may be transferred either on a peer-to-peer basis or through an intermediary, which could be the central bank, a commercial bank or a third-party agent.

Counterparty credit risk: As with all central bank liabilities, the exchange of CBDCs between banks occurs without credit risk for participants because: 1) CBDCs are binding claims on the central bank’s currency, and 2) participants do not face credit risks associated with claims on the central bank currency because the central bank is not subject to default.

Source: [Ubin-Jasper Phase 4](#) (Direct Source)

The motivations for central banks to research and experiment with W-CBDC largely depend on the relative strength of legacy financial and payment infrastructure within each respective economy.

For Emerging Market Economies (EMEs), the latest BIS surveys found that the most important factors for researching W-CBDC were to improve domestic payment efficiency and financial stability. Further, smaller EMEs that do not already have a wholesale or functioning real-time gross settlement system (RTGS) for its currency could favor these factors even more.

Advanced economies with well-established RTGS and real-time payment systems placed cross-border payment efficiency as the most important motivation behind researching W-CBDC.

MOTIVATIONS FOR ISSUING A WHOLESALE CBDC

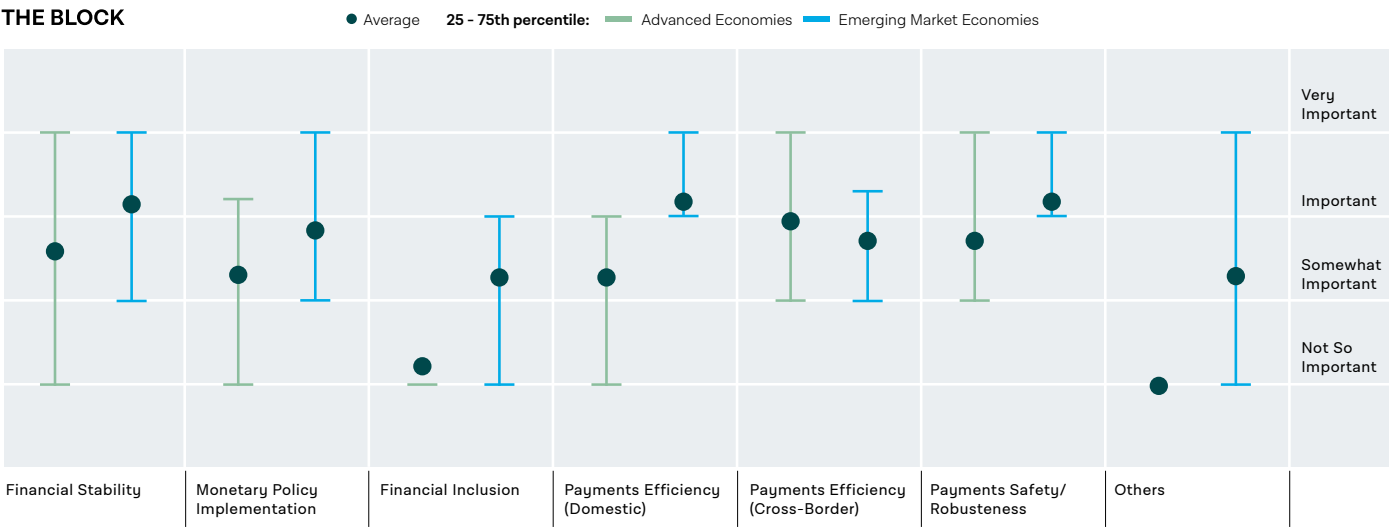


Figure 32: Motivations for central banks to issuing a wholesale CBDC across AE and EME
Source: BIS, The Block

To date, central banks have largely been more positive on wholesale applications of CBDC, relative to retail applications, when giving public speeches (see pg 36) on the topic. This is likely because wholesale CBDC applications could improve efficiencies and work in parallel to other legacy systems, while retail CBDCs could offer a paradigm shift with far-reaching implications, thus requiring more caution.

Within advanced economies, this dynamic has historically pushed central banks towards experimenting with wholesale applications using distributed ledger technology for settlement and cross-border payment.

Part III of this paper explores the history and unique findings of some of the most well-known publicly-disclosed wholesale CBDC experiments by central banks to date, including Project Stella (ECB and Bank of Japan), Project Ubin/Jasper (Monetary Authority of Singapore and Bank of Canada), and Project Inthanon/LionRock (The Hong Kong Monetary Authority and Bank of Thailand). To be sure, many of these projects involve potential applications for wholesale tokenized fiat issued by the private sector rather than a digital token issued by the central bank. In other phases of experimentation, central banks focused on testing unique aspects of distributed ledger technology, rather than tokenized central bank money.

Looking ahead, for a tokenized version of fiat to be used as a viable and safe settlement asset for wholesale applications, clear legal structures equivalent to the established frameworks set in place for

RTGS systems may need to be expanded for wholesale CBDC. Legal consideration such as payments law, contract law, settlement finality provisions, insolvency law, and conflicts of law regimes were not written with a wholesale token system built on DLT in mind, and could lead to legal gaps⁷¹. In other instances, with a lack of central intermediary, questions around governance and operational risk management considerations also still need to be addressed.

Finally, it's worth highlighting that the wholesale CBDC and DLT-based settlement experiments conducted by central banks to date are still highly exploratory in nature. Should the handful of central banks that have been public with their proof-of-concepts and early experimentation move to implement some of these systems, previous adoption curves by central banks on implementing RTGS systems, and more recently retail-fast payment systems, suggest that wider adoption of W-CBDC and/or DLT-based settlement systems is still at least over a decade away.

Diffusion of fast payments¹

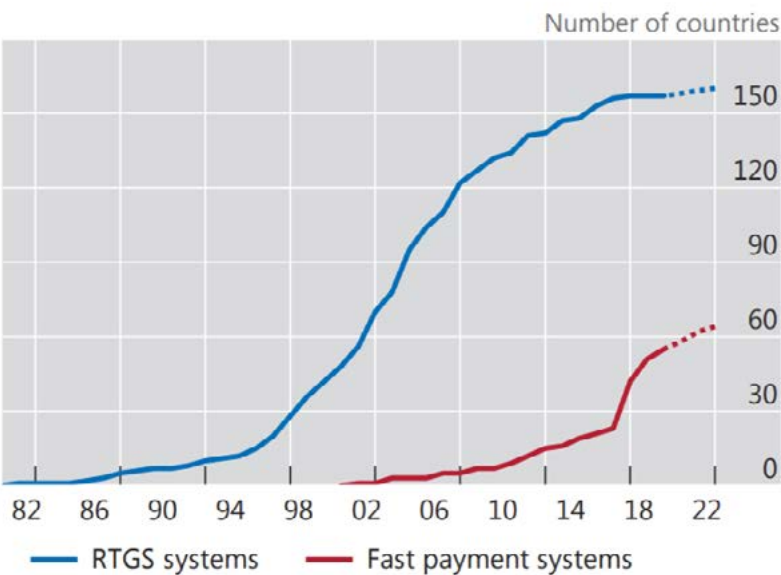


Figure 33:
Historical adoption curve of
RTGS and Fast payment
systems by central banks

Source: BIS

¹ The dotted part of the lines corresponds to projected implementation. 2017.

References:

⁶⁸ Bank of Finland, [Retail Payments and Economic Growth](#) (Hasan, De Renzis, Schmiedel 2012)

⁷⁰ Bank for International Settlements, [Impending arrival - a sequel to the survey on central bank digital currency](#) (Boar, Holden, Wadsworth 2020)

⁷¹ Bank for International Settlements, [Wholesale digital Tokens](#) (2019)

Retail vs Wholesale Payment Systems
From BIS – Central banks and payments in the digital era

A **payment system** is a set of instruments, procedures and rules for the transfer of funds among participants institutions, including the operator of the system, used for the purposes of clearing and settling payment transactions.

Payment systems are generally classified as either **retail** or **wholesale**.

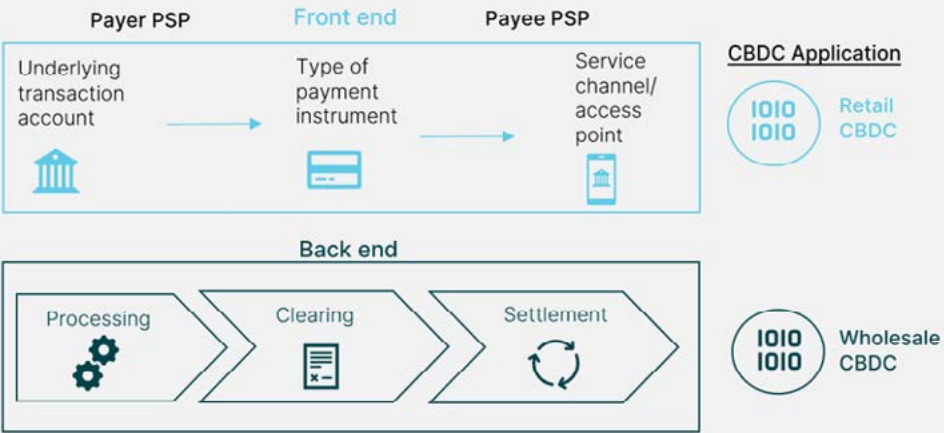
A **retail payment system** handles a large volume of relatively low-value payments, in such forms as credit transfers, direct debits, cheques, card payments and e-money transactions.

A **wholesale payment system** executes transactions between financial institutions. These payments are typically large-value and need to settle on a particular day and sometimes by a particular time.

Payment infrastructure usually involves payments flowing through a “front end” that interacts with end users and a number of “back-end” arrangements that process, clear and settle payments.

Front-end arrangements initiate the payment through: underlying transaction account (source of funds), a use of payment instrument (card, cash, etc), and to the service channel/access point which connects the payer/payee and the payment service provider (PSP).

Back-end arrangements focus on specific stages of the payment chain: processing the transaction (authentication, fraud monitoring, fee calculations, etc.), clearing the transaction (transmitting and reconciling the transaction), and settlement of the transaction (transferring funds to discharge monetary obligations between parties).



Source: [Central banks and payments in the digital era](#) (Direct Source)

Key Takeaways:

- **Project Stella is a joint research project conducted by the European Central Bank and Bank of Japan to explore the opportunity for DLT to support financial market infrastructure, payments, and securities settlement.**
- **Split over 4 Phases, phase 1 used distributed ledger technology (DLT) to process large-scale payments; phase 2, tested securities settlement in a DLT setting; phase 3, applied DLT-related technologies to improve cross-border payment efficiency; and phase 4 focused on the confidentiality and auditability of settlement assets, such as CBDC, in a DLT environment.**

History & Motivation

The European Central Bank (ECB) was one of the first central banks to officially study digital assets, releasing its “Virtual Currency Schemes” report in October 2012.⁷³ This preliminary assessment concluded that cryptocurrencies “do indeed fall within central banks’ responsibility as a result of characteristics shared with payment systems, which give rise to the need for at least an examination of developments and the provision of an initial assessment.”

From a research perspective, the ECB has written countless digital asset research papers since its 2012 report. These papers have contributed to the collaborative research efforts by central banks to better understand DLT and the potential effects of CBDC issuance.

In January 2016, ECB board member Yves Mersch touted the disruptive potential of distributed ledger technology, particularly in the payments industry. The following month, an ECB consultative report announced a Eurosystem investigation into blockchain-based services for banks. By the end of 2016, the ECB created a CBDC task force, prompting more public CBDC discussions.

ECB public retail CBDC work has largely been theoretical research
According to Mersch, retail CBDC “could either be account-based – in this case, the central bank would open an account for every interested non-bank – or it would be value-based like cash. In this case, interested non-banks would need to be equipped with electronic wallets for holding and using DBM. A transfer of DBM would require that the funds be debited from the payer’s electronic wallet and credited to the payee’s device without the involvement of the central bank.” The potential ramifications of these options differed, requiring significant exploration by Eurosystem participants. The most important factor to consider was whether introducing a retail CBDC would allow the ECB to continue honoring its mandate.

Source: [The Block](#), [ECB](#)

In December 2016, Mersch delivered a speech prioritizing the euro’s assessment as a settlement asset, with accessibility being the key factor for any future CBDC. He believed that “issuing central bank money on a distributed ledger for settlement among current holders of TARGET2 accounts could be done in a way that changes little of how central banks perform their functions. Nevertheless, broadening access, possibly even to the man or woman on the street, is often discussed under the heading ‘digital central bank currency.’ It would change the way different actors interact in financial markets and requires multidisciplinary research.” ⁷⁴ A research collaboration

with the Bank of Japan, Project Stella, was then initiated to study DLT market infrastructure use cases.⁷⁵

In January 2017, Mersch further explained options for designing, distributing, and overseeing CBDC, or Digital Base Money (DBM) – DBM is “money that is characterized by two features: (1) like banknotes in circulation, DBM is a claim on the central bank; (2) in contrast to banknotes, it is digital.” ⁷⁶

He argued that DBM already existed, as “commercial banks and some other types of institutions hold digital claims on central banks in the form of deposits.” The existing wholesale DBM was account-based, and the central bank directly registered inter-bank transfers. However, recent DLT developments have rekindled debates about issuing central bank money to non-banks, otherwise known as retail CBDC.

Members of the ECB and Eurosystem NCBs have conducted research and released their findings for both retail and wholesale CBDC. Wholesale CBDC activity has mainly occurred under Project Stella, through which the ECB has published research works and executed proof of concepts (POCs). The ECB’s retail CBDC research has mostly been theoretical, as practitioners consider not only the technical matters but the legal and policy implications as well.

Design & Implementation

Phase	Date Published	DLT Focus Area	DLT Used	Core Findings
1	September 2017	Institutional Payment Processing	Hyperledger Fabric	Using liquidity saving mechanisms phase 1 found that DLT-based solutions could meet performance needs of RTGS system; however given immaturity of DLT, ECB could not recommend the tech for large-scale payment services at the time
2	March 2018	Securities Settlement	Corda / Elements and Hyperledger Fabric	Proved numerous DLT designs could be used for securities vs cash settlement
3	June 2019	Cross-Border Payments		On-ledger escrow using HTLC proved that synchronised settlement between different types of ledgers was technically possible
4	February 2020	Confidentiality and Auditability,		Provided a foundation for choosing PETs and drafting audit schemes for settling wholesale CBDCs transactions in a DLT environment

Figure 34: Project Stella 4 Phase Summary Table
Source: The Block, European Central Bank, Bank of Japan

Since December 2016, Project Stella has explored DLT application use cases through conceptual studies and practical experiments. To date, its financial market infrastructure (FMI) results have been released in four phases.

Phase 1 experiments were conducted to determine whether existing functionalities of TARGET2 (the Real-Time Gross Settlement system for the ECB) could run in a DLT environment, specifically on Hyperledger Fabric version 0.6.1. Using liquidity saving mechanisms, Phase 1 experiments “found that DLT-based solutions could meet the current performance needs of an RTGS system. Within the restricted test environment, both average and peak payment traffic consistent with that of BOJ-NET and TARGET2 was processed without difficulty.” ⁷⁷ However, given the relative immaturity of DLT, the ECB could not recommend the technology for large-scale payment services at time.



Figure 35: Wholesale and retail transaction volume, value, and average, 2018
Source: Committee on Payments and Market Infrastructures, Red Book Statistics, 2018, with input from Gottfried Leibbrandt; BIS elaboration, The Block

Phase 2 of Project Stella focused on securities settlement, where securities were delivered against cash in a conceptual DLT environment. Drawing on existing delivery-versus-payment (DvP) methods, prototypes were developed using the Corda, Elements, and Hyperledger Fabric DLT platforms in order to practically understand how DvP functioned on DLT.

Real-Time Gross Settlement (RTGS) Systems in Europe and Japan

RTGS: According to the Bank for International Settlements (BIS), RTGS systems are a gross settlement systems (transfers are settled individually, not netting against debits and credits) where processing and final settlement of fund transfer instructions can take place continuously in real time. The origins of the RTGS systems begin with the creation of the Federal Reserve's FedWire in 1918, which was computerized in the early 1970s. Electronic RTGS systems spread rapidly among central banks in the 1980s, and have helped limit settlement and systemic risks in the settlement of large-value transfers between banks and financial institutions.

- **TARGET2:** Operated by the Eurosystem, TARGET2 settles payments across monetary operations, interbank settlements, large-value net settlement systems, and other financial market infrastructure that handles the Euro. The system settled an average of 1.7 trillion euros a day, and made up ~90% of the total share of large-value payment euro traffic in 2019
- **BOJ-NET Funds Transfer System:** The RTGS system operated by the BOJ which settles money market transactions, securities transactions, customer payments, monetary operations, and other private-sector net payment systems. The BOJ-NET system settled an average of the equivalent of 1.1 trillion euros (137 trillion yen) in 2016.

