2021

Should Central Banks Use Distributed Ledger Technology and Digital Currencies to Advance Financial Inclusion?

Michael S. Barr
Michigan Law School, msbarr@umich.edu
Adrienne A. Harris
Lev Menand
Karin Thrasher

Available at: https://repository.law.umich.edu/other/226

CENTER ON FINANCE, LAW & POLICY
UNIVERSITY OF MICHIGAN

CENTRAL BANK
OF THE FUTURE

Should Central Banks Use Distributed Ledger Technology and Digital Currencies to Advance Financial Inclusion?

Paper #_7_

Released May 17, 2021

Authors

Michael S. Barr
msbarr@umich.edu

Adrienne A. Harris
adrienah@umich.edu

Lev Menand
lmenand@law.columbia.edu

Karin Thrasher
kthrash@umich.edu

University of Michigan Center on Finance, Law & Policy
Weill Hall Suite 5211
735 S. State St.
Ann Arbor, MI 48109

http://financelawpolicy.umich.edu/central-bank-research

ISSUE BRIEF 7: SHOULD CENTRAL BANKS USE DISTRIBUTED LEDGER TECHNOLOGY AND DIGITAL CURRENCIES TO ADVANCE FINANCIAL INCLUSION?

I. Executive Summary

This brief is part of the Central Bank of the Future Project ("CBOTF"), a research project that seeks to identify ways that central banks across the world can improve access to financial products and services for underserved communities. CBOTF engages with scholars, financial regulators and policy makers, think tanks, financial institutions, fintech companies, consumer and community organizations, and other stakeholders to examine how central banks can evolve to better promote financial inclusion and financial health. CBOTF also works to find ways that businesses and nonprofits can work alongside government sector efforts for financial inclusion. One output is a series of working papers and policy briefs focused on specific topics.

This paper examines how central banks might use distributed ledger technology ("DLT") to improve access to safe and affordable financial products and services. We consider how central banks might use DLT to advance objectives such as Anti-Money Laundering ("AML") compliance and discuss both central bank digital currencies ("CBDC") and private digital currencies. We consider implementation challenges for these new approaches relating to interoperability, privacy, and efficiency. We conclude that financial inclusion is far from an assured outcome: central banks must work to ensure that any new technologies they adopt or foster do not exclude marginalized groups and instead focus with intentionality on low-income households. Moreover, difficult issues with respect to financial disintermediation, credit availability, and financial stability would need to be addressed.

This paper proceeds in four parts. Part II provides a primer on DLT and CBDC. Part III considers four ways central banks might use DLT to advance financial inclusion: to accelerate payments, to improve identity verification, to formalize collateral, and to lower compliance costs. Part IV focuses on DLT in the digital currency context, analyzing non-fiat DLT-based digital currencies and proposals to create DLT and non-DLT central bank digital currencies. Part V concludes.

II. A Primer on DLT and CBDC

A. Primer on Distributed Ledger Technology

At its core, DLT is a decentralized way of recording and sharing data.[1] A distributed ledger is an agreed-upon record of digital data spread across multiple entities.[2] DLTs have three essential features: a ledger stored in multiple locations, a mechanism to determine the accuracy of the data, and cryptographic security.[3]

Distribution has the potential to significantly change recordkeeping.[4] Before DLT, recordkeeping was generally a centralized process that required trust in a central party.[5] DLT reduces the need for such a central party and in some cases eliminates the central party entirely.

There are two types of distributed ledgers: permissionless and permissioned. Permissionless ledgers are open to everyone.[6] In permissionless ledgers, control over recordkeeping lies with all participants. No single entity can approve an entry to the ledger; rather, the entry must be approved by consensus.[7] Permissioned DLTs require trusted parties to validate ledger entries. Permissioned ledgers may be either public or private. In a private, permissioned DLT, only trusted entities may read the ledger.[8] In a public, permissioned DLT any entity may read the ledger. Permissioned ledgers share a limited consensus process: Only permitted entities may add to the ledger, and the ledger entries are checked by trusted entities in the system rather than by all actors, as in open or permissionless systems.[9]

Both private and public DLTs generally use a consensus mechanism.[10] A consensus mechanism is "a method of authenticating and validating a value or transaction on a blockchain or a distributed ledger without the need to trust or rely on a central authority."[11] While mechanisms vary in each distributed ledger depending on its design, the purpose remains the same.[12] By requiring consensus, the ledger determines whether a transaction is legitimate or not. Consensus is also important to avoid conflicting entries, ensure correct sequencing of entries, and prevent take-overs of the DLT by bad actors.

Cryptography enhances the safety of the network. Encryption is designed to eliminate false entries[13] and verify the identity of parties who add information to the ledger.[14]

B. Primer on Central Bank Digital Currency

Digital currency is a blanket term describing forms of money that are recorded and exchanged electronically, including cryptocurrency.[15] Both fiat currencies and non-fiat currencies can be digital.[16] Fiat currency is currency issued by a government that is not convertible into any commodity or other thing of value.[17] It derives its value from a number of sources, chief among them the strength and stability of the issuing government[18] monetary and fiscal policies that provide stability, and the public's assurance that fiat currency will be accepted for payments.[19] Although not

often thought of this way, bank account balances are a type of digital currency. When digital currency is issued by the central bank, the resulting instrument is a digital form of fiat currency, or a Central Bank Digital Currency ("CBDC").[20]

CBDC can take two forms: wholesale, which is used to settle transactions between institutional actors, and retail or general purpose, which is available to individuals. Unlike central bank reserves, a form of wholesale CBDC that is available only to select institutions, usually insured depository institutions, retail CBDC would be available to non-depository businesses and ordinary citizens.[21] Retail CBDCs can be account-based or token-based.[22] In the token-based model, like traditional paper currency, the digital currency could pass peer-to-peer without going through a central bank clearing system.[23]

In the account-based model, individuals hold their balances directly on the books of the central bank. This model is not like paper currency, where the instrument can anonymously circulate peer-to-peer, but rather is a deposit-transfer system, where transactions are recorded as new entries on a centralized ledger. In this model, the account owner can request a transfer of funds to another account owner. The central bank would settle the transaction by updating its central ledger.[24] These functions could be delegated to other entities, such as banks, in which case the CBDC would be held in private accounts, and private entities would arrange for transfers and other financial services, and records could be maintained through DLT.

III.   How DLT Can Advance Financial Inclusion

More than 1.7 billion people worldwide lack access to basic financial services.[25] These include people who do not have formal identification or a permanent address, those who live in rural/remote areas, and those who have been discriminated against based on their race, gender, age, income, or citizenship. DLT may be able to help central banks tackle these problems. Use of DLT is particularly promising where the benefits of decentralized access to the ledger exceed the costs (both economic and logistical) of maintaining multiple ledger copies. For example, the World Food Programme uses a DLT to collect payment for the delivery of food aid to Syrian refugees.[26] The use of DLT is also attractive to sectors that have many manual processes, such as trade finance, syndicated loans, and tracking agricultural products and commodities.[27]

This Part explores four ways central banks can use DLT to advance financial inclusion, and reviews ongoing efforts to employ DLT by central banks in four countries: Canada, France, Brazil, and Switzerland.

A. FOUR POTENTIAL APPLICATIONS

Central banks may be able to harness DLT, either directly or through the private sector, to expand access to affordable, appropriate financial services by accelerating

payments, improving identity verification, formalizing property registers, and lowering AML compliance costs.

1. <u>Accelerating payments</u>: DLT can be used by private sector firms to speed up payments, eliminating overdraft fees and cash flow problems caused by payment settlement lag times.[28] For example, in Nigeria, two companies, Stellar and Oradian, have partnered to offer instant money transfers using DLT.[29] In the United States, Accenture, SAP SE and R3 are building a prototype that uses DLT to facilitate faster payments between banks and customers.[30] Banks worldwide are also investigating how to use DLT to improve payment efficiency[31] and ease cross board remittances. Roughly 90% of top Australian, European, and North American banks are experimenting with DLT to accelerate payments.[32]

2. <u>Improving identity verification</u>: DLT can be used to improve identity verification, preventing theft and improving access to mainstream services for those without formal identification.[33] Digital identity solutions have drawn particular interest from the private sector.[34] For example, the Brazilian Federation of Banks is investigating whether DLT could be used to allow customers to share their information with more than one bank, which would lower switching costs and promote the portability of consumer financial data.[35] A DLT-based government identity system could also increase accessibility to public services for low-income and vulnerable people, supporting financial inclusion and financial health.[36] Central banks, for example, could use DLT to create a decentralized identity management system,[37] allowing individuals to receive a digital identity, expressed as a cryptographic key that serves as a digital signature for transactions.[38] Strong privacy, antidiscrimination, and consumer protection regulations will be needed for identity frameworks.

3. <u>Formalizing property registers</u>: DLT could help individuals gain access to loans and other financial services by verifying their ownership of certain collateral.[39] In the developing world, many individuals own small plots of land, equipment, and dwellings but lack formal legal title, which prevents them from using the property as collateral for loans. Of the 2.5 billion people who rely on land use for survival, only 20% own a title document.[40] DLT can lower the cost of formalizing collateral through databases that record and track title transactions. For example, the Republic of Georgia plans to use a blockchain to develop a permanent land title record system and track all transactions.[41] Similar approaches could be used to track and formalize less traditional assets and thereby provide the poor with an onramp to the financial services system.

4. <u>Lowering compliance costs</u>: Central banks also have begun exploring the use of DLT to lower compliance costs and improve oversight, both of which stand to benefit marginalized groups indirectly. Under a model developed by the Bank for International Settlements,[42] certain compliance tasks can be

automated and recorded on a ledger. For example, capital levels could be automatically verified.[43] DLT also would lower compliance costs by allowing firms to report aggregate data on a ledger without disclosing individual transactions.[44] Cheaper compliance is likely to shift the cost curve and make it more profitable for firms to offer services to low-income households. Enhanced oversight also will allow central banks to better protect consumers from predatory practices.

B. DLT EXPERIMENTS IN CANADA, FRANCE, BRAZIL, AND SWITZERLAND

Central banks are already using DLT or exploring ways to use it in the future. DLT has the potential to bring a new level of transparency,[45] and increasingly enable financial inclusion.[46] This section collects examples from Canada, France, Brazil, and Switzerland.

Canada. In 2016, Canada launched Project Jasper[47] to understand the potential impact of DLT on payment systems.[48] Project Jasper is significant because it is the first central bank DLT experiment in partnership with the private sector.[49] Most recently, the Bank of Canada and private sector institutions (TMX, R3, Payments Canada, Accenture) have experimented with using DLT to clear and settle securities transactions.[50] The system uses a DLT network to facilitate settlement and payment for securities, such as equities listed on the TSX exchange.[51] The group found that while DLT could facilitate efficiency improvements in financial market infrastructure, the ledger's scope would need to be expanded greatly to recognize full efficiency.[52] Project Jasper-Ubin is a joint endeavor between the Bank of Canada and the Monetary Authority of Singapore linking their projects, built on two different DLT networks, using Hashed Time-Lock Contracts. The project, in partnership with Accenture and JP Morgan, conducted a successful cross-border and cross-currency payment using two different DLT platforms.[53] Project Jasper-Ubin noted several areas for improvement in the use of DLT for cross-border transactions.[54] The project notes network scalability as a challenge. In a scenario with hundreds to thousands of participants on each network, alternative models may need to be used, such as using gateway nodes for participants or using an additional DLT to establish connections between the networks.[55]

France. France is examining DLT to enhance the efficiency of wholesale clearing. The Banque de France, in 2017, was the first central bank to develop a decentralized register based on the MADRE blockchain register.[56] Later in 2018, the scope of the project was limited to decentralizing the Creditor Identifier allocation mechanism by "involving banks in verifying the conditions to be met by the creditor and in maintaining the register including these identifiers."[57] This mechanism makes it possible for the Banque de France to certify the origin of direct debit requests.[58] Outside of the MADRE register, the Banque de France suggests that a further step

towards innovation would be to issue a CBDC that uses DLT to support wholesale clearing and settlement.[59]

Brazil. The Central Bank of Brazil conducted a program to investigate potential use cases for DLT.[60] The Bank identified four applications for further investigation: Identity Management Systems, Local Currency Payment Systems, the Agreement on Reciprocal Payments and Credits, and the Alternative System for Transactions Settlement.[61] Through its research, the Central Bank of Brazil concluded that although DLT has potential to bring benefits in many cases, the technology is not appropriate for some uses unless adequate privacy can be guaranteed.[62] Ultimately, Brazil partnered with Ubitquity, a U.S. based company, to create a system in which DLT is used to improve accuracy, security, and transparency of land records.[63]