According to a joint report published by the Bank of Canada, Bank of England, and MAS, there are two crucial, risk-reducing features to central bank-operated RTGS high-value payment systems, that places them at the heart of the global payments system:

"The first is that settlement takes place at a central bank, in "central bank money." Given that central banks have the lowest risk of default of any agent in the economy, this reduces the risk of settlement agent failure to close to zero. The second feature is the move to RTGS systems themselves, as opposed to systems where settlement occurs on a deferred net basis. Under a real-time system, obligations are extinguished as soon as they arise, meaning that participants are not building up credit risk between them while awaiting settlement. Central banks generally adopted this model over the 1980s and 1990s as the technology developed to support real-time settlement. The move to RTGS systems effectively eliminates settlement risk from high-value payment systems. Several central banks are now facing challenges related to operating legacy infrastructure."

Source: [ECB TARGET2 Facts](#), [ECB Stella Project Report](#), [BIS RTGS](#), [Cross-border Interbank payments and settlements](#), Riksbank

The 3 main findings from Project Stella Phase 2: ⁷⁸

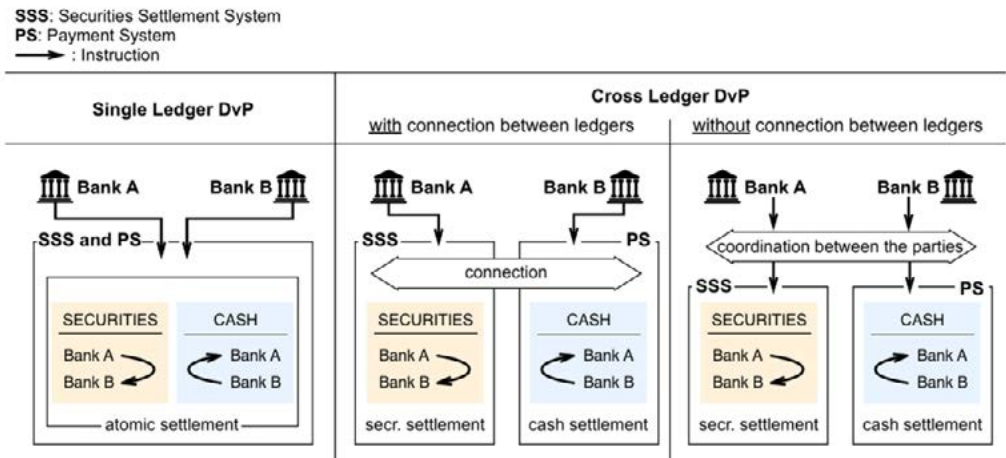
- 1) DvP can run in a DLT environment subject to the specificities of the different DLT platforms.
- 2) DLT offers a new approach for achieving DvP between ledgers, which does not require any connection between ledgers.
- 3) Depending on their specific design, cross-ledger DvP arrangements on DLT may entail a certain complexity and could give rise to additional challenges that would need to be addressed.

Phase 2 also proved that numerous DLT designs could be applied for securities vs. cash settlement. In particular, a novel "cross-chain atomic swap" method didn't require ledgers to be interconnected – using digital signatures and Hashed Timelock Contracts (HTLC), atomic settlement was possible.

Figure 36:
Stella Phase 2 Illustration (cross-ledger DvP)

Source: ECB - Project Stella

Stella Phase 2 found DvP can run in DLT environment on either the same ledger or separate ledgers (cross-ledger DvP)



Delivery-versus-Payment (DvP)
"The term DvP is typically used when discussing securities settlement, where settlement of securities and funds occur on a gross basis, with final transfer of securities from the seller to the buyer (delivery) occur at the same time as the final transfer of funds from the buyer to the seller (payment)."

Source: [BIS RTGS](#)

Phase 3 broadened the DLT research scope into cross-border payments.

International payments are typically slower and more expensive than domestic payments; credit risk also increases during the fund transfer process between entities. Synchronized payment

experiments were conducted between combinations of distributed and centralized ledgers. Phase 3 assessed five cross-ledger payment methods, including simple payment channels, trustlines, on-ledger escrow using HTLC, third-party escrow, and conditional payment channels with HTLC. These methods were illustrated as bilateral counterparty agreements used for settling obligations in a cross-border payment chain.

Phase 3 found that "only payment methods with an enforcement mechanism, either through the ledger itself or through a third party, can ensure that the transacting parties who completely satisfy their responsibilities in the transaction process are not exposed to the risk of incurring a loss on the principal amount being transferred." Additionally, on-ledger escrow using HTLC proved that synchronized set-

tlement between different types of ledgers was technically possible. Therefore, cross-border payment safety can be improved using synchronized payment methods that secure funds along the payment chain, ultimately mitigating credit risk exposure.

How Hashed Timelock Contracts (HTLC) can provide atomic settlement

“Exchanging goods with digital assets can be tricky. Even once a counterparty has been found, executing the actual transaction can carry risks – the most problematic being that one side can renege on their side of the trade and run away with the other party’s assets.

The risks incurred are fundamentally due to lack of transaction atomicity: in a typical exchange, parts of a trade can succeed while others fail. This lack of atomicity is problematic and makes it difficult for entities to trade with untrusted counterparties. Ultimately, this leads to a reliance on institutionalized trust and the proliferation of rent-seeking.

Atomic swaps (settlement) allow users to exchange digital assets atomically, so the transaction either succeeds in its entirety or fails, returning all funds to their original holders. With atomic swaps, users can trade cryptoassets with untrusted counterparties without risking funds.

On Bitcoin and chains whose scripting languages derive from Bitcoin, atomic swaps are typically constructed using a hash time locked contract (HTLC). This is a type of smart contract that sends funds to one address if a secret is revealed within a certain window of time, and otherwise sends the funds to another address. This construction involves two parties, an initiator and a participant. HTLC-based swaps are most frequently used to exchange assets across blockchains.

One of Bitcoin’s most valuable features is HTLC. The feature, which has existed since the first release of Bitcoin, enables users to create transactions that are invalid (unspendable) until a certain amount of time has passed. HTLCs in a general sense, allow transacting parties to set up an effective “escrow-type” transaction that can enable atomic transactions, or the ability to exchange assets without risking the loss of funds.

In some instances, there have been early attempts at leveraging HTLCs across separate blockchains to enable cross-chain atomic swaps, which could lead to better interoperability across different platforms.”

Source: [Atomic swaps and CoinSwaps](#). Helmy, The Block Research | [A look at Bitcoin’s timelocks](#). Zheng, The Block Research

Phase 4 focused on the confidentiality and auditability of settlement assets, such as CBDC, in a DLT environment. Privacy-enhancing techniques (PETs) were explored for making transaction information confidential to non-approved third parties while also maintaining auditability.

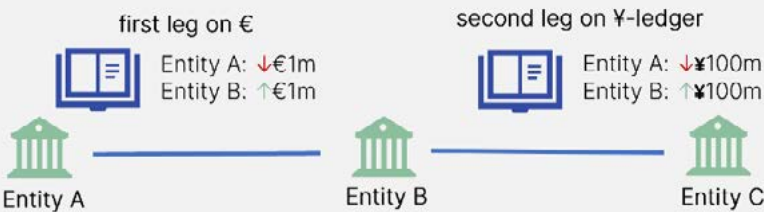
Three types of PETs: ⁷⁹

- 1) Segregating PETs: ensure that each participant can only view a subset of all transactions conducted in the network.

- 2) Hiding PETs: make use of cryptographic techniques to prevent third parties from interpreting transaction details.
- 3) Unlinking PETs: make it difficult for third parties to determine transacting relationships from the sender/receiver information recorded on the ledger.

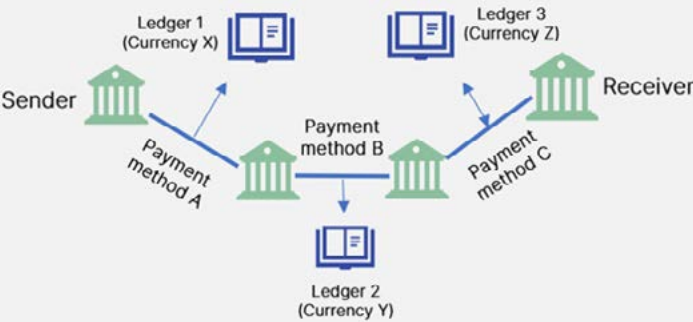
A simplified example of credit risks present in cross-border transactions... and how Stella Phase 3 explored synchronized payments between DLT ledgers and HTLC

“Credit risk might arise if a party fails prior to completion of a cross-border transfer. In this simplified example, Entity A intends to send ¥100 million to Entity C by sending €1 million to Entity B (e.g. an intermediary bank), which has access to both euro and yen ledgers, and in turn sends ¥100 million on behalf of Entity A. If Entity B fails after the first leg of the transfer is complete (i.e. the €1m-transfer from A to B) but before the second leg of the transfer is complete, Entity A faces the risk of loss of its funds. This risk can be mitigated if the payments are synchronised and funds are locked, but in today’s world such synchronisation rarely happens.”



and how Stella Phase 3 explored synchronized payments between DLT ledgers and HTLC across a “payment chain”

“A cross-border payment chain is composed of a series of bilateral payments (between the Sender and the Connector, between Connectors, and between the Connector and the Receiver) that are synchronised via a cryptographic condition. Some of the payment methods explored in Stella phase 3, for example, use a smart contract to enforce a conditional payment, whereby funds are temporarily locked until a cryptographic condition for the payment is fulfilled. When the condition is fulfilled, payment of the locked fund is executed.”



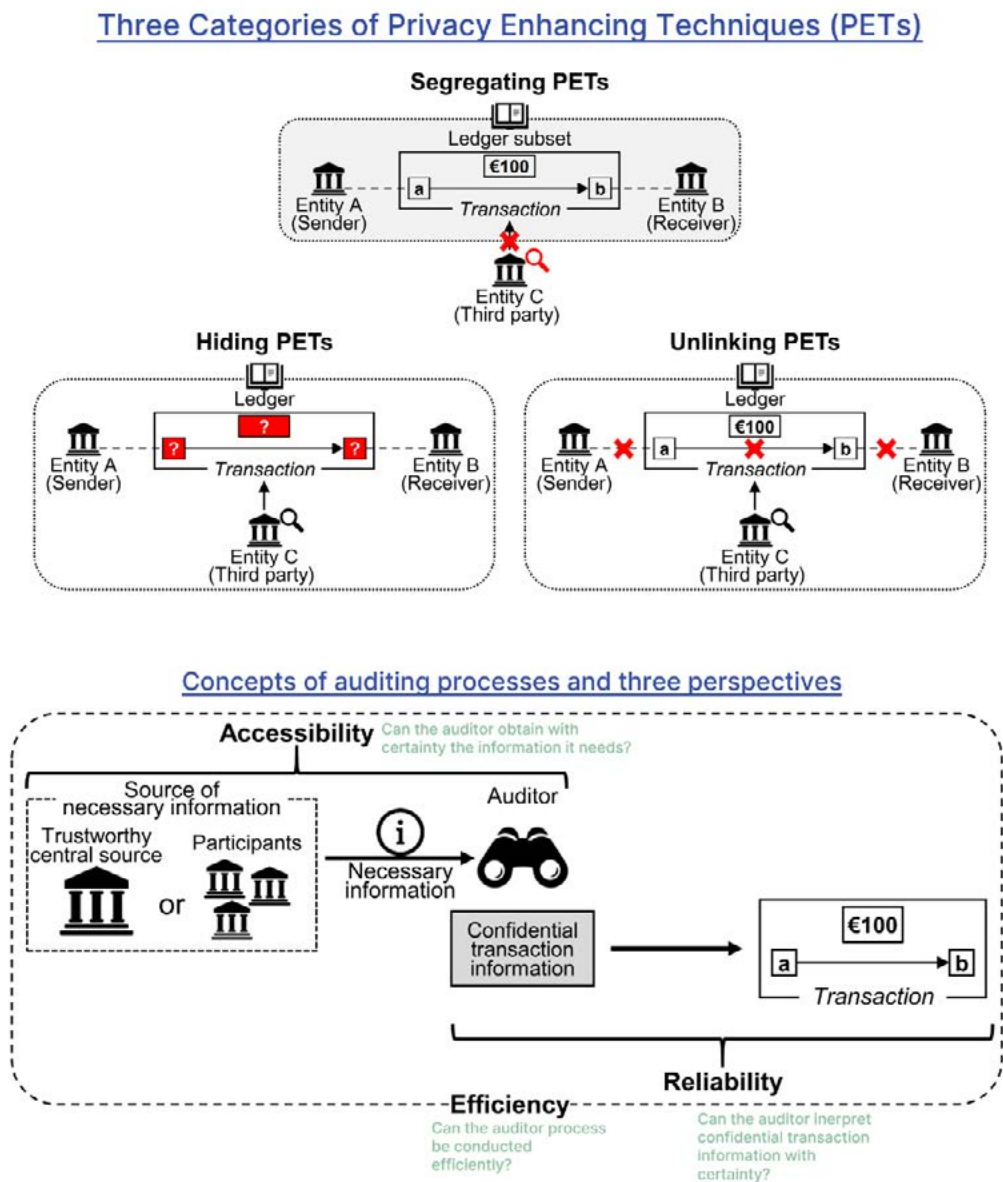
Source : Stella – [Synchronised cross-border payments](#). June 2019

Effective auditing was still possible using PETs, but only if the auditor received information that was both accessible and reliable. Auditing was most effective when information was obtained from a trustworthy central source, as it would ensure vital process characteristics were maintained without requiring cooperation among participants. However, this increased single point of failure risk to the network.

The outcomes of Project Stella Phase 4 provided a foundation for choosing PETs and drafting audit schemes for settling wholesale CBDCs transactions in a DLT environment. To date, all Project Stella findings have not considered legal or regulatory constraints and are only examined through a technical scope.

Figure 37:
Project Stella Phase
4 PETs

Source: ECB - Project
Stella



References:

⁷² Bank of Japan Stella Releases: European Central Bank, Bank of Japan, [Project Stella Report: Phase 1](#) (2017) European Central Bank, Bank of Japan, [Project Stella Report: Phase 2](#) (2018) European Central Bank, Bank of Japan, [Project Stella Report: Phase 3](#) (2019) European Central Bank, Bank of Japan, [Project Stella Report: Phase 4](#) (2020)

⁷³European Central Bank, [Virtual Currency Schemes](#) (2012) ⁷⁴European Central Bank, [Virtual currency schemes – a further analysis](#) (2015) ⁷⁵European Central Bank, [Distributed Ledger Technology: role and relevance of the ECB](#) (Mersch 2016) ⁷⁶European Central Bank, [Digital Base Money: an assessment from the ECB's per-](#)

[spective](#) (Mersch 2017) ⁷⁷European Central Bank, Bank of Japan, [Stella project leaflet](#) (2017) ⁷⁸European Central Bank, Bank of Japan, [Project Stella second report – leaflet](#) (2018) ⁷⁹European Central Bank, Bank of Japan [Project Stella fourth report – leaflet](#), (2020)

Key Takeaways:

- The Ubin Project was a multi-year, multi-phase collaborative project that involved a handful of central banks and financial institutons and service providers. Currently, all five phases have been completed.
- Phase 1, explored the use of a tokenized Singapore Dollar (CBDC) for interbank payments; Phase 2, looked at DLT for specific RTGS functions with a focus on Liquidity Savings Mechanisms; Phase 3, tested DvP capabilitie when settling tokenized as-sets across different blockchains; Phase 4, experimented with cross-border payments with DLT systems under different models including W-CBDC, proved a prototype commercial blockchain network for multi-currency payments to improve crossborder pay-ment functionality.
- The project's systematic research of DLT, platform develop-ment, transactions and settlements, as well as the interaction between different enterprise networks will help define the proj-ect’s impact on the financial system in the years to come

History & Motivations

Project Ubin began as a collaborative project across the Monetary Authority of Singapore (MAS), the Association of Banks in Singapore (ABS), and several international financial institutions to explore the use of distributed ledger technology for clearing and settlement use cases.

The Ubin Project was a multi-year, multi-phase project. Currently, all five phases have been completed.

Phase	Date Conducted	Phase Goal	Partners	Blockchain used	Takeaways
1	Nov 2016 - Mar 2017	Explore the use of a tokenized Singapore Dollar (CBDC) for inter-bank payments	Partnered with R3 and a con-sortium of finan-cial institutions	Private Ethereum	Interbank payments can be made possible by integrating DLT with MAS' Real-Time Gross Settlement (RTGS) system allowing for 24/7 uptime and data integrity
2	Oct 2017 - Nov 2017	Looked at DLT for specific RTGS functions with a foc us on Liquidity Savings Mecha-nisms	Partnered with financial insti-tution consor-tiums	Tested Corda, Hyperledger Fabric, and Quorum	Successfully demonstrated across industry partners that DLT could provide key functions of RTGS sys-tem such as queuing mechanism and gridlock resolution, and could also improve privacy and risks of single points of settlement failure vs cur-rent legacy systems
3	Aug 2018 - Nov 2018	Wanted to test DvP capabilities when settling tokenized assets across different blockchains	Partnered with Anquan, Deloitte and Nasdaq	Quorum, Hyperledger Fabric, Ethereum, and Chain	Successfully demonstrated that DvP settlement finality, and interledger interoperability is achievable with DLT
4	Nov 2018 - May 2019	Tested cross-border payments with DLT systems under different models	Partnered with Bank of Can-ada and Bank of England along with JP Morgan and Accenture	Bank of Canada used R3 Corda and MAS used Quorum	Successful experiment of cross-border currency payments using CBDC between Bank of Can-ada and MAS
5	Nov 2019 - July 2020	Tested a pro-totype block-chain network for multi-currency payments to improve cross-border payment functionality	Partnered with JP Morgan Temasek and Accenture	Quorum	Proved commercial viability of blockchain-based payments net-works for multi-currency cross bor-der payment applications

Figure 38: Project Ubin Summary Table
Source: MAS - Project Ubin

The first two phases of Project Ubin focused on building technol-ogy capabilities in the context of domestic payments networks. The next two phases focused on the interoperability of blockchain-based

networks for Delivery-versus-Payment (DvP) and cross-border Payment-versus-Payment (PvP). These four phases proved the technical viability of the project. The final phase, completed in July 2020, focused on the operating model and tested the commercial viability of blockchain-based payment networks.

Looking ahead, the research and experimentation from Project Ubin is helping to shape future live commercial solutions that leverage DLT and tokenized fiat – the latter could include central bank-issued digital currency.

Phase 1: Tokenized SGD⁸⁰

One of the original core ideas to test within Project Ubin was to explore a central bank digital currency – a tokenized form of the Singapore Dollar (SGD) – on a distributed ledger. The first phase of Project Ubin lasted for 6 weeks starting in November 2016 as a basis for evaluating the feasibility & impact of DLT, and determining the elements required for future improvements.

The research objectives of the first phase of the project were divided into two parts:

TECHNICAL WORKSTREAM	RESEARCH WORKSTREAM
<ul style="list-style-type: none">A working interbank transfer prototype on a private Ethereum network was builtThe Ubin Phase 1 prototype evolved Project Jasper's monetary model, and a new Smart Contract codebase was developed.In addition, BCSIS successfully conducted end-to-end integration between the private Ethereum network and MEPS + test environment via their CPG.	<ul style="list-style-type: none">The research workstream built a solid foundation of questions and initial points of view across topics ranging from monetary policy to legal and operational concerns for taking this prototype to production.

Phase 2: Re-imagining RTGS⁸¹

The Monetary Authority of Singapore (MAS) and the Singapore Banking Association (ABS) announced Phase 2 in October 2017. In conjunction with a consortium of financial institutions, the group successfully developed three different models of software prototypes for decen-

tralized liquid savings and inter-bank payment & settlement.

The goal of Ubin's second phase was to develop three prototypes with specific RTGS functions. Each prototype was developed on a different DLT platform. Corda, Hyperledger Fabric, and Quorum were the 3 DLT platforms chosen, all of which ran on the same cloud hosting service through Microsoft Azure. A key function demonstrated by Ubin in Phase 2 was the ability to implement a liquidity saving mechanism (LSM) without compromising privacy in a distributed network. These prototypes were developed to meet the following six key standards:



Digitalisation of Payments
Central Bank Digital Currency (CBDC) with real-time gross settlement capabilities



Privacy of Transactions
Only relevant parties will have visibility to transaction details




Decentralised Processing
Distributed and resilient infrastructure with no single point of failure



Settlement Finality
Final and irrevocable settlement of payment instructions with deterministic finality



Payment Queue Handling
Uniform queueing system with prioritisation, holding and cancellation facilities



Liquidity Optimisation
Implement netting and gridlock resolution algorithms to maximise liquidity efficiency

Phase 3: Delivery versus Payment (DvP)⁸²

The HKMA and the Singapore Exchange (SGX) announced in August 2018 that the two parties have cooperated to develop delivery versus payment (DvP) capabilities for the settlement of marked assets on different blockchain platforms. The three supporting companies were designated as technical partners for the project, by utilizing the open-source software delivered by Ubin Phase 2.

Phase 4: Cross-border Payment versus Payment (PvP)⁸³

At this stage, the Monetary Authority of Singapore, Bank of Canada (BoC), and the Bank of England conducted a cross-border interbank payment and settlement study to evaluate alternative models that could enhance cross-border transactions. This study raised the need for alternative models that increase speed, lower costs, and improve transparency. It also discussed how to implement various payment models from a technical and non-technical perspective. Following this work, the MAS and BoC connected their respective

project payment networks, Ubin and Jasper, and conducted a successful cross-border payment experiment using CBDCs.⁸⁴

The Ubin-Jasper project successfully achieved cross-border (Canada and Singapore), cross-digital currency (CAD with SGD), and cross-platform (Corda with Quorum) atomic transactions using HTLC. In this process, there was no need for a third party to facilitate the transaction. Project Jasper used Corda, and Project Ubin used Quorum.

Bank of Canada's Project Jasper

The first phase of Project Jasper was launched in March 2016 and was the first prototype of an Ethereum-based interbank transfer system, developed to test the implications of DLT solutions, including wholesale central bank digital currency (W-CBDC) settlement through the use of central bank tokenized digital depository receipts. Touted as “the first time in the world a central bank coordinated with the private sector with a DLT experiment” by the Bank of Canada, the project included participation from Payments Canada, R3, and a number of Canadian banks.



Phase 2 was launched in September 2016 to expand on the learnings from Phase 1. A major goal of Phase 2 was to evaluate the scalability and flexibility of DLT by moving to R3's Corda platform (introduced the concept of a “notary node”) to see whether the system could address shortcomings of Phase 1, including: settlement finality, transaction throughput, privacy, and the cost of liquidity.

Phase 3 extended the Phase 2 proof-of-concept scope to include settlement of exchange-traded equities, where the notion of an integrated end-to end settlement process for securities payments was explored. The proof of concept allowed for immediate clearing and DvP, demonstrating the possibility of completing post-trade settlement on a DLT platform. The ability to settle transactions immediately significantly reduces counterparty risk and frees up collateral. Phase 3 also expanded the concept of a digital depository receipt (DDR) used to represent Bank of Canada deposits, integrating this “cash on ledger” with other assets, such as foreign exchange and securities. This allowed the POC participants to settle securities against the Bank of Canada cash on the ledger. The expansion of tokenized forms of assets and central bank liabilities (Phase 3 ended in 2018) evolved into the full CBDC test case in Phase which partnered with Monetary Authority of Singapore, with corporate participation from JP Morgan and Accenture.

Project Jasper's goals were to model out BoC issued digital currency for use in issuance and settlement, leverage rapid prototyping to test and validate business assumptions, and collaborate with other banks to test the broader implications of DLT and wholesale CBDC applications. Through this work, Project Jasper helped Project Ubin in terms of designing its own architecture, code, and pilot lessons.

Source: Jasper Phase III, Project Jasper Phase 2, Project Jasper

“According to a 2016 McKinsey report, the average cost for a US bank to execute a cross-border payment via the correspondent banking network was in the range of \$25-\$35, more than 10x the cost of an average domestic payment ”⁸⁵

Through the work of the Bank of Canada, Bank of England, and MAS, the group assessed 5 hypothetical models of cross-border payment and settlement systems, three of which were models that used W-CBDC:

“Our proposals are hypothetical, intended to enable an analysis of the relative merits and challenges of different models. These models are not exhaustive, nor does their discussion here reflect an intention to implement, or an endorsement of, any specific future approach. We seek to explore whether these models might deliver any of the future-state capabilities and benefits identified in the report. Where they do not, we identify the technical or non-technical barriers requiring additional technical and policy exploration.”⁸⁶

Smart contracts and how they differ across blockchains

“Smart contracts are self-executing computer programs that perform predefined tasks based on a predefined set of criteria or conditions. Smart contracts cannot be altered once deployed, which ensures the faithful completion of contractual terms. The implementation of smart contracts varies with the platform in use:

In a Quorum smart contract, an asset or currency is transferred into a program. The program runs the code and at the same time validates a condition. It automatically determines whether the asset should go to a person or be refunded to the sender.

In a Corda contract, the executable code validates changes to state objects in transactions. The state objects are data held on the ledger that contains the information such as sender, receiver and the amount to be paid.”

- Model 1:** Current and planned initiatives within and across jurisdictions for cross-border payment and settlement. The baseline model.
- Model 2:** RTGS operators as “super-correspondents”
- Model 3a:** W-CBDCs that can be held and exchanged only in their home jurisdictions
- Model 3b:** W-CBDCs that can be held and exchanged beyond their home jurisdictions
- Model 3c:** A single, universal W-CBDC backed by a basket of currencies

Looking specifically at the models that tested wholesale CBDC, the tokenization of cash (W-CBDC) follows a digital depository receipt (DDR) model like the one implemented in the previous Jasper projects.

Source: Jasper-Ubin Design Paper (Direct Reference)

A participating bank can obtain CAD W-CBDC tokens from the Bank of Canada by pledging cash from its existing account at the bank. The Bank of Canada then issues CAD W-CBDC tokens for the given amount and transfers the same amount from the requester’s account to a pool account. Similarly, a participating bank can redeem CAD W-CBDC tokens it owns at the Bank of Canada in exchange for the underlying cash in its account, transferred from the pool account.

The project successfully implemented and demonstrated the ability to perform atomic transactions between a Quorum-based network in Singapore and a Corda-based network in Canada using HTLC (transfer of SGD\$105 between local Bank A in Singapore and local Bank B in Canada with the FX rate of 1 SGD to 0.95 CAD). Various failure scenarios were also successfully tested across specific points in a transaction execution, and the bank found HTLC to be equipped to handle various failure scenarios.

For a detailed description of these models, please refer to the Project Ubin Phase 4 documents. The summary tables provided on the next few pages outline the various models tested in Phase 4, which highlight current pain points within existing cross-border payment and settlement systems relative to the potential opportunities and challenges with the other models.

Phase 5: Enabling Broad Ecosystem Collaboration ⁸⁷

MAS announced in November 2019 that it worked with JPMorgan Chase (JP Morgan) and Temasek to develop a production-ready prototype that can facilitate payment in different currencies on a single blockchain network (called Ubin V network).

Features include delivery and payment access to private exchange settlement, conditional payment & trade custody, and payment commitments for trade financing. Enterprises can also access the network and use its services through open interfaces. Phase 5 research highlighted that the model can be used for international settlement with the potential to provide cheaper, faster, and more robust cross-border payments. It also has paved the way for further live pilots and experiments for the industry at large.

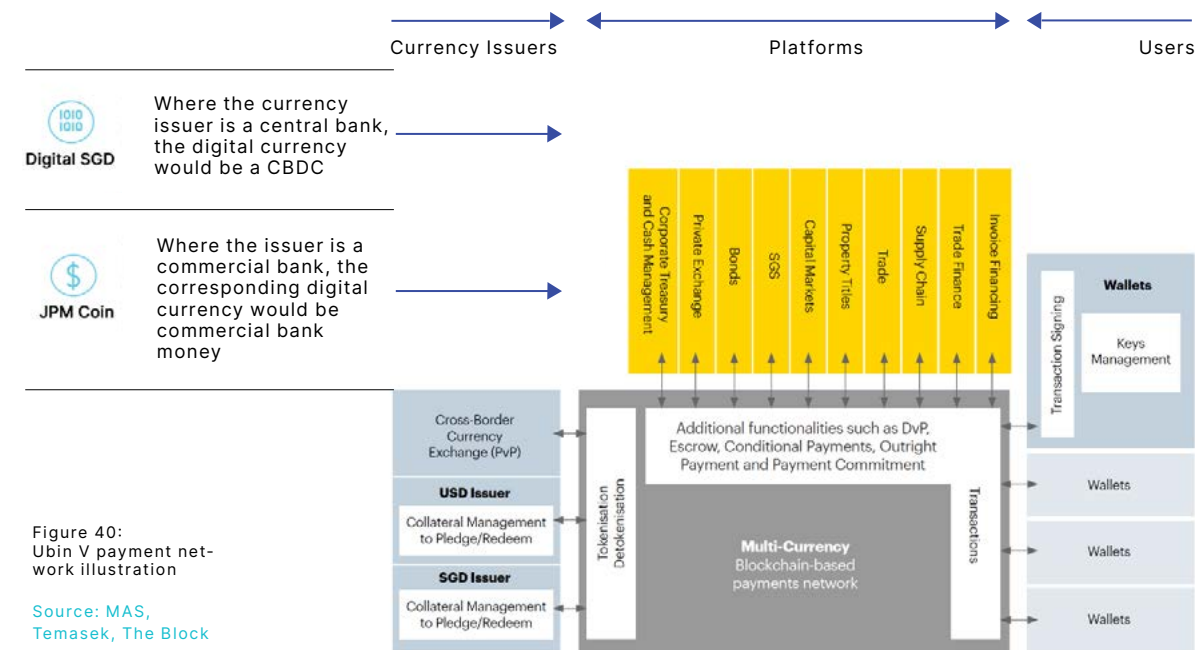
The Ubin V payment network allows access to currency issuers, multiple third-party platforms (the ability to be blockchain agnostic), and end users via wallets.

Root causes of pain points	Mismatch in operating hours of RTGS systems and banks across different jurisdictions and time zones	Reliance on multiple intermediaries (with associated cost and complexity) for cross border payments and settlements
Future State	1Extended availability of domestic and international payment capability	2Direct, peer-to-peer payment and settlement
Model 1: Existing and planned initiatives	Achieving this requires changes across numerous RTGS operators. These changes must be matched by commercial banks driving changes in infrastructure to offer services to clients who demand greater availability of payment services	<ul style="list-style-type: none">Continued reliance on the correspondent banking model, as current and planned payment initiatives do not fundamentally shift the model, but rather seek to improve it.Domestic RTGS developments may allow for synchronous movements between domestic systems based on messaging networks; development of this capacity will be determined on jurisdiction by jurisdiction.
Model 2: Expanded role for in-country RTGS operators without DLT / W-CBDCs	<ul style="list-style-type: none">Similar to Model 1, achieving this requires changes across numerous RTGS operators. These changes must be matched by commercial banks driving changes in infrastructure to offer services to clients who demand greater availability of payment services	<ul style="list-style-type: none">Reduces the number of entities involved to effecting cross-border payments.The position of central banks as ‘super correspondents’ would make their role much more active than is currently the case.
Model 3a Jurisdiction-specific W-CBDCs where these W-CBDCs can be transmitted and exchanged only in their home jurisdictions and not beyond	<ul style="list-style-type: none">The starting intention is to design a platform to enable 24-7 payment and settlement. Therefore the model would not be limited by the operating hours of the existing RTGS platform.Commercial banks will need to match this with infrastructure changes in order to offer services to clients.If this is achieved independently of extending RTGS operating hours then mechanisms for collateralizing positions outside of operating hours will be needed. This may impact the liquidity efficiency of the model.	<ul style="list-style-type: none">Correspondent banks performing cross-border payments; however, a reduced number of intermediary banks are involved in the process.It may be possible to set up a synchronous settlement mechanism in this model, which would minimize settlement risk.
Model 3b Jurisdiction-specific W-CBDCs where these W-CBDCs are exchanged beyond their home jurisdictions:	<ul style="list-style-type: none">Similar to Model 3a, however, there is likely to be an added challenge in operating multicurrency W-CBDC wallets if RTGS Model 3b operating hours do not align.	<ul style="list-style-type: none">Enables peer-to-peer cross-border payments between banks using W-CBDCs as long as both sending and beneficiary banks hold wallets in the relevant central banks.To achieve this, there must be some mechanism for customer due diligence or KYC checks to be undertaken between banks in order to exchange peer-to-peer payments.It may be possible to set up a synchronous settlement mechanism in this model, which would minimize settlement risk.
Model 3c Using a single, universally accepted W-CBDC	<ul style="list-style-type: none">A U-W-CBDC would not rely on the availability of domestic RTGS systems. Nevertheless, the platform supporting the exchange would need to operate close to 24-7 and the participating banks would need to have near 24-7 operational capability to reap the benefits.	<ul style="list-style-type: none">Enables peer-to-peer cross-border payments between banks using U-W-CBDCs.To achieve this, there must be some mechanism for customer due diligence or KYC checks to be undertaken between banks in order to exchange peer-to-peer payments.It may be possible to set up a synchronous settlement mechanism to be set up in this model, which would minimize settlement risk.