Switzerland. The Swiss government has enacted cryptocurrency friendly legislation and regulations, earning Switzerland's canton of Zug the nickname "crypto valley."[64] Presently, the Swiss Federal Council is aiming to increase legal certainty surrounding DLT. Legal certainty and transparent regulation can help provide clarity in the financial services industry[65]; clarity may underpin financial inclusion by addressing relevant risks, protecting consumers, and fostering innovation and competition.[66] The Federal Department of Finance, the Swiss Financial Market Supervisory Authority, and the Federal Office of Justice created the prerequisites for examining the legal framework, aiming to ensure technology-neutral regulations.[67] The Swiss DLT Act includes the regulation of crypto assets in the event of bankruptcy; the creation DLT trading venues; and the introduction of Uncertificated Register Securities, which provides for the tokenization and transfer of rights. On February 1, 2021, the parts of the DLT-act that amend the Swiss Code of Obligations, the Federal Intermediated Securities Act, and the Federal Act on International Private Law entered into force.[68] These provisions include the introduction of Uncertificated Register Securities.[69] The remaining provisions will likely enter into force on August 1, 2021.[70]

IV.   How Digital Currencies Can Advance Financial Inclusion

This Part focuses on digital currency. First, it explains why non-fiat digital currencies have had a limited impact on financial inclusion to date. Second, it considers how central bank digital currencies, whether designed using DLT or other ledger technologies, may be more effective in promoting financial inclusion. Finally, it outlines pilot projects at several central banks around the world.

A. NON-FIAT DLT-BASED DIGITAL CURRENCIES

Non-fiat, DLT-based digital currencies such as Bitcoin, Ethereum, Ripple, Bitcoin Cash, and Litecoin[71] are often promoted as a way to reduce the population of unbanked and underbanked individuals.[72] These currencies even have been used for

20

microfinance loans.[73] However, there are several significant barriers that limit their ability to include marginalized groups. As an initial matter, digital currencies require access to technology and generally require stable access to the internet, and lack of such access is a common problem for low-income and marginalized segments of the population.[74] Furthermore, non-fiat digital currencies are often un- or under-regulated, fluctuate significantly in value, and pose a variety of consumer protection risks.[75] Many people are reluctant to use non-fiat currency for these reasons[76] and because non-fiat digital currencies are not backed by any government.[77]

Moreover, the espoused competitive advantage enjoyed by these currencies is eroding as countries increase their monitoring and enforcement in order to reduce illicit activity.[78] These efforts are already raising the costs of using these services. For example, within the United States, anti-money laundering laws require cryptocurrency exchanges and digital wallet providers to keep and share customer data with institutions on the receiving end of digital funds transfers.[79] The decentralized nature of cryptocurrencies makes compliance with these laws a time-consuming, technically difficult and costly endeavor.[80] One downstream effect may be to drive consumers away from digital currencies rather than to expand their use and bolster financial inclusion.

B. CENTRAL BANK DIGITAL CURRENCY

There are two main ways to design a CBDC:[81] (1) as a token that functions like traditional paper currency and can pass peer-to-peer without going through a central bank clearing system, and (2) as an account that functions like a traditional bank account and that provides traditional benefits such as fraud protection and customer service.[82] In the account-based model, individuals hold their balances as accounts with the central bank. This model is not like paper currency, where the instrument can anonymously circulate peer-to-peer, but rather is a deposit-transfer system, where transactions are recorded as new entries on a centralized ledger. In this model, the account owner can request a transfer of funds to another account owner. The central bank would settle the transaction by updating its central ledger.[83] As noted above, key consumer-facing functions can be delegated to banks or other financial service providers so that central banks do not need to take on retail duties for which they are not expert and lack the necessary infrastructure. In such a model, however, difficult questions would arise as to whether the bank pricing for such retail services would end up re-introducing barriers to financial services for the poor.

CBDCs have several notable features. First, CBDCs could allow for faster and cheaper payments, when compared to traditional bank account wires, and facilitate more efficient clearing operations on a domestic and cross-border scale.[84] Two attributes allow for this streamlining of operations. First, transactions can be recorded on the central bank's ledger itself instead of using a third-party actor to complete payments. Experts argue this diminishes reliance on decentralized

20

encryption technologies, which can slow down the entire payments system.[85] Second, CBDC is also more difficult to counterfeit than paper notes.[86] CBDC may also be able to advance financial inclusion and consumer protection.[87] These advantages are derived, first, from the cost-savings that arise from the use of CBDC.[88] Because CBDC can lower the cost of accessing one's funds, financial service providers could see lower expenses related to operations, bookkeeping, and cash distribution.[89] This in turn may mean lower fees passed onto consumers themselves.[90] Second, CBDC may reduce liquidity risks as compared with checks.[91] In contrast to the multi-day delays associated with check payments, CBDC transfers can happen immediately.[92]

Proponents of private digital currency argue that CBDC is not likely to be issued anonymously, and that central banks will likely clear the transactions or have access to the data on such clearing.[93] The potential absence of anonymity in payments has been widely cited as a policy concern by those who favor cash or non-fiat, private digital currency.[94] Others are concerned that moving to a cashless society will exacerbate financial exclusion. For example, the United Kingdom has determined that they are not ready to go fully cashless because of financial inclusion concerns, though promulgating a CBDC does not necessarily mean going cashless.[95] Others warn that CBDCs may risk exacerbating both digital inequality and financial exclusion among those already socioeconomically excluded given the digital divide.[96]

Nonetheless, retail CBDC may be more likely to improve financial inclusion than private digital alternatives.[97] A retail CBDC could encourage consumers to trust mobile financial services, expanding the impact these services have on the underserved and unbanked.[98] Further, retail CBDCs may improve payment efficiency and interoperability.[99] Emerging market economies value domestic payment efficiency and financial inclusion and are seemingly more willing to pilot CBDCs.[100] Emerging markets also have less friction in implementing CBDC because they are less encumbered by a legacy payments infrastructure.[101]

C. ONGOING CBDC PLANS AND PILOTS

At least forty central banks around the world are engaged in CBDC work. Over thirty are researching both wholesale and retail systems. And many have started pilot projects.[102] This Section reviews assessments commissioned by Sweden, Canada, Uruguay, Switzerland, the European Union, and the U.K; efforts underway in China and Cambodia to implement a fully functional CBDC and wallet;[103] and proposals in the United States for a U.S. digital dollar.