Figure 39: Project Ubin Phase 4 Models testing pain points with legacy systems vs other models including W-CBDC
Source: The Block, KPMG, MAS, Bank of Canada, Bank of England

Root causes of pain points	Lack of common, consistent payment standards (technical and operational) and regulatory requirements across jurisdictions
Future State	Consistency of payment standards (technical and operational) and regulatory requirements across jurisdictions
Model 1: Existing and planned initiatives	<ul style="list-style-type: none">Achieving this requires the adoption of current and evolving standards for payment data, format and process by existing payment system infrastructures (ISO 20022, etc.).
Model 2: Expanded role for in-country RTGS operators without DLT / W-CBDCs	<ul style="list-style-type: none">Achieving this requires the adoption of current and evolving standards for payment data, format and Model 2 process by existing payment system infrastructures (ISO 20022 etc.).
Model 3a Jurisdiction-specific W-CBDCs where these W-CBDCs can be transmitted and exchanged only in their home jurisdictions and not beyond	<ul style="list-style-type: none">This model could be designed to support current and evolving payment data and format standards (ISO 20022 etc.) and to integrate with existing payment system infrastructures.If standards evolve independently in domestic jurisdictions and develop differences, how jurisdictions interact with the platform will have to be managed. Any difference across the W-CBDC platforms in different jurisdictions will introduce cost and complexity for banks with multiple W-CBDC accounts.It is possible that designing a platform to comply with current and evolving data standards from the outset presents less of a technical challenge than migrating existing infrastructure (as per Models 1 and 2), but the challenge of integrating this platform with legacy architecture does persist.If all participating banks in the platform must use current and evolving data standards at the point of implementation, the adoption of the standard is more certain than in Models 1 and 2.
Model 3b Jurisdiction-specific W-CBDCs where these W-CBDCs are exchanged beyond their home jurisdictions:	<ul style="list-style-type: none">This model could be designed to support current and evolving payment data and format standards (ISO 20022 etc.) and to integrate with existing payment system infrastructures.To exchange and hold tokens in multi-currency wallets, it will be necessary for technical and operational standards to remain highly aligned and harmonized across all W-CBDC platforms.It is possible that designing a platform to comply with current and evolving data standards from the outset presents less of a technical challenge than migrating existing infrastructure (as per Models 1 and 2), but the challenge of integrating this platform with legacy architecture does persist.If all participating banks in the platform must use current and evolving data standards at the point of implementation, the adoption of the standard is more certain than in Models 1 and 2.
Model 3c Using a single, universally accepted W-CBDC	<ul style="list-style-type: none">This model could be designed to support current and evolving payment data and format standards (ISO20022 etc.) and to integrate with existing payment system infrastructures.To exchange and hold a U-W-CBDC globally, it will be necessary for technical and operational standards to remain completely aligned and harmonized across all W-CBDC platforms.It is possible that designing a platform to comply with current and evolving data standards from the outset presents less of a technical challenge than migrating existing infrastructure (as per Models 1 and 2), but the challenge of integrating this platform with legacy architecture does persist.If all participating banks in the platform must use current and evolving data standards at the point of implementation, adoption of the standard is more certain than in Models 1 and 2.

Root causes of pain points	Lack of a standardized payment status notification capability across the common payment messaging network used by banks	Challenges associated with legacy payments infrastructure across networks, central banks and commercial banks
Future State	Payment status visibility to participants and certainty of outcome	Modernized flexible technical payment system infrastructure
Model 1: Existing and planned initiatives	<ul style="list-style-type: none">Initiatives such as SWIFT gpi look to provide end-to-end payment status visibility across the payment chain – however the service is limited by the speed of adoption of this feature and availability to only member banks	<ul style="list-style-type: none">While this does not directly address legacy payment infrastructure issues, new initiatives may encourage investment and renewal in both commercial and central bank systems.
Model 2: Expanded role for in-country RTGS operators without DLT / W-CBDCs	<ul style="list-style-type: none">Could address the payment visibility issue Model 2 depending on details of model implemented.	<ul style="list-style-type: none">Does not directly address issues arising from legacy payment systems infrastructure.
Model 3a Jurisdiction-specific W-CBDCs where these W-CBDCs can be transmitted and exchanged only in their home jurisdictions and not beyond	<ul style="list-style-type: none">Could potentially enable end-to-end visibility of cross-border payment transactions across the payment chain (perhaps using DLT or related technology). However this would require an account-to-account tracking mechanism (enabled by DLT or otherwise). Deeper investigation and analysis are needed for an appropriate technical solution to deliver this.<ul style="list-style-type: none">Further work would also be needed to ensure that this solution can apply across disparate networks and both domestic and international payment systems which would be required to give complete end-to-end visibility.	<ul style="list-style-type: none">Likely to require large systems changes at both central banks and commercial banks. This should lead to more flexible, scalable systems that encounter fewer problems than current legacy infrastructure.Development of a new platform concentrates operational risk in a new market infrastructure; this could create a significant point of failure.The integration of any new platform into the financial system will rely on legacy infrastructure. This may encourage investment and renewal, as per Model 1 or replace current platforms, but it will still rely on existing infrastructure.
Model 3b Jurisdiction-specific W-CBDCs where these W-CBDCs are exchanged beyond their home jurisdictions:	<ul style="list-style-type: none">Could potentially enable end-to-end visibility of cross-border payment transactions across the payment chain (perhaps using DLT or related technology). However, this would require an account-to-account tracking mechanism (enabled by DLT or otherwise). Deeper investigation and analysis are needed for an appropriate technical solution to deliver this.Further work would also be needed to ensure that this solution can apply across disparate networks and both domestic and international payment systems which would be required to give complete end-to-end visibility	<ul style="list-style-type: none">Likely to require large systems changes at both central banks and commercial banks. This should lead to more flexible, scalable systems that encounter fewer problems than current legacy infrastructure.Development of a new platform concentrates operational risk in a new market infrastructure; this could create a significant point of failure.The integration of any new platform into the financial system will rely on legacy infrastructure. This may encourage investment and renewal, as per Model 1 or replace current platforms, but it will still rely on existing infrastructure.
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For CBDCs, if a central bank were to use the network to distribute digital currencies through the platform, then the corresponding digital currency on the network would be a W-CBDC.

For commercial banks that issue digital currencies on the network, these respective digital currencies would effectively be commercial bank money. The Ubin V platform allows for both issuers (central banks and commercial banks) across geographical borders. This provides for multiple currencies to be issued and transacted across the network, enabling DvP and foreign currency risk reduction throughout this process.

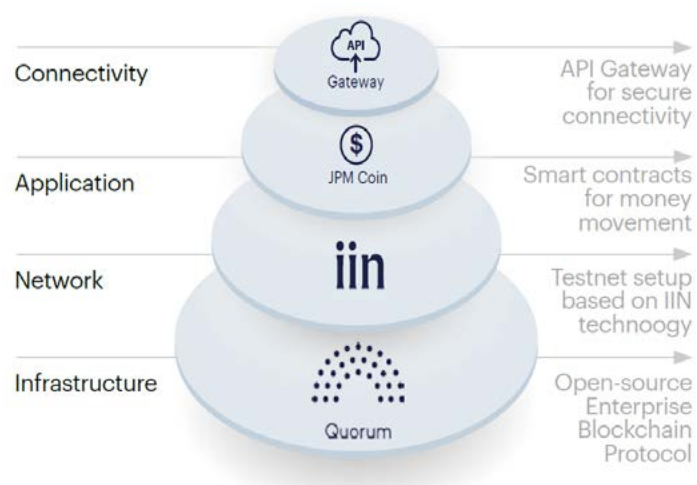


Figure 41: Illustration of Quorum blockchain with JPM coin application

Source: JP Morgan, MAS, Temasek

The network was tested with Singapore Dollars (SGD) and US Dollars (USD), and aims to work with other central banks and commercial banks to include other currencies. Ubin V network uses JP Morgan's Quorum blockchain, as well as the bank's IIN and JPM Coin product (smart contract functionality that enables token issuance and transactional capabilities). Outside of token issuance and transfer, the Ubin V network also provides for the conversion of tokens back into fiat and the ability to offer conditional payment flows through

the use of multi-signature escrowing capabilities via JPM Coin smart contracts.

Ubin project summary

The Ubin project, similar to comparable wholesale initiatives Project Jasper and Project Stella, was less about W-CBDC schemes and more of a progression of experiments by MAS on transforming the financial system through blockchain and distributed ledger technology.

The systematic research of DLT, platform development, transactions, and settlements as well as the interaction between different enterprise networks will help define the project's impact on the financial system in the years to come.

Should MAS ever consider a launch of a CBDC for wholesale applications, the work from Ubin will likely be instrumental in its design and launch.

Finally, Project Ubin's significance extends not only to Singapore. The collaboration between MAS and other central banks and financial institutions around large-scale cross-border payment experiments could lead to future commercialization of tokenized fiat for the use of large value, multi-currency cross-border payments.

References:

⁸⁰ Deloitte, Monetary Authority of Singapore, [Project Ubin: SGD on Distributed Ledger \(2017\)](#)

⁸¹ Association of Banks in Singapore, Monetary Authority of Singapore, [Project Ubin Phase 2 \(2017\)](#)

⁸² Deloitte, Monetary Authority of Singapore, [Delivery versus Payment on Distributed Ledger Technologies \(2018\)](#)

⁸³ Bank of Canada, Bank of England, Monetary Authority of Singapore, [Cross-Border Interbank Payments And Settlements \(2018\)](#)

⁸⁴ Bank of Canada, Monetary Authority of Singapore, [Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies \(2019\)](#)

⁸⁵ McKinsey, [Global Payments 2016](#). pg 15

⁸⁶ Bank of Canada, Bank of England, Monetary Authority of Singapore [Cross-Border Interbank Payments and Settlements \(2018\)](#)

⁸⁷ Temasek, Monetary Authority of Singapore, [Project Ubin Phase 5: Enabling Broad Ecosystem Opportunities \(2020\)](#)

Given your involvement in the final phase 5 of Ubin, what in your view has been the biggest takeaway/and learning from the project, and what opportunities exist going forward around wholesale CBDC applications within interbank settlement?

**Interview with Prady Agrawal
Director, Blockchain at Temasek**

We partnered with the Monetary Authority of Singapore, JPMorgan, Accenture and a broad set of industry participants for Phase 5 of Project Ubin. It has validated the feasibility of multi-currency payment networks and the potential of blockchain technologies in transforming payment systems. The initiative demonstrated the commercial applicability, viability and benefits of the payment network prototype across industries.

Through the prototype that was developed, payments in different currencies were successfully settled on the same network. The prototype also enabled the use of smart contracts for transactions involving assets on private exchanges, conditional payments and escrow for trade, as well as payment commitments for trade finance. It was also evident that continued collaboration between financial and non-financial firms on a multi-currency payments network could drive new products and services and generate new business opportunities.

At Temasek, opportunities to build a better, smarter, and more sustainable world continue to shape our investment direction. We see the transformative potential of innovative technologies across various sectors. We are excited by the prospect of greater adoption and commercialisation involving blockchain technologies, especially in the area of payments. A multi-currency settlement network, modelled after the Project Ubin payments network prototype, could enable faster and cheaper transactions than conventional cross-border payments channels, thereby developing next generation domestic and cross-border payments infrastructure.

Key Takeaways:

- **Ithanon-LionRock is a joint central bank digital currency research initiative launched by the Hong Kong Monetary Authority and the Bank of Thailand that began in 2018.**
- **In May 2019, the Hong Kong Monetary Authority and the Bank of Thailand issued a Memorandum of Understanding to jointly study the application of the Central Bank's digital currency for cross-border payment.**
- **In December 2019, the two parties completed the proof-of-concept research and the prototypes of participating banks based on distributed ledger technology.**

History & Pilot Design

Project LionRock: The Hong Kong Monetary Authority began researching central bank digital currencies in 2017, and after a related study⁸⁸ concluded that the prospects for a retail CBDC were limited due to an already well-established and efficient payment infrastructure in Hong Kong. This naturally led the bank to prioritize the technical impact and challenges of distributed ledgers, including the comparison of DLT and traditional technologies, the benefits of DLT for existing financial applications, and the challenges of using DLT technology for cross-border payments.

Project Inthanon: Bank of Thailand's independent CBDC project was divided into two phases. The first phase consisted of tokenization of cash, tokenization of bond, gridlock resolution, and an automated liquidity provision. The second phase of research explored bond life cycle management, DvP for interbank repo & trading, and data reconciliation & compliance.

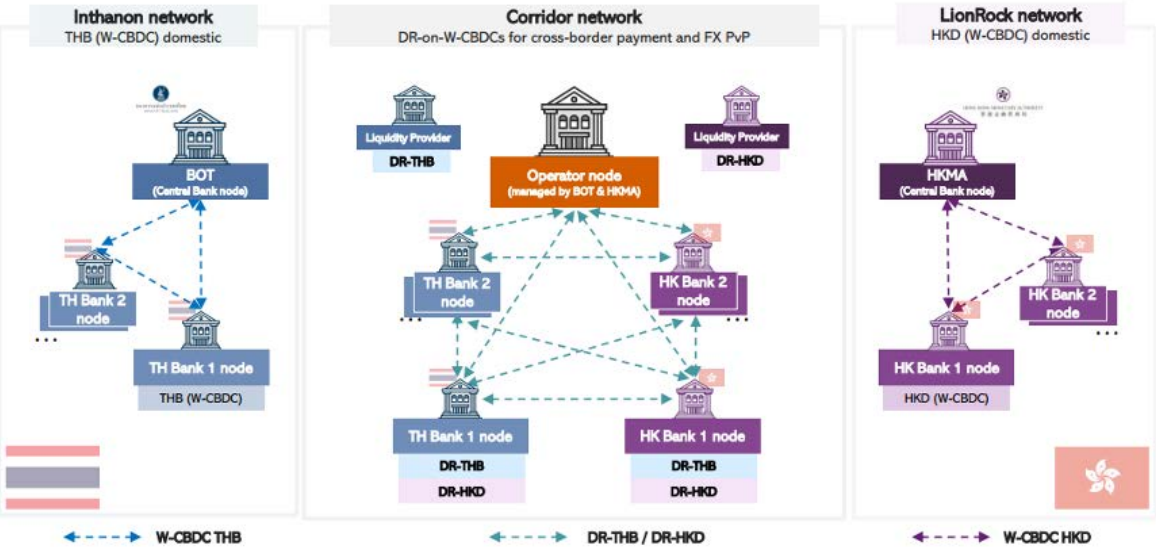
In the joint research of Inthanon-LionRock, the two parties focused on the cross-border payment level – from DvP to PvP – including cross-border settlement efficiency, liquidity management efficiency, local regulatory compliance, and a foundation for wider scope.

Proposed Model

The project explored various models of cross-border payment, including cross-participation and asset expansion. In the final proposed model, the PoC had the following characteristics :⁸⁹

- The Central Bank issues and controls wholesale CBDC (W-CBDC), which is only used in domestic and foreign banks that have no accessibility to local currency or W-CBDC.
- The network uses a “corridor network,” which is designed for cross-border settlement based on Corda. Banks from Hong Kong or from Thailand separately join the LionRock network and Inthanon network. Depository Receipts (DR) on the W-CBDC issued by a central bank will be used in the corridor network for banks to carry out cross-border and FX PvP transactions.
- A queueing mechanism, gridlock resolution, and liquidity provisioning will run as a liquidity management process system in the corridor network.

Figure 42: Illustration of Project Inthanon/LionRock corridor network with W-CBDCs
Source: Bank of Thailand, Hong Kong Monetary Authority



Key functionality of this model:

1. Depository Receipt conversion

W-CBDC and DR will be used to convert bidirectionally in the corridor network for banks to manage their local currency liquidity in an on-demand way that is requested by the bank. Excessive DR held by banks can be converted back to W-CBDC to reduce the DR position and increase local currency liquidity (HKD or THB).

2. Cross-border fund transfer

There are three types of payment that can be carried out through the corridor network, in the form of DR:

- a) Sending DR-LCY funds to a foreign bank
 - A Hong Kong bank sends DR-HKD to a Thai bank
 - A Thai bank sends DR-THB to a Hong Kong bank
- b) Sending DR-FCY funds to another local bank
 - A Hong Kong bank sends DR-THB to another Hong Kong bank
 - A Thai bank sends DR-HKD to another Thai bank
- c) Sending DR-FCY funds to a foreign bank
 - A Hong Kong bank sends DR-THB to a Thai bank
 - A Thai bank sends DR-HKD to a Hong Kong bank

3. Foreign Exchange (FX) execution

Banks in the corridor network can facilitate FX transactions through the Board Rate (Hong Kong savings deposit rate), request for quote, and off-corridor arrangement, and settle in an atomic PvP fashion. In Inthanon-LionRock, there is no preference for which FX transaction method should be utilized.

4. Cross-border funds transfer with embedded FX execution

The corridor network introduces two transfer methods:

- a) Funds transferred with embedded FX transaction via Board Rate
- b) Funds transferred with embedded FX transaction via Off-Corridor Arrangements

There is minimal difference between both methods. Distinctly, the rate provided on the corridor or off the corridor will utilize an oracle or external database.

5. Liquidity management

A queueing mechanism is used to solve the temporary liquidity insufficiency for banks in the corridor network by settling the sufficient ones as a priority.