Cambodia. Cambodia began testing a CBDC in 2019 in order to reduce the often-crippling remittance fees many Cambodians incur when sending and receiving money from other countries.[104] Cambodia piloted the Bakong Project, which facilitates money transfer while enhancing financial inclusion.[105] The CBDC went live on

20

October 28, 2020.[106] Bakong utilizes blockchain to facilitate peer-to-peer transactions across customers at participating banks.[107] The platform acts as a digital wallet, and can support transactions in the dollar or the Cambodian riel.[108]

Canada. Canada is treating CBDC as a "contingency plan."[109] In February 2020, the government noted that a CBDC would only be "beneficial or even necessary" if physical cash dried up to the point where Canadians could no longer use it for a wide range of transactions, or if alternative digital currencies became more widely used than the Canadian dollar.[110] Nonetheless, Canada has been active in exploring the potential for CBDC. In May 2019, the Bank of Canada and the Monetary Authority of Singapore conducted a successful cross-border payment using their respective DLT-based payment networks: Project Jasper and Project Ubin.[111] This transfer is significant because it showcased the possibility of transferring CBDCs over two different DLT platforms.[112] The transfer could encourage faster and cheaper international payments.[113]

China. The People's Bank of China (PBOC), the Chinese central bank, has been developing the Digital Renminbi (also known as "DCEP") since 2014.[114] The PBOC is now piloting DCEP in five major cities[115] and collaborating with several large Chinese corporations to test the currency.[116] Corporate partners include Didi Chuxing (a ride sharing service) and Meituan Dianping (China's largest wholesale shopping platform).[117] Industry sources have suggested that DCEP's development was accelerated by COVID-19.[118] Public comments by PBOC officials have revealed some details about DCEP. The system is reportedly not based on blockchain technology and relies on a centralized two-tiered issuance structure from the central bank to financial institutions.[119] DCEP is issued and redeemed via commercial banks and third-party payment companies such as Alibaba, although users can transfer DCEP without bank accounts, using compatible digital wallets such as AliPay and WeChat Pay. DCEP is designed to be an alternative to cash for small payments. Finally, DCEP transactions are not anonymous; the PBOC has a record of user identities and activity.[120]

European Union. The European Central Bank's ("ECB") Governing Council announced their intention to advance work on the possible issuance of a digital euro in October 2020.[121] The ECB's motivations for developing the digital euro are protecting accessibility and safeguarding the Eurosystem from foreign digital money or the decline of cash.[122] The digital euro would be introduced alongside cash and would be accessible to individuals and institutions for retail payments.[123] The ECB has not yet committed to any technical form for the digital euro but recognizes that it has a duty to balance compliance, accessibility, robustness, safety, efficiency, and privacy.[124]

Sweden. Sweden's central bank, the Riksbank, is pursuing CBDC to address a 50 percent decline in the use of cash since 2007.[125] If cash continues to disappear, businesses may become even less incentivized to accept it, as accepting cash often

generates increased costs.[126] A cashless society may exclude marginalized groups from the financial system, including the elderly, people with disabilities, and people who do not have access to alternate payment instruments.[127] In order to address this problem, the Riksbank has begun piloting the e-krona project. The bank released its first report in September 2017. The e-krona will likely take the form of a value-based token, as the Riksbank believes it does not have a clear mandate to issue an account-based e-krona.[128] Sweden's next step is to develop a technical design.[129] In 2020, the Riksbank announced a pilot project to test a technical solution that is based on DLT.[130] The Riksbank has hired an outside technology firm for the currency.[131]

Switzerland. The Swiss government, by contrast, has concluded that a Swiss CBDC would threaten financial stability.[132] While CBDCs have been lauded for their potential to improve payments and reduce financial crime, the Swiss government has cast doubt on whether CBDC can meet these expectations. Switzerland is not currently pursuing a retail or general purpose CBDC; however, it has not completely ruled out a wholesale CBDC confined for use among financial institutions to enhance trading and payment efficiency.[133]

United Kingdom. The United Kingdom has been vocal about maintaining the use of cash.[134] If CBDC were to be introduced, U.K. authorities say it would be as a complement, rather than a substitute, for cash and commercial bank deposits.[135] The Bank of England has not decided on whether to pursue CBDC,[136] but Bank of England former Governor Mark Carney, an advocate of CBDCs generally, argued policy makers should work to replace the U.S. dollar with a digital global reserve currency. According to Carney, a digital reserve currency could enhance financial stability.[137]

Uruguay. The Central Bank of Uruguay has completed a pilot program on a general purpose CBDC called the "e-peso" as a part of a wider financial inclusion program. The program ran for six months and was mainly used by affiliated merchants and for peer-to-peer transfers.[138] The system allowed for instant settlement and did not require internet connection.[139] The e-peso trial was considered a success: there were no technical issues, and the number of participating businesses and interested banks grew over time.[140] At the conclusion of the trial in April 2018, the Central Bank of Uruguay called for other central banks to embrace technology and promote financial inclusion in cooperation with the private sector.[141]

United States. In the United States, there is a non-governmental effort underway to promote a token-based digital dollar. This effort is spearheaded by a partnership between the Digital Dollar Foundation and Accenture, known as the "Digital Dollar Project."[142] The Project's proposed digital dollar would take a tokenized form and exist alongside fiat paper money and the banking system. Its touted benefits include the possibility of using digital payments in cross-border securities settlement; facilitating widespread institutional access to large value payments; reducing fraud

and counterparty risk; diversifying payment rails used for retail purchases; and expanding access to financial services for under- and unbanked populations.[143]

Account-based CBDC is also gaining traction. In March 2020, Senator Sherrod Brown sponsored[144] the Banking for All Act and pressed (unsuccessfully) to include the bill as part of the pandemic relief package known as the CARES Act.[145] The bill would permit U.S. citizens, residents, and domiciled businesses to create digital dollar wallets through the Federal Reserve.[146] These digital wallets would be called "FedAccounts."[147] Retail services for FedAccounts would initially be provided by existing banks and ultimately by the U.S. Postal Service and Federal Reserve.[148] The federal government would provide all Americans with the option to receive relief payments through FedAccounts[149]—not unlike the existing Treasury Direct framework through which unbanked individuals can receive social security benefits on a prepaid debit card.[150] The goal is to streamline the process through which individuals without bank accounts can receive emergency assistance.[151] One of the advantages of FedAccounts as envisioned in the legislation is its built-in consumer protections. FedAccounts would have no account fees, and no minimum account balances. FedAccounts also would provide customers with "reasonable protection" against data breaches that lead to fraud.[152] Critics are concerned that FedAccounts would displace the private banking system, reducing financial intermediation and destabilizing the financial system, while offering inferior customer service.