- Multi-Asset Liquidity Saving Mechanism (MLSM): A netting solution when gridlock occurs periodically in the corridor network.
- Allow Just-in-Time Liquidity to Resolve Deadlock: complementary solution when no netting solution is available, which calls for Automated Liquidity Provisioning to provide additional tokens or foreign currency liquidity.
- Token Conversion for Liquidity Management: DR token and W-CBDC conversion mechanism.

6. Regulatory compliance and enforcement

There are also some regulatory considerations regarding real-time monitoring (fund transfer, FX rate DR conversion) and THB-specific regulations. However, as it is still a PoC, there is not much information added to this arrangement.

Conclusion

The joint research project of the Hong Kong Monetary Authority and the Bank of Thailand reflects a broader collaborative trend of central banks working together to test wholesale CBDC use cases via exploratory pilots. It also adds another experiment to the growing literature of central bank digital currencies for wholesale applications that include DvP, PvP, and cross-border finance.

Looking ahead, Project Inthanon-LionRock is still in a PoC stage. The technical, regulatory, operational, and legal considerations will continue to be explored, as well as whether an underlying blockchain platform should be used.

Part IV

China Digital Currency Electronic Payment: DC/EP

136 China DC/EP

IN COLLABORATION WITH **HASKEY**

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Key Takeaways:

- Although there have been no official PBOC documents on DC/EP design, several high-level government officials have begun to publicly discuss DC/EP in the wake of Libra.
- The PBOC partnered with seven state-owned companies, including banks and telecom companies, at the end of 2019 to help with the DC/EP pilot phase.
- While PBOC governor Yi Gang said the central bank does not yet have a timetable for the official launch of digital yuan (May 2020), Yi did confirm that DC/EP may be piloted at the 2022 Beijing Winter Olympics.
- DC/EP provides another interesting case study on economies with concentrated private payments markets, and how central banks may look to drive further payment competitiveness using CBDC.

○ 2014/2015 - 2017

○ 2019

<div>The People's Bank of China starts digital currency electronic payment (DC/EP) research 2014/2015</div> <div>The People's Bank of China officially established the Digital Currency Research Institute Jan 2017</div>	<div>Mu Changchun, Deputy Chief in the Payment and Settlement Division of PBOC, says China's central bank digital currency is "ready" after 5 years of development at the China Finance 40 Group meeting Aug 2019</div> <div>China's President Xi Jinping stressed that the country should commit to accelerating the development of block-</div>	<div>chain and aim at taking the leading position in the emerging technology Oct 2019</div> <div>Mu Changchun says DC/EP holders will not receive interest payments, and that the PBOC will first issue the currency to commercial banks who will then distribute to general public Nov 2019</div>	<div>PBOC partners with seven state-owned companies - the Industrial and Commercial Bank of China, Bank of China, China Construction Bank and the Agricultural Bank of China, China Telecom, China Mobile and China Unicom - to roll out DC/EP test Dec 2019</div>
<div>The PBOC says DC/EP is progressing smoothly, with "top-level" design completed, announcing in a new paper Jan 2020</div> <div>PBOC confirms it has been internally testing DC/EP in 4 cities, including the cities of Shenzhen and Suzhou. Apr 2020</div> <div>A Chinese state-owned bank, the Agricultural Bank of China, released a mobile test</div>	<div>app that supports the People's Bank of China (PBOC)'s digital currency project. Apr 2020</div> <div>People's Bank of China (PBOC) governor Yi Gang has said that the central bank doesn't yet have a timetable for the official launch of digital yuan. Yi said the current pilot tests are "still a routine work in the research and development process, and does not mean that the digital</div>	<div>RMB will be officially issued. There is no timetable for when it will be officially launched". Yi also confirms DC/EP might see use at 2022 Beijing Winter Olympics May 2020</div> <div>Suzhou municipal government employees will receive 50% of their May transportation subsidies in DC/EP as part of a test. The digital currency will be issued to them by four state-owned banks, includ-</div>	<div>ing the Agricultural Bank of China, the Industrial and Commercial Bank of China, the Bank of China, and the China Construction Bank. May 2020</div> <div>China's ride-sharing giant Didi Chuxing is set to trial the country's central bank digital currency (CBDC) for its 550 million user base May 2020</div>

○ 2020

History & Motivation

Among most central banks, the People’s Bank of China (PBOC), the Chinese Central bank, has been well-recognized as one of the first central banks in the world to actively research central bank digital currency (CBDC). Beginning in 2014, members of the PBOC & organizations tied to the PBOC have published work publicly relating to digital currency. They have also engaged with international organizations like the BIS and IMF on the topic for over the last 5 years. However, it was not until the start of 2017 when the PBOC officially established its Digital Currency Research Institute.⁹⁰

Since the establishment of this research institute, the DC/EP project largely remained under the radar until June 2019, when Facebook unveiled its Libra stablecoin initiative. Although there have been no official documents on the new currency’s design, several high-level government officials began to publicly discuss DC/EP in the wake of the Libra announcement.⁹¹

In August 2019, a senior official at the PBOC, Mu Changchun (Deputy Chief in the Payment and Settlement Division), stated at the China Finance 40 Group meeting that the DC/EP prototype exists and is “ready” after five years of development. By December, the PBOC had partnered with seven state-owned companies, including banks and telecom companies, to help with the pilot phase.

In April 2020, the PBOC confirmed it had been internally testing DC/EP in 4 cities, including Shenzhen and Suzhou, while the Agricultural Bank of China released a mobile test app to support the project.⁹³

While PBOC governor Yi Gang said the central bank does not yet have a timetable for the official launch of digital yuan (as of May 2020),⁹⁴ Yi did confirm that DC/EP may be piloted at the 2022 Beijing Winter Olympics.

DC/EP and China’s mobile payment market

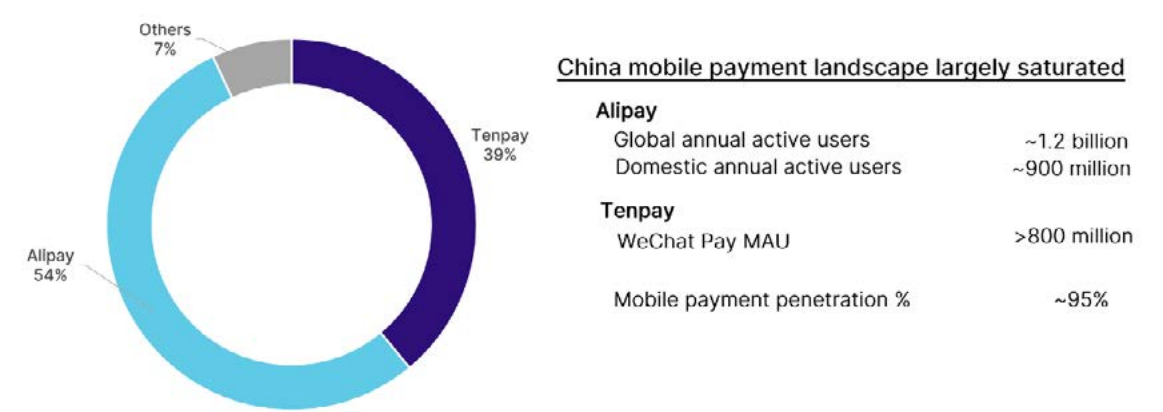
According to IPSOS⁹⁵ China has developed the world’s largest mobile payment market with more than 1 billion active annual users and a total penetration rate among smartphone users at nearly 95%. Within this mobile payment landscape, payment giants Alipay and Tenpay combine to represent over 90% of total market share. From this perspective, it’s worth questioning the impact DC/EP could have on

this ecosystem given the success and largely saturated mobile payment landscape that already exists in China.

Early DC/EP test app mobile wallets appear to be similar to third-party payment tools such as Alipay and WeChat.

Figure 43: China's mobile payment landscape is largely saturated and dominated by Alipay and Tenpay

Source: IPSOS, JP Morgan, The Block



The DC/EP mobile wallet test uses scan code payment, remittance, payment collection, and bumping (mobile tap to pay, or mobile to mobile tap to pay). One key area of differentiation is the intended ability for DC/EP to be transferred between different account systems, which is impossible for WeChat and Alipay.

In addition, the current electronic payment method supports single offline payment in most daily life scenarios, while DC/EP could allow both parties to go offline briefly in various scenarios.

The central bank's interest is in making DC/EP payment convenience as competitive as possible. According to the current patent release information (discussed in the next section), DC/EP could support chip card swiping and mobile phone near-field communication methods on the client-side. More importantly, DC/EP would enjoy the central bank's credit endorsement, and its security would likely be higher than that of third-party payment options.

No matter how the final consumer-facing DC/EP app is designed, DC/EP could form a partial replacement for the payment business of third-party payment institutions. For example, third-party payment institutions have typically cooperated with some financial institutions to provide access to consumer payment data, which can be used to score consumers and to provide services like card issuance.

Another consideration to note is that if the PBOC were to open third-party payment institution access directly to DC/EP, it could affect the reserves of the respective third-party institutions. Although no official announcement has been made, it is likely that Alibaba, Tencent, and other fintech companies will act as DC/EP distributors in a similar fashion to commercial banks. According to patents filed by Alipay, fintech companies may apply to become DC/EP distributors and could then provide DC/EP-based financial services to users.⁹⁶

Although DC/EP is a supplement to a payment method (a substitute for cash), it could cause users to choose between third-party payment institutions and DC/EP wallets – at present, there is not much cash balance in circulation, especially for mobile phone users in cities.

From this perspective, DC/EP provides another interesting case study on economies with concentrated private payments markets, and how central banks may look to drive further payment competitiveness using CBDC.

Figure 44: Comparing DC/EP to competing forms of money

Source: The Block

	DCEP	Cash Notes	Digital Payments (Alipay, etc)	Libra	Bitcoin
Cost	Lower than cash	Printing and transportation cost	Lower than cash	Node running and reserve maintenance cost	Mining cost
Anonymity	Partially anonymous according to PBOC, but KYC may be needed to register digital wallets	Anonymous	KYC needed for onboarding	KYC needed for large transactions	Anonymous
Legal Status	To be accepted unconditionally	To be accepted unconditionally	Depend on merchants	Depends on merchants	Legal in some countries
Offline Payments	Yes, although technical details are unclear	Yes	For a limited amount, and one of the two counterparties needs to be online	Unclear	Yes, but involves special hardware set-up
Bankruptcy Risk	Backed by the central bank	Backed by the central bank	Possible default risk of the payment service providers	Possible default risk of the Libra Association	No bankruptcy risk but price fluctuates significantly
Operation Model	Central bank - Commercial banks - Users	Central bank - Commercial banks - Users	Commercial banks - Payment service providers - Users	Libra Association - Distributors - Users	Miners - Users

Beyond payment competitiveness, the PBOC has revealed little about the end goal and ultimate motivations of exploring and implementing DC/EP. Still, some have speculated that it is meant to be a vehicle for RMB globalization and a challenge to the U.S. dollar's role as the world's reserve & financial settlement currency.

Some experts believe that DC/EP could provide the necessary conditions to expand the global influence of the RMB. China may give businesses in other countries incentives to exchange their local currencies for DC/EP to pay for goods and services from China, for instance. Such transactions would bypass the existing international wire system, SWIFT, used for processing information for cross-border payments, which has been leveraged by the U.S. government in its efforts to sanction other countries.⁹⁷

The PBOC launched the Cross-border Interbank Payment System (CiPS) which handles both Chinese and English messages to process & clear RMB for international cross-border transactions – reducing its reliance on SWIFT.

Even so, if foreign institutions or retail users want to use RMB for cross-border payment, these users would historically need to find an RMB bank account that works within the corresponding banking network. DC/EP would offer a significant improvement for these users, as anyone globally with a DC/EP digital wallet could access the currency.

Considering the implications of global access to a digital settlement asset that is the liability of the PBOC, some suggest this could “effectively promote China’s monetary sovereignty.” ⁹⁸

Design & Implementation

In thinking through the design characteristics of DC/EP as it is being publicly proposed, it’s helpful to follow a “1,2,3 framework” – 1 token (digital currency issued by PBOC), 2 databases (data centers managed by PBOC and commercial banks), 3 centers (used to manage identity and KYC/AML properties).

DC/EP, the token

The token is currently designed to be a M0-like digital currency, or a replacement for cash that will bear no interest. Reports from senior officials suggest it will follow a two-tier system where the token is pegged to the RMB, issued by the central bank, and backed by the PBOC’s reserves. Commercial banks can acquire DC/EP from the central bank and then distribute it to the public through wallet interfaces.

The PBOC’s digital currency research institute filed 65 patents between 2017 to 2019, revealing more about how the bank is thinking about potential design mechanisms.⁹⁹ While PBOC will apparently control the centralized database that tracks all DC/EP transactions, commercial banks will function as digital wallet providers and manage user communications with the central bank for transaction queries. The PBOC has suggested that technical design will not be pre-determined, but rather evolve through market selection.

DC/EP, the two databases

As DC/EP is designed to handle high-frequency transactions for retail

users which will require high throughput over the trading system, a centralized ledger will be implemented for digital currency issuance, clearance, and settlement. Distributed ledger technology (DLT) will also be adopted for digital currency registration to ensure data accuracy and security.

According to the PBOC’s Deputy Chief in the Payment and Settlement Division, the bank has considered using blockchain as the infrastructure layer for the new digital currency but decided to “maintain technological neutrality without presupposing a technical route.” ¹⁰⁰

The two databases are:

- 1) A digital currency issue database, which refers to the database of the central bank's digital currency issue fund on the PBOC's private cloud for digital currency.
- 2) A digital currency commercial bank database, which refers to the database where commercial banks store the info of DC/EP, either locally or in the PBOC's private cloud for digital currency.

Under the two-tier database operating system, China's CBDC should be released in a loosely coupled account and adhere to a centralized management model. These two databases are designed to fit the demand of the safety store and issue/withdraw process and facilitate accurate bookkeeping.

DC/EP will be issued at the central bank and distribute through commercial bank. The central bank holds the liability to the public to ensure macroprudential and monetary policy control functions of the central bank. Commercial banks, as an interface with retail users, would offer digital currency deposit, withdrawal and circulation services, and in collaboration with the central bank also help to ensure supply stability.

DC/EP, the three “identity” centers: ¹⁰¹

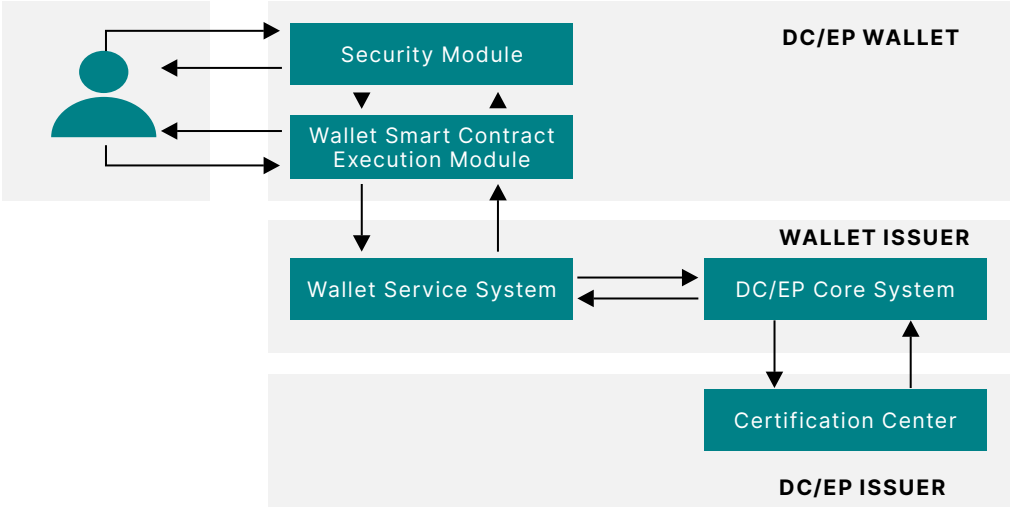
The certification center is the core component to manage anonymity. It is proposed to adopt Public Key Infrastructure (PKI) for financial institutions or VIP customers and use Identity-Based Cryptography (IBC) for lower-end users.

The registration center records token ownership and matches digital currency with respective digital identity. It also records the entire life-

details will be authenticated by commercial banks first and then forwarded to the central bank. The central bank pulls data for users then sends the information back through the commercial banks.

Figure 46:
Illustration of DC/EP
distribution models

Source: The Block



Recent DC/EP Developments

The Agricultural Bank of China was one of the companies tasked by the PBOC last year to run the pilot program, beginning with the launch of a mobile test app that supports DC/EP for those that are on an approved “white-list.” 105

The app displays several features related to the new digital currency, including digital currency exchange, wallet management, transac-

tion tracking, and connecting other wal-
lets. The app is available via four cities' local branches of the Agricultural Bank of China, including Shenzhen, Xiong'An, Chengdu, and Suzhou.