In June 2020, when asked about the Digital Dollar Project, Federal Reserve Chair Jerome Powell commented that digital currencies should be within the purview of the central bank, not private entities.[153] In August 2020, Fed Governor Lael Brainard elaborated that the central bank was actively researching DLT and the potential uses of CBDC.[154] Governor Brainard announced that the Fed had partnered with the Massachusetts Institute of Technology to build and test a possible digital dollar.[155] Governor Brainard noted that the purpose of this testing was to "inform [the Fed's] understanding of private sector arrangements," while simultaneously flagging that a broad set of stakeholders must be engaged before the Fed issues a CBDC.[156] Treasury Secretary Janet Yellen has signaled an interest in the digital dollar, concluding that "too many Americans don't have access to easy payments systems and banking accounts… [T]his is something that a digital dollar, a central bank digital currency, could help with."[157] It is unclear what direction the Federal Reserve plans to take.

V.   Conclusion

DLT and CBDC may offer ways to assist central banks in enhancing financial inclusion by improving payment systems, providing for identity validation, and lowering the costs of KYC compliance and remittances. CBDCs could expand access to financial services and reduce dependency on cash. Yet DLT and CBDC are not panaceas, and it is far from assured that such policy solutions will foster financial inclusion. In fact, some commentators have characterized digital currencies as "a

technocratic solution that cannot solve the underlying causes of financial exclusion."[158] If implemented incorrectly, digital currency could actually aggravate existing inequalities.[159] For example, a CBDC is unlikely to assist individuals without access to the internet or smartphones.[160] Nor will it help unbanked individuals who do not possess the necessary identification to meet KYC requirements.[161] And engaging with the technology requires a base level of financial and digital literacy that many individuals may not possess.[162] These barriers must be addressed before CBDCs can reach their full potential for low-income, unbanked households.

CBDCs and DLT also raise other questions: Will distributed systems be interoperable with existing payment systems?[163] Can DLT be scaled more quickly than other potential payment innovations to advance financial inclusion? Can a CBDC achieve a desirable balance between privacy, security, and blocking use of the financial system for money laundering, terrorist financing, and other illicit activities? Will digitized currency include vulnerable populations? Should central banks issue CBDC directly to households? What would the effects be on the financial system in terms of disintermediation, credit allocation and availability, and financial stability? These are among the important questions that must be explored further to determine the use and value of DLT and digital currency for the central bank of the future.

Appendix A
Glossary of Terms

Central Bank Digital Currency (CBDC) is a form of money issued by a central bank intended to serve as legal tender.[164] CBDC takes two forms: wholesale, which is used to settle transactions between institutional actors, and retail or general purpose, which is available to individuals. Unlike central bank reserves, a form of wholesale CBDC that is available only to select institutions, usually insured depository institutions, retail CBDC would be available to nondepository businesses and ordinary citizens.[165] Retail CBDCs can be account or token based, and the verification of transactions can be centralized or decentralized, depending on the technology used to create the currency.[166]

Consensus mechanism is "a method of authenticating and validating a value or transaction on a blockchain or a distributed ledger without the need to trust or rely on a central authority."[167] While consensus mechanisms vary in each distributed ledger depending on its design, the purpose remains the same: to determine whether a transaction is legitimate or not.[168] Consensus is also important to avoid conflicting entries, ensuring correct sequencing of entries, and preventing take-overs of the DLT by bad actors.

Cryptography enhances the safety of the network. Encryption is designed to eliminate false entries[169] and verify the identity of parties who add information to the ledger.[170]

Digital currency is a blanket term describing forms of money that are recorded and exchanged electronically, including cryptocurrency.[171] Both fiat currencies and non-fiat currencies can be digital.[172] (Fiat currency is currency issued by a government that is not convertible into any commodity or other thing of value.[173] It derives its value from a number of sources, chief among them the strength and stability of the issuing government[174] and monetary and fiscal policies which assure the public that fiat currency will be accepted for tax payments.[175]) For example, bank account balances are a type of digital currency. When digital currency is issued by the central bank, the resulting instrument is a digital form of fiat currency, or a Central Bank Digital Currency ("CBDC").[176]

Contemporary examples of non-fiat currencies include Bitcoin, Ethereum, Ripple, Bitcoin Cash, and Litecoin.[177] These "virtual currencies" are a type of digital currency. They are "a digital representation of value, not issued by a central bank, a credit institution, or e-money institution, which in some circumstances can be used as an alternative to money."[178] There are several important differences between standard, physical currencies and virtual currencies as they exist today. Virtual currency is not currency from a legal perspective:[179] it is not a liability of a central

bank,[180] nor is it typically regulated as currency by governments.[181] In most cases, an algorithm determines supply, unlike fiat currency in which supply is determined by governmental authorities.[182] Virtual currency tends to involve few (if any) consumer protections.[183] And virtual currencies are generally not very good moneys: Their value is unstable, and they are used as a payment method only among certain members of narrow virtual communities.

Distributed Ledger Technology (DLT) is a decentralized way of recording and sharing data.[184] A distributed ledger is an agreed-upon record of digital data spread across multiple entities.[185] DLTs have three essential features: a ledger stored in multiple locations, a consensus mechanism,[186] and cryptographic security.[187] Before DLT, recordkeeping was a centralized process that required trust in a central party.[188] DLT reduces the need for such a central party and in some cases eliminates the central party entirely.

Types of Distributed Ledger Technologies:
  (1) **Permissionless ledgers** are open to everyone, and control over recordkeeping lies with all participants. No single entity can approve an entry to the ledger; rather, the entry must be approved by consensus.[189]
  (2) **Permissioned, *public* DLTs** allow any entity to read the ledger, but only allow trusted entities to add to it or validate entries.
  (3) **Permissioned, *private* DLTs** restrict access for reading, adding to, or validating the ledger entries to trusted entities in the system, rather than by all actors, as in open or permissionless systems.[190]

References

[1] World Bank Group. (2017). *Distributed Ledger Technology (DLT) and Blockchain* (FinTech Note No. 1). Retrieved from http://documents.worldbank.org/curated/en/177911513714062215/pdf/122140-WP-PUBLIC-Distributed-Ledger-Technology-and-Blockchain-Fintech-Notes.pdf

[2] Del Río, C. A. (2017). Use of distributed ledger technology by central banks: A review (Uso de la tecnología de contabilidad distribuida por los bancos centrales: Una revisión). *Enfoque UTE, 8*(5), 1–13. Retrieved from http://scielo.senescyt.gob.ec/pdf/enfoqueute/v8n5/1390-6542-enfoqueute-8-05-00001.pdf

[3] World Bank Group, *supra*.