The PBOC and other financial institutions have yet to publicly disclose any docu-
ments, notices, operating specifications, or laws & regulations on DC/EP to the public. However, senior officials of the central bank, government, and other reg-
ulatory agencies have expressed opin-
ions and shared updates about China's CBDC. Below is a list of some of the



Figure 47: Example of DC/EP mobile test app from Agricultural Bank of China
Source: The Block, Hashkey

chronological statements made, some of which help to highlight key changes in thinking around DC/EP by these officials.

Figure 48:
Example of DC/EP
mobile test app from
Agricultural Bank of
China

Source: Hashkey

Official		
Fan Yifei Vice President of the Central Bank	2018 Jan	1.The Central Bank of China's digital currency should adopt a two-tier operating system 2. Under the arrangement of the two-tier operating sys-tem, China's central bank digital currency should be released in a loosely coupled account, and adhere to a centralized management model 3. China's current central bank digital currency design should focus on M0 instead of M1 and M2 4. Maintain prudent about launching smart contracts with central bank digital currency
	2019 Sep	1. DC/EP originated from idea of former Governor Zhou Xiaochuan 2. Functions and properties are exactly the same as banknotes, but in form of digital payment 3. Benefits: protect monetary sovereignty and legal cur-rency status; costs of printing, recycling, and storage of cash are high; legitimate payment privacy protection 4. Big data method mentioned for anti-money launder-ing, anti-tax evasion, and anti-terrorist financing 5. Wallets are ascribed to users based on their respec-tive KYC levels. 6. No predetermined technological path 7. Precluding financial disintermediation
Huang Qifan Former Deputy Chairman of the Financial and Economic Committee of the National People's Congress	2019 Oct	1. Best way to practice currency rights is to issue sov-ereign digital currency by the government and the central bank 2. It is also necessary to formulate a new rule that enables digital currency to be linked to sovereign credit, and to national GDP, fiscal revenue, and gold Reserve
	2020 May	1. Central Bank Digital Currency Research Institute has applied for 84 patents involving digital currencies, covering digital currency generation, delivery, circula-tion, verification, exchange, recycling and other solutions 2. China's CBDC will also support offline payment, chip card swiping, and mobile phone near-field communi-cation payment in the future. The traditional monopoly position of Alipay and WeChat on mobile payment may be shaken.

How serious of a priority is China and the People’s Bank of China placing on DC/EP. What does the next 12 months look like?

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Interview with Chuanwei David Zou
Chief Economist of Wanxiang Blockchain, Associate Research Fellow for PBoC

I think the PBoC is very serious on the DC/EP project — it is one priority among several for PBoC — The top priority is always the monetary policy, but it also has priority for macro-prudential regulations. DC/EP is a strategic move for the PBoC. So we need to take into account several facts: The PBoC has worked on that DC/EP project since 2014. That's five years before Libra. And China has, I think, the world's most advanced mobile payment systems. And the PBoC has lots of experience, very deep experience, in how to develop and regulate the payment sector.

As far as I know and I think important players in China, including banks and payment companies, have an interest in joining the DC/EP ecosystem. There are also service providers of hardware, software, and cybersecurity that would be interested as well. DC/EP is a significant upgrade for China payment infrastructures — there are a lot of business opportunities and it will require lots of investment.

But looking ahead over the next 12 months, DC/EP likely will still be in the pilot stage and focused on the domestic retail payment, with ever expanding use cases. The pilot program started in the four cities. Now it's expanded to Didi and Meituan. I think that there will be more use cases in the digital economy in China, because the PBoC wants to thoroughly understand the robustness of the system design, as well as see what retail use cases, user experience and

adoptions occur, along with how to manage the risk in the DC/EP systems I think after the twelve months, the PBOC may figure out what's the right go to market strategy, and how PBoC could work with the market players like e-commerce businesses, payment companies, hardware/software companies, and cybersecurity firms to effectively bring to market.

Beyond domestic use-cases, the pilot program will also be extended to foreign visitors when Beijing hosts the Winter Olympics in 2022. So when foreign people come to China they won't need a Chinese bank account, they can open a DC/EP wallet and they can use the digital yuan when they are in China. But after they go back to their home countries they can bring the DC/EP with them. So that's [one example] of how DC/EP could cross the border of China. In terms of cross-border payment opportunities, PBoC has a strategic goal for renminbi internationalization, and DC/EP will provide a new approach for the cross-border use of the renminbi.

—

Chuanwei David Zou

Chief Economist of Wanxiang Blockchain, Associate Research Fellow for PBoC

Part V

A brief look at other CBDC discussions within advanced economies

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History & Motivation

Beyond exploratory papers, the Bank of England (BOE) has not advanced efforts to create a CBDC. The BOE, however, was one of the first central banks to initiate research into CBDCs with its February 2015 “One Bank Research Agenda” discussion paper.¹⁰⁶ In the paper, the BOE proposed questions as to why a central bank might issue a CBDC. The paper also inspired university researchers to experiment with the creation of RSCoin, a digital currency designed to be issued and managed by central banks.¹⁰⁷

The first public acknowledgement of CBDCs by a BOE official was in September 2015. In a speech, BOE Chief Economist Andrew G. Haldane weighed the possibility of using blockchain technology to support a central bank-issued digital currency, adding that work on CBDCs form “a core part of the Bank’s current research agenda.”¹⁰⁸ In July 2016, the BOE released a working paper exploring the macro-economic impact of a CBDC. This would become the first in a series of working papers researching CBDCs.^{109 110}

In May 2018, the BOE released two more working papers: one exploring the design of a CBDC and another on the impact of a CBDC on monetary policy.¹¹¹ In late 2019, the BOE teamed up with the Bank of Canada and the Monetary Authority of Singapore to publish a paper exploring cross-border payments and wholesale CBDCs for large settlements, and in early 2020, the BOE announced the creation of a central bank group to explore potential use cases for CBDCs.¹¹²

The BOE provided a clearer look into its CBDC efforts in March 2020. In a discussion paper, the BOE described its CBDC efforts and explored how a Bank of England-issued CBDC would work and the opportunities it would present for the BOE to achieve its objectives.¹⁰³

The BOE cited a variety of motivations for creating a CBDC, including:

- Supporting innovation in payments
- Avoiding the risk from private monies like cryptocurrencies
- Improving payment infrastructure
- Declining cash use

In its discussion paper, however, the BOE reiterated that it “has not yet made a decision on whether to introduce CBDC, and intends to engage widely on the benefits, risks and practicalities of doing so.”

Design

Because the BOE has not officially initiated the process of developing a CBDC and running a pilot program, there is limited information on the technology behind a potential digital Pound. However, it presented some approaches it might take to create a CBDC in its March 2020 discussion paper.

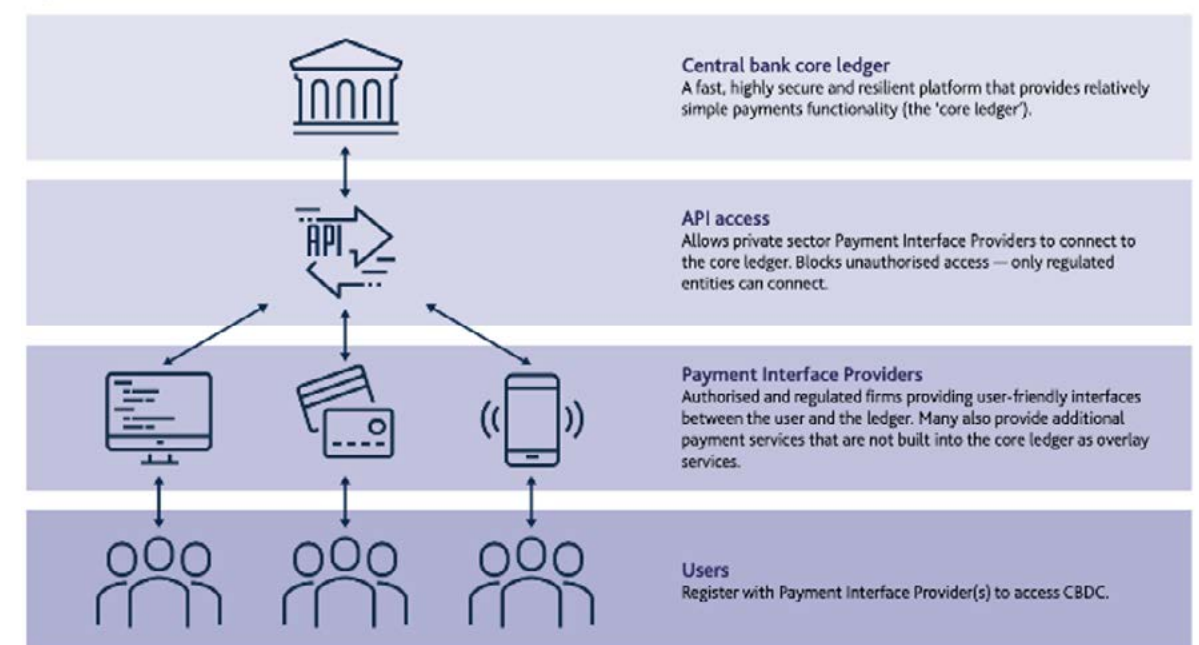
The CBDC that the BOE has been exploring will be focused on retail payments. While the BOE has noted that the CBDC being researched can work with both an account-based currency model as well as a token-based one, it did suggest that the core ledger technology underlying the CBDC “could use pseudonymous accounts.”

The infrastructural makeup of the CBDC would be multi-layered.

The first layer would be the core ledger technology developed to provide fast and secure payments. Second would be an API layer providing payment interface providers with direct access to the core ledger. This API layer will also allow the BOE to verify participants and provide authorized access for regulated entities. The third and final layer as described in the discussion paper would be a payment interface layer of consumer-facing service providers like banks and payments services. The providers on this layer will provide the direct interface between consumers and the CBDC. The providers will also perform KYC and onboard users onto the CBDC platform.

Figure 49:
Bank of England illustrative model of CBDC among UK households and businesses

Source: Bank of England



The architecture of the CBDC is currently undecided. The BOE is still exploring the tradeoffs between a direct model and a hybrid model, but according to the latest discussion paper, is leaning towards a hybrid model.

In a direct model, the BOE would provide all CBDC-related services, the core technology, and consumer-facing products. This, as the BOE cites, is “less likely to achieve our overall objectives or meet our design principles than an approach that involves both the Bank and the private sector,” as the United Kingdom has a high-level of financial inclusion and an “innovative private payments sector” that can better service consumers. However, the BOE noted that it is “essential” that only the central bank itself can create and destroy the CBDC.

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Europe

The European Central Bank (ECB) is responsible for administering monetary policy within the eurozone, a currency union through which 19 of the 27 European Union (EU) member states agreed to use the Euro exclusively.

Under the Eurosystem, the Eurozone’s 19 national central banks (NCBs) implement the monetary policy prescribed by the ECB. The 8 Non-Euro area NCBs are responsible for conducting their respective national monetary policies and do not participate in decision-making for the Eurozone. However, all 27 EU NCBs are united by the European System of Central Banks (ESCB), through which they work with the ECB to improve cooperation between the Eurosystem and non-eurozone member states.

The ECB and NCBs are bound by the Treaty on the Functioning of the European Union (TFEU), which includes statutes of both the European System of Central Banks and European Central Bank.

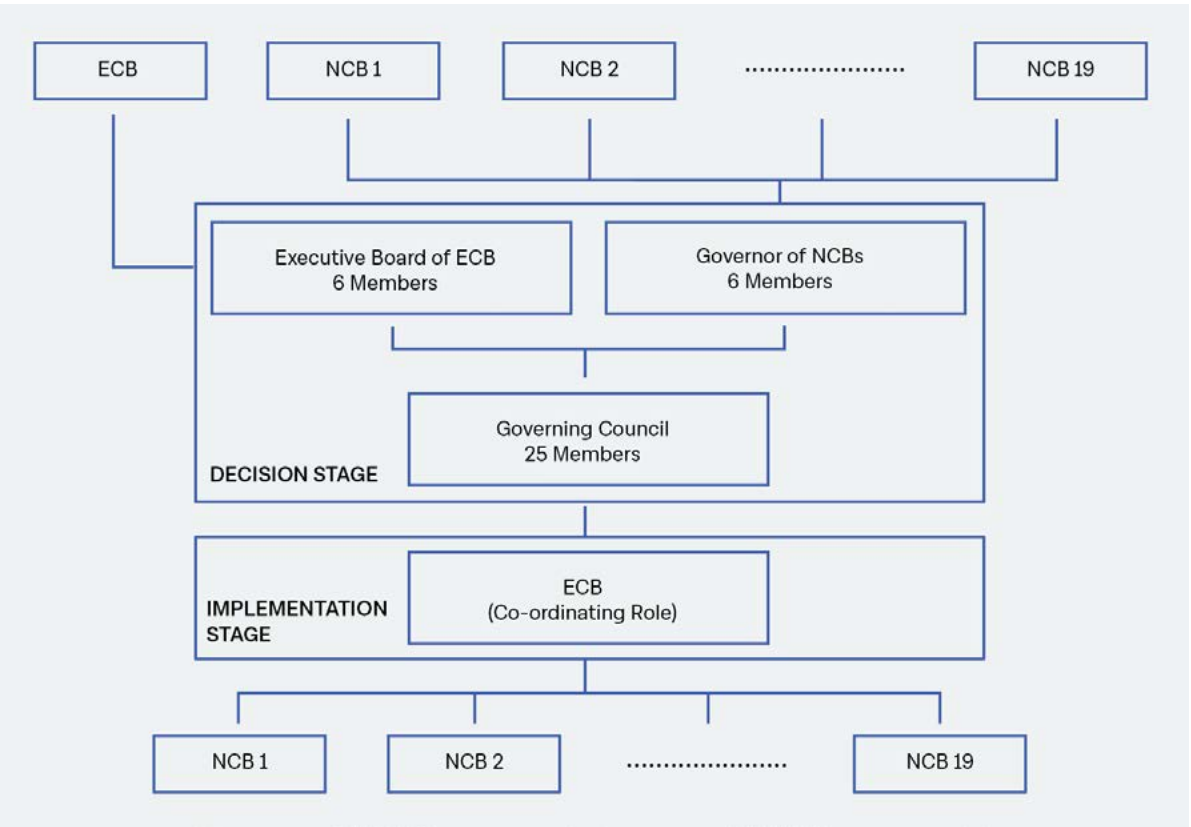


Figure 50: European Union Monetary Structure
Source: ECB, The Block

Implementing a CBDC legally falls under the tasks and responsibilities of the ESCB. Therefore, the ECB has taken the lead on exploring potential CBDCs within the Eurozone.

The ECB has already initiated exploration of wholesale CBDC and DLT for settlement via Project Stella – when analyzing the opportunity to issue a retail CBDC, the ECB has taken a measured approach.

According to Yves Mersch, Vice-Chair of the Supervisory Board of the ECB:

“Setting up a CBDC would require a solid legal basis, in line with the principle of conferral under EU law. One key consideration here is whether a retail CBDC could and should have the same legal tender status as banknotes and coins ... without legal tender status, the legal basis would need to be clarified, as would the relationship between a CBDC and euro banknotes and coins, along with the process by which one could be exchanged for the other.” 114

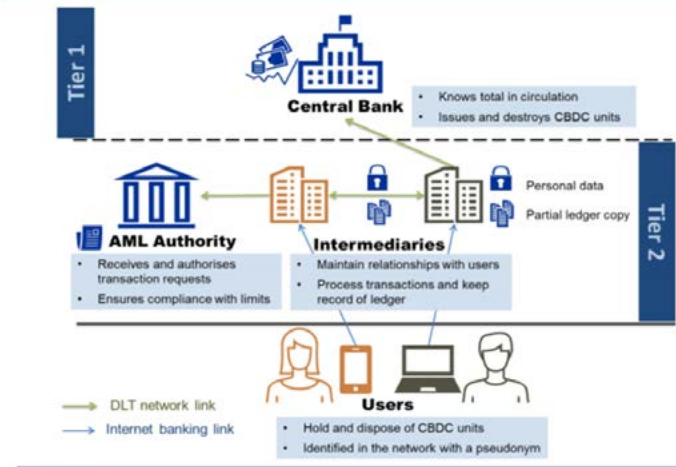
ECB officials want confidence that a retail CBDC is necessary and above all, that the euro’s currency stability would be ensured.

General-purpose CBDC activities are currently led by the ESCB’s EUROchain research network, consisting of the ECB innovation lab and an expert network of 18 NCBs. To date, The ECB’s retail CBDC research is mostly theoretical, as the EUROchain research network considers not only technical complexities but the legal and policy implications for the eurozone as well.

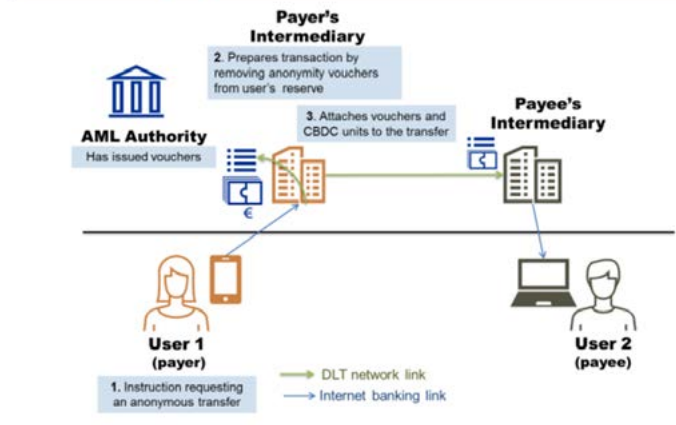
In collaboration with Accenture and R3, EUROchain developed a proof of concept built on R3’s Corda platform. According to In Focus Issue 4, the POC “features four entities (two intermediaries, one central bank and an AML authority – each represented in the network by a node that operates a CorDapp5), an intuitive web application allowing interaction between users, and a set of application programming interfaces (APIs) allowing communication and interaction between different parties.” 115

The EUROchain proof of concept could also enable levels of anonymity, as CBDC transfers could be conducted without central banks by using anonymity vouchers. Payers first send CBDC transfer instructions “indicating the amount, the pseudonym of the payee (account

Figure 1
Two-tier model and relationship between entities



Transfer with anonymity vouchers



Transfer with AML checks

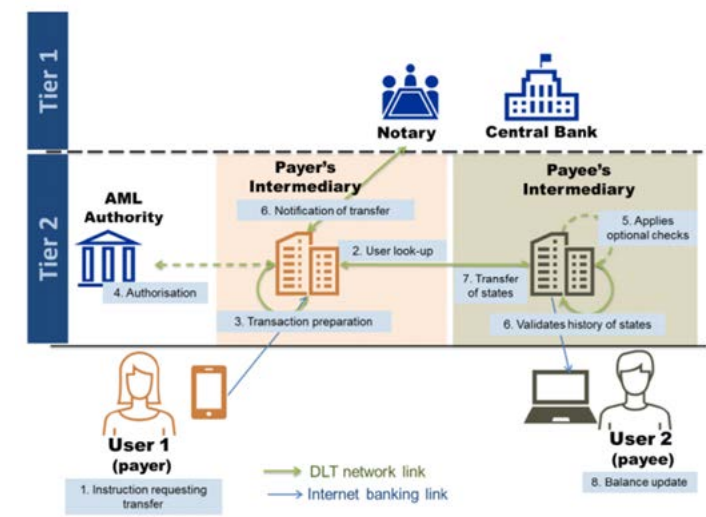


Figure 51: ECB CBDC two-tier model, with accompanying anonymity and AML check features
Source: ECB, The Block

identifier and intermediary identifier) and whether or not the payment should be made anonymously.” Transfers are initiated by the intermediary’s node after AML checks are verified.

Alternatively, transactions can also “be accepted by the payee’s intermediary with no need for approval from the AML authority if the payer has a sufficient number of anonymity vouchers and asks to use them. In that case, the payer’s intermediary removes the necessary vouchers from the user’s reserves and attaches them to the transfer of CBDC, to prove to the payee’s intermediary that the transaction can be validated without checks being carried out by the AML authority.”

If the payer does not have enough vouchers or they elect to forego them, a transfer can be done with AML checks – the payer’s intermediary will route the transfer plus any additional needed information to the AML authority, which will then either approve or reject the transfer based on the information provided. Once approved, the payee’s intermediary will accept the payment.

It is important to note that EUROchain has developed other retail CBDC POCs in the past and will continue to develop others – none of the current research or POCs to-date are meant for practical implementation. However, all efforts will be helpful for assessing how a CBDC would work in practice as well as the potential economic impact.

In January 2020, the ECB published its “Tiered CBDC and the financial system” working paper by Director General of Market Infrastructure and Payments (DG-MIP) Ulrich Bindseil. The paper highlights 2 arguments against CBDC – the “risk of structural disintermediation of banks and centralization of the credit allocation process within the central bank” and the “risk of facilitation systemic runs on banks in crisis situations.”¹¹⁶

Bindseil proposes a two-tiered remuneration structure to control the amount of CBDC, solving the quantitative control problem and undoing potential bank disintermediation. Bindseil’s findings merit further review by those interested in better understanding the intricacies of CBDC and the potential impacts to the commercial banking system.

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Canada

The Bank of Canada offers a unique case study of a central bank that has actively researched CBDCs since 2016 with a number of on-going working papers, tested piloted wholesale implementations via a 4 phase project known as Project Jasper, and still recently came to the conclusion that the bank does not yet see a “compelling” case to issue a Canadian digital dollar.

While it was reported in October 2019 that the Bank of Canada was exploring the possibility of issuing a central bank digital currency,¹¹⁷ in February 2020 the Deputy Governor Bank of Canada, Timothy Lane, said in a speech the bank would not be moving forward with a CBDC at this time. ¹¹⁸

- Lane did, however, note two scenarios where that would likely change:
- 1) Cash could no longer be used for a sufficiently wide range of transactions, giving payment services increased market power, boxing out unbanked from the financial system, and losing the ability to conduct transactions privately
 - 2) Private digital currencies, like Libra, become widespread and potentially challenge Canadian monetary sovereignty

In both scenarios, Lane also noted that the decision to push forward with a CBDC would need to be made by Canadians and their elected representatives. The bank has placed itself in a position to move forward should the case arrive.

For now, the Bank of Canada will consult with the governments and key stakeholders in provinces and territories across Canada to learn if they want a digital currency and how they would want it. To this end, the central bank has recently joined a working group with the central banks of England, Japan, the European Union, Sweden, and Switzerland, as well as the Bank for International Settlements. ¹¹⁹

Perspectives on CBDC in Japan

Beyond the Bank of Japan involvement with the ECB on the joint wholesale research initiative Project Stella, the BOJ has also examined legal issues regarding CBDC issuance in Japan. In addition, the BOJ has occasionally raised concerns about CBDC issuance in Japan, mainly through Deputy Governor Masayoshi Amamiya's speeches.

In 2019, the BOJ Institute for Monetary and Economic Studies commissioned a Study Group on Legal Issues regarding Central Bank Digital Currency¹²⁰ to examine challenges surrounding CBDC issuance in Japan.

The report examines CBDC issuance models and discussed crucial legal issues that may arise from implementation of CBDC within the Japanese legal framework.

For example, the report notes that only BOJ banknotes and coins are permitted as legal tender under current law and indicated that electronically-recorded CBDC is unlikely to legally qualify as BOJ banknotes. Therefore, CBDC issuance would be possible under current law only if it were regarded as an operation that fulfills the BOJ's purpose. Otherwise, the laws (Bank of Japan Act and the Act on Currency Units and Issuance of Coins) would have to be amended or new legislation would have to be passed to issue CBDC. This is a contrast to economies with central banks that were able to justify CBDC issuances as banknotes, like Banco Central Del Uruguay.

The report also discusses civil and criminal legal issues, legislation on data collection, and administrative and competition law. It concludes that CBDC issuance involves diverse legal issues that may require new legislation to address. Furthermore, the specific design of CBDC regulation may differ significantly depending on the purpose of CBDC issuance.

In a BOJ conference in March 2020,¹²¹ Deputy Governor Amamiya asserted that -three things about money and the payment and settlement systems should not and will not change:

- 1) **The basic architecture of money.** There are two forms of money: token-based and account-based. Future payment services will likely develop based on either of these two forms.
- 2) **The two-tiered monetary system.** The two tiers are the central bank and private banks. The former exclusively supplies base

consisting of cash and central bank deposits, while the latter provide deposits through credit creation.

- 3) **The fundamental roles of the central bank.** Even if use of physical cash were to decline and the Japanese economy becomes cashless, the BOJ would still conduct monetary policy under the two-tiered monetary system by controlling bank reserves on deposit at the BOJ and acting as the lender of last resort.

By contrast, he highlighted three things that will change as the payment and settlement systems evolve in the wake of IT innovations:

- 1) **Cashless payments will steadily expand in the retail payments market.** In Japan, cashless payments seem to be increasing. At the same time, however, cash in circulation has been growing 2% annually and the preference for cash remains surprisingly strong. Nonetheless, evolution into a cashless society is inevitable over the long run.
- 2) **Diversification of payment service providers is likely to continue.** Recent progress toward a cashless society seems to be led by non-bank payment services providers (NBPSPs). Diversification of payment service providers will likely have various impacts on financial regulation as well as payment and settlement system operations.
- 3) **Money and data will become more closely linked.** Many NBPSPs provide convenient cashless payment services but their proliferation has increased the importance of addressing issues concerning protection and effective use of personal data.

Amamiya also argued that CBDC can help remove impediments to P2P payments and significantly improve interoperability between different brands of private digital money. However, he also cautioned that many issues need to be addressed.

CBDC could also pose a risk of crowding out existing private services. If transaction costs associated with CBDC are much lower than the fees charged by private payment services, most merchants would prefer to be paid in CBDC instead of private digital money. CBDC could hurt private businesses and discourage innovation, depending on its core infrastructure's design and pricing. In addition, if firms and individuals prefer holding CBDC over bank deposits, CBDC could alter the two-tiered monetary system itself.

Mr. Amamiya emphasized that central banks need to deepen their understanding of the challenges and risks as well as the benefits of issuing CBDC.

Cashless trends in Japan

Cashless payments are increasing in Japan but remain much less prevalent than in more digitally advanced nations. The Japanese government is targeting 40% cashless payments by 2025, which would be a twofold increase from 2016.

After Japan raised its consumption tax rate to 10% from 8% in October 2019, the government worked together with financial services companies to promote cashless payments by temporarily issuing consumption tax rebates of up to 5% on cashless purchases. This promotion has likely boosted cashless payments.

Conclusion

The BOJ has been formally researching CBDCs since January 2020 when it partnered with five other major central banks — the Bank of England, the Bank of Canada, the European Central Bank, the Sveriges Riksbank (Sweden), and the Swiss National Bank to experiment with the technology.

Although the BOJ does not have any specific plans to issue CBDC at this moment, it is continuously studying the opportunities and risks surrounding CBDC and expressing its views. In July 2020, reports surfaced¹²² that suggest the Japanese government will include a CBDC plan in its policy framework in 2020, the inclusion of which would make it an “official government policy.” Following the report, the BOJ also set up a new dedicated team to further study digital currencies.

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“It has been an incredibly important catalytic event to sort of shake the tree when Libra showed up out of the blue... Libra forced us to think hard about what we do.” ¹²⁴

— Stefan Ingves, Governor of Central Bank of Sweden

“Libra has undoubtedly been a wakeup call for central bank and policymakers.” ¹²⁵

— Benoit Coeure, Executive Board Member, ECB

“It’s tough to predict if Libra will ever live up to its promises or even come into existence. But it is a good example of a transformative technology that affects how the Bank needs to respond to the future of money.” ¹²⁶

— Timothy Lane, Deputy Governor Bank of Canada

“[Libra] was a bit of a wakeup call that this is coming fast, and could come in a way that is quite, you know, widespread and systemically important fairly quickly if you use one of these big tech networks like Libra did,” ¹²⁷

— Jerome Powell, Federal Reserve Chairman

U.S. – Private market initiatives are leading the initial charge

To date, the Federal Reserve has taken a conservative approach towards the public facing discussion of CBDCs. However, given the prospect of a tech company-controlled global currency like Facebook’s idea for Libra, and the rise of China’s DC/EP, that may be changing.

In August 2020, the Fed published some findings of its “FooWire” trial, which was developed using the Hyperledger Fabric blockchain software. According to the central bank’s researchers, that trial “highlighted the potential of DLT for certain payment uses, the quick speed with which a system could be implemented, the potential simplicity of smart contracts, and the range of functionality offered by such platforms.”¹²³ Additionally, the Federal Reserve Bank of Boston announced¹³³ it will work with researchers from MIT’s Digital Currency Initiative (DCI) on a “multi-year collaboration” to build and test a “hypothetical” open-source central bank digital currency platform. In a speech announcing this project, Fed governor Lael Brainard stressed that the Fed has still yet to make a formal decision on whether to officially pursue a digital currency launch.¹³⁴

The project will serve to develop a deeper understanding of the "capacities and limitations" of technology that could underpin various designs, rather than serving as a prototype. Any codebase that is developed will be offered as open-source software for others to experiment with.

"We are carefully monitoring the activities of other central banks to identify potential benefits that may be relevant in the U.S. context...To date, our observation is that many of the challenges they hope to address do not apply to the U.S." — Jerome Powell

The initiative will be broken out over multiple phases, and the first phase will test hypothetical CBDC models for "wide-scale" general purpose use and explore whether DLT technology can meet the high standard of a theoretical U.S. CBDC. Beyond this, the project intends to access other technological architectures and tradeoffs.

In an accompanying speech, "An Update on Digital Currencies,"¹³⁵ Brainard noted that "the Federal Reserve is active in conducting research and experimentation related to distributed ledger technologies and the

potential use cases for digital currencies. Given the dollar's important role, it is essential that the Federal Reserve remain on the frontier of research and policy development regarding CBDCs."¹³⁶

Libra: The Story Thus Far

The story of how Libra — the stablecoin initiative bootstrapped by social media giant Facebook — shocked the world with its plan to offer a low-volatility form of money to the unbanked people of the world began in June 2019.

On the 18th of that month, the consortium of firms backing Libra officially unveiled their plans. Backed by a currency token basket, and powered by a smart contract platform envisioned to be "secure, scalable, and reliable," Libra's stated mission was simple: serve billions of people and emphasized banking the unbanked.

"Libra holds the potential to provide billions of people around the world with access to a more inclusive, more open financial ecosystem," David Marcus, the project lead from Facebook, said at the time.

The original concept envisioned the Libra Association issuing its own security tokens (STOs) called Libra Investment Tokens, as a way to fund incentive programs and cover operating costs. On the technical side, Libra was to start out on a permissioned blockchain, but overtime transition to become "permissionless" over time.

The project has evolved significantly since the initial concept ran up against extraordinary pressure from policymakers and central banks around the world once it debuted.

Indeed, in light of an eventual showdown with members of Congress — that came amid

broader scrutiny of Facebook — Libra began to undergo a shift from a standalone currency to something more akin to a payments system. What's more, CEO Mark Zuckerberg said that Facebook would be willing to leave the Libra Association entirely should the project be rejected by U.S. regulators.

Since then, the Libra Association has moved to shore up its KYC/AML credentials via hirings and unveil broad changes to the project's initial vision. These include a plan to roll out multiple currency-backed tokens and an implicit welcoming mat for central banks to issue currencies on its network.

"Over time, our hope is that the Association will be able to collaborate with central banks on issues such as direct custody of cash or cash equivalents and very short-term government securities or the integration of the Libra payment system with CBDCs," the group said. "This would reduce credit and custody risk, streamline the operations of the Reserve, and provide additional comfort to Libra Coin holders."

Indeed, the Libra Association tapped a former FinCEN director as its general counsel and HSBC's top lawyer as its CEO. These hires represent what might be the loudest signal possible that Libra is serious about building, to quote Marcus, "a comprehensive network-level system around anti-money laundering (AML), Combatting the Financing of Terrorism (CFT), and sanctions enforcement." The Association also brought in Sterling Daines, formerly of Credit Suisse, as its chief compliance officer.

Whether Libra will ultimately earn the trust of global regulators and watchdogs remains to be seen. But the fact remains that the project is, perhaps, the most prominent private-sector digital currency initiative in the world today.

And as indicated by Federal Reserve chairman Jerome Powell, Libra "lit a fire" under the work being done by central banks around the globe on their respective digital currency projects.

Source: The Block, Michael McSweeney

Governor Brainard also noted the Fed would expand the Fed's TechLab experimentation with "technologies related to digital currency and other payment innovations." She emphasized that these engagements and research would be separate from the "significant policy process that would be required to consider the issuance of a CBDC... along with extensive deliberations and engagement with other parts of the federal government and a broad set of other stakeholders."

These experiments have taken place amid the rise of Libra, the stablecoin initiative originally backed by social media giant Facebook. Its summer 2019 debut was quickly met by a mix of curiosity and skepticism from the world's regulators, and soon many of the world's central banks weighed in on the project's potential impact. Indeed, Libra would be cited as an inciting element for some CBDC projects.

Libra and China's DCEP have inspired reactions not just from the Fed but also Capitol Hill. In September 2019, Congressman French Hill

and Bill Foster requested that the Fed explore a potential CBDC.¹²⁸ In response, Powell wrote:¹²⁹ "We are carefully monitoring the activities of other central banks to identify potential benefits that may be relevant in the U.S. context...To date, our observation is that many of the challenges they hope to address do not apply to the U.S."

Powell also confirmed in the letter that the Fed is still not developing a U.S. dollar CBDC, and said there are a number of challenges that are unclear how to resolve, including policy and legality issues (like whether it would even constitute as legal tender under U.S. law) as well as operational challenges of whether it pays interest, and how a CBDC impacts monetary supply.