[4] Committee on Payments and Markets Infrastructure, & Markets Committee. (2018, March). *Central bank digital currencies*. Retrieved from https://www.bis.org/cpmi/publ/d174.pdf

[5] Bacon, J., Michels, J. D., Millard, C., & Singh, J. (2018). Blockchain Demystified: A Technical and Legal Introduction to Distributed and Centralized Ledgers. *Richmond Journal of Law & Technology, 25*(1), 1–106. Retrieved from https://jolt.richmond.edu/files/2018/11/Michelsetal-Final-1.pdf

[6] ITU-T Focus Group Digital Financial Services, & Perlman, L. (2017, March). *Distributed Ledger Technologies and Financial Inclusion* (FG-DFS). Retrieved from https://www.itu.int/en/ITU-T/focusgroups/dfs/Documents/201703/ITU_FGDFS_Report-on-DLT-and-Financial-Inclusion.pdf

[7] *Id.*

[8] *Id.*

[9] *Id.*

[10] World Economic Forum, & Lannquist, A. (2019, March). *Central Banks and Distributed Ledger Technology* . Retrieved from http://www.weforum.org/docs/WEF_Central_Bank_Activity_in_Blockchain_DLT.pdf

[11] KPMG, Seibold, S., & Samman, G. (2016). *Consensus: Immutable agreement for the Internet of value*. Retrieved from https://assets.kpmg/content/dam/kpmg/pdf/2016/06/kpmg-blockchain-consensus-mechanism.pdf?utm_content=buffer84bc3&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer. "Consensus Mechanism" has been described in a variety of ways. *See, e.g.,* Policy Department for Economic, Scientific and Quality of Life Policies, Houben, R., & Snyers, A. (2018, July). *Cryptocurrencies and blockchain: Legal context and implications for financial crime, money laundering and tax evasion*. Retrieved from https://www.europarl.europa.eu/cmsdata/150761/TAX3%20Study%20on%20cryptocurrencies%20and%20blockchain.pdf ("a predefined specific cryptographic validation method that ensures a correct sequencing of transactions on the blockchain.")

[12] World Economic Forum & Lannquist A., *supra*. (Corda, Hyperledger Fabric, Quorum, and Ethereum are the most popular implementations of permissioned blockchain network implementations used by Central Banks.)

[13] Dentons, & Molino, T. (2018, July 11). The practical uses of distributed ledger technology. Retrieved June 4, 2020, from https://www.dentons.com/en/insights/articles/2018/july/11/the-practical-uses-of-distributed-ledger-technology

[14] World Bank Group, *supra*.

[15] He, D., Habermeier, K., Leckow, R., Haksar, V., Almeida, Y., Kashima, M., … Verdugo-Yepes, C. (2016, January). *Virtual Currencies and Beyond: Initial Considerations* (SDN/16/03). Retrieved from https://www.imf.org/external/pubs/ft/sdn/2016/sdn1603.pdf

[16] Federal Reserve Board. (2019, December 18). *Speech by Governor Brainard on update on digital currencies, stablecoins, and the challenges ahead* [Press release]. Retrieved June 4, 2020, from https://www.federalreserve.gov/newsevents/speech/brainard20191218a.htm

[17] Goldberg, D. (2005, October). *Famous Myths of "Fiat Money". Journal of Money, Credit and Banking*, *35*(5), 957-967. Retrieved July 14, 2020, from https://www-jstor-org.proxy.lib.umich.edu/stable/pdf/3839155.pdf?refreqid=excelsior%3Ab207fe59c3c2c8cb76fb4b4eb92ef215

[18] Investopedia. (2019, April 20). *Fiat vs. Representative Money: What's the Difference?* https://www.investopedia.com/ask/answers/041615/what-difference-between-fiat-money-and-representative-money.asp

[19] Goldberg, D. (2012). The tax-foundation theory of fiat money. *Economic Theory, 50*(2), 489-497. Retrieved July 14, 2020, from www.jstor.org/stable/41486019

[20] World Bank Group, *supra.*

[21] Mancini Griffoli, T., Soledad Martinez Peria, M., Agur, I., Ari, A., Kiff, J., Popescu, A., & Rochon, C. (2018, November). *Casting Light on Central Bank Digital Currencies*. Retrieved from https://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2018/11/13/Casting-Light-on-Central-Bank-Digital-Currencies-46233

[22] *Id.*

[23] Nabilou, H. (2019, February). Central Bank Digital Currencies: Preliminary Legal Observations. *Journal of Banking Regulation*, 1–30. Retrieved from https://ssrn.com/abstract=3329993.

[24] Mancini Griffoli et al., *supra.*

[25] Deloitte, Lichtfous, M., Yadav, V., & Fratino, V. (2018, November). *Can blockchain accelerate financial inclusion globally?* Retrieved from https://www.deloitte.com/content/dam/Deloitte/lu/Documents/technology/lu-blockchain-accelerate-financial-inclusion.pdf

[26] Dentons & Molino, *supra.*

[27] World Bank Group, *supra.*

[28] ITU-T Focus Group Digital Financial Services & Perlman, *supra.*

[29] *Id.*

[30] Business Wire (2019, October). *Accenture and SAP Build Prototype that Uses Distributed Ledger Technology to Enable More Efficient, Secure and Reliable Payments Between Banks and Customers.* Retrieved from https://www.businesswire.com/news/home/20191024005169/en/Accenture-and-SAP®-Build-Prototype-that-Uses-Distributed-Ledger-Technology-to-Enable-More-Efficient%C2%A0Secure-and-Reliable-Payments-Between-Banks-and-Customers.

[31] Lannquist, A. (2019, April 3). 10 ways central banks are experimenting with blockchain. Retrieved June 4, 2020, from https://www.weforum.org/agenda/2019/04/blockchain-distrubuted-ledger-technology-central-banks-10-ways-research/

[32] Easen, E. (2018, September). *Can blockchain ease global payments?* Retrieved November 9, 2020, from https://www.raconteur.net/finance/payments/dlt-blockchain-global-payments/

[33] Deloitte, Lichtfous, Yadav & Fratino, *supra.*

[34] Central Bank of Brazil, de Vilaca Burgos, A., de Oliveira Filho, J. D., Vinicius Cursino Suares, M., & Sarres de Almeida, R. (2017, August). *Distributed ledger technical research in Central Bank of Brazil* (Positioning Report). Retrieved from https://www.bcb.gov.br/content/publicacoes/outras_pub_alfa/Distributed_ledger_technical_research_in_Central_Bank_of_Brazil.pdf; India's Aadhaar system, while not based on DLT, showcases some benefits of a widespread identity management system, like the delivery of social welfare. Gstrein, O., and Kochenov, D. (2020, March 12). *Digital Identity and Distributed Ledger Technology: Paving the Way to a Neo-Feudal Brave New World?* Retrieved from https://www.frontiersin.org/articles/10.3389/fbloc.2020.00010/full

---

35 *Id.*

36 *Id.*

37 Deloitte, Lichtfous, Yadav & Fratino, *supra.*

38 India's centralized Aadhaar system showcases some benefits of a widespread identity management system, like the delivery of social welfare. *See* Masiero, S. (2018, September). *Explaining Trust in Large Biometric Infrastructures: A Critical Realist Case Study of India's Aadhaar Project.* Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1002/isd2.12053

39 Blockchain Commission, (2018). *The Future is Decentralized: Block Chains, Distributed Ledgers & The Future of Sustainable Development (Volume 1).* Retrieved from https://www.slideshare.net/SergioFernndezdeCrdo/the-future-is-decentralized-block-chains-distributed-ledgers-the-future-of-sustainable-development-volume-1

40 *Id.*

41 ARMA Canada Region, Lemieux, V. L., Hofman, D., Batista D., Joo, A., (2019, May). *Blockchain Technology and Recordkeeping.* Retrieved from http://armaedfoundation.org/wp-content/uploads/2019/06/AIEF-Research-Paper-Blockchain-Technology-Recordkeeping.pdf

42 BIS Monetary and Economic Department, & Auer, R. (2019, September). *Embedded supervision: how to build regulation into blockchain finance* (BIS Working Papers No. 811). Retrieved from https://www.bis.org/publ/work811.pdf

43 *Id.* Further, machine learning has the potential to enhance compliance and financial stability. For a discussion on the use of machine learning in compliance and supervision, see Financial Stability Board, (2017, November). *Artificial intelligence and machine learning in financial services.* Retrieved from https://www.fsb.org/wp-content/uploads/P011117.pdf

44 *Id.*

45 Deloitte (2018). *Inclusion through distribution: How blockchain supports financial inclusion.* Retrieved from https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/financial-services/deloitte-cn-fs-inclusion-through-distribution-en-181220.pdf

46 Deloitte (2020). *The changing paradigm of distributed ledger technologies: The social impacts of financing opportunities, risk, and financial inclusion.* Retrieved from https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology/2020-gbcs-ip-bcm.pdf

47 Wood, B. M. (2019, October 16). Canada exploring consumer CBDC to replace cash. Retrieved June 4, 2020, from https://www.ledgerinsights.com/canada-exploring-consumer-cbdc/

48 Payments Canada. (2018, September 10). Project Jasper. Retrieved June 4, 2020, from https://www.payments.ca/industry-info/our-research/project-jasper

49 Bank of Canada, *Digital Currencies and Fintech: Projects.* Available at https://www.bankofcanada.ca/research/digital-currencies-and-fintech/projects/#project-jasper

50 Bank of Canada, Accenture, Payments Canada, r3, & TMX. (2018, October). *Jasper Phase III: Securities Settlement Using Distributed Ledger Technology.* Retrieved from https://www.payments.ca/sites/default/files/jasper_phase_iii_whitepaper_final_0.pdf

51 Clay, M. (2018, November). *Bank of Canada Proves Blockchain Can Settle Equities in Project Jasper Phase III.* Retrieved from https://news.coinsquare.com/government/bank-of-canada-proves-blockchain-can-settle-equities-in-project-jasper-phase-iii/

52 Bank of Canada, Accenture, Payments Canada, r3, & TMX, *supra.*

53 Accenture & Gan, J. (2019, June 10). *A new frontier in payments.* Retrieved from https://www.accenture.com/us-en/insights/banking/pushing-payments-forward

54 Bank of Canada & Monetary Authority of Singapore (2019). *Jasper-Ubin Design Paper: Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies.* Retrieved from https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf

55 *Id.*

[56] Beau, D. (2019, November 22). *Denis Beau: What policy framework to help building innovation and growth into Europe's capital market?* [Press release]. Retrieved June 4, 2020, from https://www.bis.org/review/r191122c.htm

[57] Quiniou, M. (2019). *Blockchain*. Hoboken, NJ, United States: Wiley.

[58] *Id.*

[59] Beau, *supra.*

[60] Central Bank of Brazil, de Vilaca Burgos, de Oliveira Filho, Vinicius Cursino Suares & Sarres de Almeida, *supra.*

[61] *Id.*

[62] *Id.*

[63] Flores, D., Lacombe, C., Lemieux, V., (2018, January). Real Estate Transaction Recording in the Blockchain in Brazil- Case Study 1. Retrieved November 9, 2020, from https://www.researchgate.net/publication/322665512

[64] Simpson, I. (2017, October 7). ICO Central: Why Switzerland Will Remain Crypto Valley. Retrieved June 4, 2020, from https://www.coindesk.com/ico-central-switzerland-will-remain-crypto-valley

[65] Team Ripple (2020, August 19). *How Does DLT Engender Greater Financial Inclusion?* Retrieved from https://ripple.com/insights/how-does-dlt-engender-greater-financial-inclusion/

[66] BIS Committee on Payments and Market Infrastructure (2016, April). *Payment aspects of financial inclusion.* Retrieved from https://www.bis.org/cpmi/publ/d144.pdf

[67] Federal Department of Finance FDF. (2018, March 20). *G20 meeting of finance ministers in Argentina: challenge of digitisation* [Press release]. Retrieved June 4, 2020, from https://www.efd.admin.ch/efd/en/home/dokumentation/nsb-news_list.msg-id-70165.html

[68] Balzli, T. (2021, February 1). *Partial Entry into Force of the Swiss DLT-act.* Retrieved from https://www.pwc.ch/en/insights/regulation/partial-entry-swiss-dlt-act.html