Powell went on to state that while the Federal Reserve was following digital currencies, it was not something the central bank was "actively considering." He also cited a lack of consumer demand., "Consumers have plenty of payment options," he said, adding that "they are not clamoring for this."¹³⁰

In December 2019, Steven Mnuchin, the U.S. Treasury secretary, said at a House Financial Services Committee hearing that he saw little reason to aggressively push for a digital dollar: "Chair Powell and I have discussed this at length – we both agree that in the near future, in the next five years, we see no need for the Fed to issue a digital currency."¹³¹

An often underappreciated fact, however, is regardless of what Powell and Mnuchin think, Congress has the power to create a digital dollar via legislation, which ultimately could meet the definition of a retail CBDC.

Indeed, in March 2020, a draft economic relief bill from Democrats in the House of Representatives in response to Covid crisis proposed one potential design: the bill would have compelled the Federal Reserve to make central bank money — by way of electronic accounts — available to the public, and not just commercial banks. The proposal was ultimately stripped from the bill, but it was later refiled by Sen. Sherrod Brown of Ohio.¹³²

Meanwhile, Congress has held several hearings that have focused fully or in part on the question of a digitized dollar. Former CFTC chair J. Christopher Giancarlo, and Co-Founder of The Digital Dollar Foun-

dation (see the below box), has pushed for the U.S. government to directly fund experimental work in this area. And while it remains unclear if Congress will go down this path, proponents of a digitized dollar have found at least some receptive ears on Capitol Hill — particularly when the issue is placed in the context of competition with other nations, namely China, and private entities like Facebook.¹³⁷ In that light, if Congress were to act and pass a bill that required the creation of a digital dollar and the President signs on, the Fed will have to comply, ready or not.

Digital Dollar Project Current Digital Dollar Proposal
From Digital Dollar Foundation response to The Office of the Comptroller of the Currency

"The Digital Dollar Foundation is a not-for-profit organization created to encourage public discussion and education about a United States central bank digital currency ("CBDC") in order to advance the needs of global financial systems and consumers.

We describe a technology neutral tokenized digital dollar that has the same legal status as physical bank notes in the United States. This CBDC would be issued by the Federal Reserve System and enjoy the full faith and credit of the US government, represent a third format of central bank money, and be fully fungible with Federal Reserve notes (bank notes / physical cash) and reserves. It would operate as a bearer instrument similar to physical cash, but in a digital world.

While we believe that a true CBDC issued by the Federal Reserve would provide a substantial upgrade to the public infrastructure of money, we note that a CBDC is not antithetical to the development of private sector initiatives, including around stablecoins. We accordingly believe that both a US CBDC and stablecoins can and should coexist in a diverse and resilient payment landscape. We further emphasize that even though a US CBDC would be issued by the Federal Reserve, we make no assumptions and believe more exploration is needed as to whether the Federal Reserve, private technology service providers, a consortium of regulated banks and firms, or other types of entities would operate the network or "payment rails."

The Digital Dollar Foundation proposes that issuance, distribution and redemption of a US CBDC take place just as cash does today in the two-tier banking system. It would be issued by the Federal Reserve to domestic banks or regulated entities against reserves. Banks would distribute Digital Dollars to domestic end-users' digital wallets against bank deposits and against collateral to non-resident banks. It would be redeemed against bank deposits and collateral at banks and against reserves at the central bank. The token-based properties would allow Digital Dollars to be intermediated through existing channels and critically maintain the fractional lending system."

Source: [The OCC](#), Digital Dollar Foundation

"We are learning from the rest of the world that problems can arise or challenges can arise that would need the Federal Reserve to respond — potentially with new technology and potentially with a central bank

digital currency,” assistant vice president in the secure payments group at the Federal Reserve Bank of Boston said during a recent CBDC webinar produced by The Block.¹⁴²

In that hypothetical — or in any case in which a central bank is pushed by its government to explore a digital currency (pure retail CBDC, or synthetic) for that matter — it’s not hard to envision some of the development, investment, and experiments that are occurring within the digital asset industry at large as having some part to play. Should a digital dollar or retail CBDC involve some type of tokenization, DLT, and or private-public key cryptography, the infrastructure currently in place to support the digital asset industry (wallets, exchanges, custodians, stablecoin providers, etc.) would likely serve a role in supporting such an instrument.¹³⁸

While beyond the scope of this report, not lost on central bankers is the growing usage and demand of stablecoins more broadly.¹⁴⁰ In July, the aggregate supply of stablecoins passed \$13 billion (up 6 times the value in the past two years), while stablecoin transaction volume on blockchains surpassed more than \$80B in the month of July alone.¹⁴¹ Annualizing transaction volumes in 2020 brings this value to more than \$460 billion for the year. Some are quick to point out that the vast majority of this volume comes from trading flow, however, it's important to emphasize that these volumes do still occur on-chain and represent a flow of value from one address to another, i.e. they are a payment flow. While not an equitable comparison, for context total payment volume for PayPal in 2019 was \$712 billion.¹³⁹ Looking ahead, further research is needed to explore the potential opportunities and synergies of stablecoin models within the broad stroke of CBDCs.

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¹²⁵ Bank for International Settlements, [Introductory remarks to the Committee on the Digital Agenda of the Deutscher Bundestag](#) (Cœuré 2019)

¹²⁶ Bank of Canada, [Money and Payments in the Digital Age](#) (Lane 2020)

¹²⁷ The Block, [Fed chair Powell says Facebook's Libra 'really lit a fire' on the question of a digital dollar](#) (McSweeney 2020)

¹²⁸ Congressman French Hill, [Fed Chair Jerome Powell: U.S. looking into digital currency](#) (2019)

¹²⁹ Congress of the United States, [In a letter](#) (2019)

¹³⁰ The Block, [Fed Chair Jerome Powell: Consumers are not "clamoring" for central bank backed cryptocurrencies](#) (Zheng 2019)

¹³¹ Federal Reserve Bank of Boston, [The Federal Reserve Bank of Boston announces collaboration with MIT to research digital currency](#) (Reynolds 2020)

¹³² United States Senate Committee on Banking, Housing, and Urban Affairs, [Brown Introduces New Legislation To Help Hardworking Americans In The Coronavirus Relief Package](#) (Brown 2020)

¹³³ The Federal Reserve, [Speech by Governor Brainard on "An Update on Digital Currencies"](#) (Brainard 2020)

¹³⁴ The Block, [Boston Fed, MIT partner on central bank digital currency research project](#) (McSweeney 2020)

¹³⁵ The Federal Reserve, [Speech by Governor Brainard on "An Update on Digital Currencies"](#) (Brainard 2020)

¹³⁶ The Federal Reserve, [Speech by Governor Brainard on "An Update on Digital Currencies"](#) (Brainard 2020)

¹³⁷ The Block, [Giancarlo pitches Congress on piloting a 'digital dollar' in the U.S.](#) (Orcutt 2020)

¹³⁸ The Block, [Mapping Crypto Custody](#), (Zheng 2019)

¹³⁹ The Block, [PayPal 2019 Annual Report](#), (2020)

¹⁴⁰ Federal Reserve, [Digital Currencies, Stablecoins, and the Evolving Payments Landscape](#), (Brainard 2019)

¹⁴¹ The Block, [July by the Numbers](#), (Cermak 2020)

¹⁴² The Block, [An emerging consensus on the U.S. dollar: Figure out how to fix it now in case it breaks later](#), (Orcutt 2020)

After an initial inclusion of a digital dollar in an early draft bill (that was eventually removed), and the latest congressional hearings that touched on the potential for digital dollars to help with fiscal stimulus disbursement, do you feel Central Bank Digital Currencies are getting tangible reception in Washington?

In DC, certainly in Congress, there is very little serious talk of crypto these days. There is very little talk beyond COVID relief at the moment — maybe China foreign policy and social reform — very little talk about really anything else, and certainly not crypto. If it is crypto-related, it is about CBDC. So in that sense, [CBDC] is getting some reception.

What is the advantage from the central bank's perspective of working with the Libra network rather than other DLT-based protocols, or non-DLT systems, that have been piloted with CBDC in the past? What value would Libra bring to the table in these discussions, and potential future pilots?

With more than 70% of the world’s central banks reviewing the risks and opportunities of CBDCs as a part of their own digital transformation agenda, the case for public-private collaboration on digital currencies is clear. On the one hand, if central banks offer digital currencies it would forego many of the reserve, risk management and stabilization mechanisms privately-issued stablecoins must develop.

On the other, the advent of an open blockchain-based wallet environment creates opportunities to enhance interoperability enabling retail functionality without sacrificing public sector oversight of monetary policy. In short, privately-issued stablecoins and CBDCs are not conflicting concepts, but rather complementary designs — both of which will require trusted, secure and compliant delivery networks, which is where solutions like the Libra payment system can serve as a bridge.

176		Timeline work cited	
October 2008		November 2015	
Satoshi Nakamoto releases Bitcoin white paper		BIS CMPI releases “Digital Currencies” report	
October 2012		2016	
The ECB releases it “Virtual Currency Schemes” re- port, declaring that digital assets fall under the central banks’ responsibility		March 2016	
		Bank of Canada, Payments Canada and R3 launch “Project Jasper” research initiative	
		June 1st-3rd 2016	
2013		Over 90 Central Banks attend “Finance in Flux: The Technological Transformation of the Financial Sector” event in DC	
January 23rd 2014		July 18th 2016	
Vitalik Buterin releases Ethereum white paper		BOE releases “The macroeconomics of central bank issued digital currencies” work paper	
September 2014		November 15th 2016	
BIS forms the CPMI (Committee on Payments and Market Infrastructures)		R3 and JP Koning release “Fedcoin: A Central Bankissued Cryptocurrency”	
October 19th 2014		November 16th 2016	
JP Koning writes “Fedcoin” blog post		Monetary Authority of Singapore (MAS) starts “Project Ubin”	
December 2014		November 11th 2016	
The Central Bank of Ecuador starts “Dinero Electróni- co” program		The Hong Kong Monetary Authority (HKMA) releases “Whitepaper On Distributed Ledger Technology”	
2015		November 22nd 2016	
The PBOC starts Digital Currency/Electronic Payment (DC/EP) research		Bank of Canada releases “Central Bank Digital Currencies: A Framework for Assessing Why and How” Paper	
February 2015		December 6th 2016	
BOE publishes “One Bank Research Agenda”		ECB’s Yves Mersch delivers “Distributed Ledger Technology: role and relevance of the ECB” speech in Berlin	
May 26th 2015		2017	
George Danezis and Sarah Meiklejohn release RSCoin white paper		March 2017	
September 18th 2015		Sweden’s Riksbank e-krona project begins	
BOE’s Andrew Haldane delivers “How low can you go?” speech			

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August 31st 2017	Central Bank of Iceland releases “Rafkróna?” interim report
“Distributed ledger technical research in Central Bank of Brazil” positioning report	October 26th 2018
	Sweden’s Riksbank releases “E-krona project, report 2”
September 17th 2017	November 12th 2018
BIS publishes “Central bank cryptocurrencies” in Quarterly Review	IMF releases “Casting light on central bank digital currencies” working paper
September 20th 2017	November 2018
Sweden’s Riksbank releases “E-krona project, report 1”	The Bank of Israel's CBDC team releases findings
October 5th 2017	
The Monetary Authority of Singapore (MAS) and The Association of Banks in Singapore (ABS) announce Consortium exploring RTGS	2019
November 3rd 2017	January 1st 2019
Central Bank of Uruguay President, Mario Bergara, launches E-Peso Pilot	The Bank of Lithuania launches blockchain sandbox platform-service, LBChain
December 2017	January 8th 2019
Danmarks Nationalbank releases “Central bank digital currency in Denmark?” report	BIS releases “Proceeding with caution - a survey on central bank digital currency” paper
	February 21st 2019
2018	The Eastern Caribbean Central Bank (ECCB) and Bitt Inc. (Bitt) sign a contract to a CBDC pilot
March 2nd 2018	March 1st 2019
The Central Bank of The Bahamas Governor delivers “Digital Currency - Extending the Payments System Modernisation Initiative” Speech	The Central Bank of The Bahamas selects NZIA Limited as technology partner for “Project Sand Dollar”
May 25th 2018	April 29th 2019
BOE releases “Central bank digital currencies — design principles and balance sheet implications” staff paper	The South African Reserve Bank (SARB) releases CBDC Expression of Interest
May 18th 2018	June 7th 2019
Norges Bank working group completes initial phase of CBDC study	The National Bank of Ukraine releases Analytical Report on the E-hryvnia Pilot Project
July 2018	June 18th 2019
Central Bank of Brazil releases “Currency in the Digital Era” working paper	Facebook’s Libra V1 white paper released
September 2018	

June 21st 2019	December 17th 2019
France creates G7 task force to study Libra	ECB releases “Exploring anonymity in central bank digital currencies” paper
June 27th 2019	December 24th 2019
A Norges Bank working group releases findings from phase two of CBDC study	The Central Bank of The Bahamas releases “Project Sand Dollar” white paper and initiates pilot phase in Exuma
July 2nd 2019	December 31st 2019
Committee Democrats Call on Facebook to Halt Cryptocurrency Plans	Switzerland’s Federal Council crypto franc (e-franc) report findings
July 17th 2019	December 2019
David Marcus Head of Calibra, Facebook testifies before Congress	The Central Bank of Lithuania releases “CBDC – in a whirlpool of discussion” paper
July 29th 2019	December 2019
The National Bank of Cambodia launches “Bakong Project” Pilot	The Hong Kong Monetary Authority (HKMA) and the Bank of Thailand (BOT) complete Project Inthanon-LionRock POC
August 23rd 2019	2020
BOE Governor Mark Carney delivers “The Growing Challenges for Monetary Policy in the current International Monetary and Financial System” at Jackson Hole Symposium	
August 2019	January 1st 2020
The Central Bank of Lithuania releases Digital Currencies and Central Banking: A Sense of Déjà Vu	ECB releases “Tiered CBDC and the Financial System” working paper
October 18th 2019	January 16th 2020
BIS CPMI releases “Investigating the impact of global stablecoins” Paper by the G7 Working Group on Stablecoins	J. Christopher (“Chris”) Giancarlo, Former CFTC Chair Launches The Digital Dollar Project
October 23rd 2019	January 22nd 2020
Facebook’s Mark Zuckerberg testifies about Libra before Congress	The Hong Kong Monetary Authority (HKMA) and the Bank of Thailand (BOT) release Inthanon-LionRock report
December 5th 2019	January 23rd 2020
ECB drafts “Innovation and its impact on the European retail payment landscape” Note	BIS updates “Impending arrival - a sequel to the survey on central bank digital currency” paper
December 12th 2019	March 2020
BIS CMPI releases “Wholesale digital tokens” report	BIS publishes “The technology of retail central bank digital currency” report

April 16th 2020	
Libra Association releases White Paper v2.0	
April 19th 2020	
The People’s Bank of China (PBOC) confirms that it has been internally testing DC/EP in four cities	
<div>Papers of Interest:</div>	
2020	2018
<ul style="list-style-type: none">World Economic Forum, Central Bank Digital Currency Policy-Maker Toolkit, (2020)MIT DCI, Redesigning digital money: What can we learn from a decade of cryptocurrencies? (Ali, Narula 2020)BIS, Taking stock: ongoing retail CBDC projects, (2020)IMF, A Survey of Research on Retail Central Bank Digital Currency, (2020)BIS, The technology of Retail Central Bank Digital Currency, (2020)Bank of Canada, Privacy in CBDC technology, (Darbha, Arora 2020)BIS, Central banks and payments in the digital era, (2020)	<ul style="list-style-type: none">Bank of England, Broadening Narrow Money: Monetary Policy with a Central Bank Digital Currency, (2018)Bank of Canada, Central Bank Digital Currency and Monetary Policy, (Davoodalhosseini 2018)
	2017
	<ul style="list-style-type: none">Bank of Canada, Central bank digital currency: Motivations and implications, (Walter, Ben Siu-Cheong 2017)NBER, Central Bank Digital Currency and the Future of Monetary Policy, (Bordo, Levin 2017)IEEE, Multi-Blockchain Model for Central Bank Digital Currency, (2017)
2019	2016
<ul style="list-style-type: none">BIS, Proceeding with Caution - A Survey on Central Bank Digital Currency, (Barontini, Holden 2019)NBER, Central Bank Digital Currency: Central Banking For All?, (2019)	<ul style="list-style-type: none">Bank of England, The macroeconomics of central bank issued digital currencies, (Barrdear, Kumhof 2016)Bank of Canada, Central Bank Digital Currencies: A Framework for Assessing Why and How, (Fung, Halaburda 2016)
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<ul style="list-style-type: none">IMF, Casting Light on Central Bank Digital Currency, (2018)Bank of England, Central Bank Digital Currencies - Design Principles and Balance Sheet Implications, (Kumhof, Noone 2018)	

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