[69] *Id.*

[70] *Id.*

[71] European Parliament, *Virtual currencies and central banks monetary policy: challenges ahead* (July 2018) https://www.europarl.europa.eu/cmsdata/149900/CASE_FINAL%20publication.pdf

[72] Magdas, A. (2014, March 17). Cryptocurrencies and Financial Inclusion – Why I Am a Skeptic… For Now at Least | Center for Financial Inclusion. Retrieved June 4, 2020, from https://www.centerforfinancialinclusion.org/cryptocurrencies-and-financial-inclusion-why-i-am-a-skeptic-for-now-at-least

[73] Pinto, A. (2020, March 4). Unbanked to big banks: How crypto facilitates financial inclusion. Retrieved June 4, 2020, from https://www.ibm.com/blogs/blockchain/2019/04/unbanked-to-big-banks-how-crypto-facilitates-financial-inclusion/

[74] OECD/IDB (2016), *Broadband Policies for Latin America and the Caribbean: A Digital Economy Toolkit*, OECD Publishing, Paris, https://doi.org/10.1787/9789264251823-en

[75] Peters, G. W., Panayi, E., & Chapelle, A. (2015, August 19). Trends in crypto-currencies and blockchain technologies: A monetary theory and regulation perspective. Retrieved from https://arxiv.org/pdf/1508.04364.pdf

[76] Magdas, *supra.*

[77] Other reasons consumers shy away from non-fiat digital currencies include consumer data privacy concerns; the "knowledge gap," where risk averse individuals and those uncomfortable using new technologies are deterred from using this form of currency; the limited areas of the global marketplace where these currencies are currently accepted as payment; and the irreversible nature of the transactions. *See Id.*

[78] *Id.*

20

79 Broughton, K. (2019, June 21). Anti-Money-Laundering Watchdog Calls for Stronger Cryptocurrency Regulations. *Wall Street Journal*. Retrieved August 2, 2020, from https://www.wsj.com/articles/anti-money-laundering-watchdog-calls-for-stronger-cryptocurrency-regulations-11561155841?mod=article_inline

80 Broughton, K. (2019, September 16). Crypto Firms Assess How to Comply with Anti-Money-Laundering Standards. *Wall Street Journal*. Retrieved August 2, 2020, from https://www.wsj.com/articles/crypto-firms-assess-how-to-comply-with-anti-money-laundering-standards-11568626200

81 Mancini Griffoli et al., *supra*.

82 Nabilou, *supra*, at 1-30.

83 Mancini Griffoli et al., *supra*.

84 Ye, C. (2019, December 13). The current landscape of central bank digital currencies. Retrieved June 4, 2020, from https://www.brookings.edu/blog/techtank/2019/12/13/the-current-landscape-of-central-bank-digital-currencies/

85 Calabia, F. C. (2020, July). Could the Poor Bank on Stablecoins? *Bill and Melinda Gates Foundation*, 9. Retrieved August 2, 2020, from https://www.findevgateway.org/sites/default/files/publications/submissions/72141/Calabia_Could_the_Poor_Bank_on_Stablecoins_20200721_Final.pdf.

86 Ye, *supra*.

87 Lagarde, C. (2018, November 13). *Winds of Change: The Case for New Digital Currency* [Press release]. Retrieved June 5, 2020, from https://www.imf.org/en/News/Articles/2018/11/13/sp111418-winds-of-change-the-case-for-new-digital-currency. The use of CBDCs to facilitate privacy is not widely accepted. Rather, most institutions acknowledge that many forms of CBDCs would reduce consumer privacy. Borio, C., & Song Shin, H. (2019, March 5). *BIS Quarterly Review, March 2019* [Press release]. Retrieved June 5, 2020, from https://www.bis.org/publ/qtrpdf/r_qt1903.htm

88 Cooper, B., Esser, A., & Allen, M. (2019, June). The use cases of central bank digital currency for financial inclusion: A case for mobile money. Retrieved from https://www.cenfri.org

89 *Id.*

90 *Id.*

91 *Id.*

92 *Id.*

93 White, L. H. (2019, February 12). Efficient "Central Bank Digital Currency" Is a Fantasy. Retrieved June 4, 2020, from https://www.cato.org/blog/efficient-central-bank-digital-currency-fantasy

94 Mancini Griffoli et al., *supra*.

95 Institute and Faculty of Actuaries, Achord, S., Chan, J., Collier, I., Nardani, S., & Rochemont, S. (2017, November). *A Cashless Society: Benefits, Risks, and Issues (Interim Paper)*. Retrieved from https://www.actuaries.org.uk/system/files/field/document/A%20Cashless%20Society-%20Benefits%2C%20Risks%20and%20Issues%20%28Interim%20Paper%29%20-%20disclaimer.pdf

96 Cooper, Esser & Allen, *supra*.

97 Monetary and Economic Department, Boar, C., Holden, H., & Wadsworth, A. (2020, January). *Impending arrival - a sequel to the survey on central bank digital currency* (BIS Papers No. 107). Retrieved from https://www.bis.org/publ/bppdf/bispap107.pdf

98 Cooper, Esser & Allen, *supra*.

99 *Id.*

100 Monetary and Economic Department, Boar, Holden, & Wadsworth, *supra*.

101 *Id.*

102 *Id.*

20

[103] Nelson, D. (2020, June 19). Cambodia Plots a Dollar-Free Future with Blockchain-Based Payments: White Paper. *Nasdaq*. Retrieved from https://www.nasdaq.com/articles/cambodia-plots-a-dollar-free-future-with-blockchain-based-payments%3A-white-paper-2020-06-19

[104] Nelson, D. (2019, October 18). *Cambodia's Central Bank Testing Digital Wallet to Ease Cross-Border Payments*. Retrieved June 4, 2020, from https://www.coindesk.com/cambodias-central-bank-testing-digital-wallet-to-ease-cross-border-payments

[105] Chan, S. (2019, July 23). NBC tests new mobile payment app. Retrieved June 4, 2020, from https://www.khmertimeskh.com/626244/nbc-tests-new-mobile-payment-app/

[106] Nelson, D. (2020, October 28). Retrieved from https://www.nasdaq.com/articles/cambodia-central-bank-launches-bakong-blockchain-payments-system-2020-10-28

[107] Bakong. (2020). The Next-Generation Mobile Payments and Banking. Retrieved June 4, 2020, from https://bakong.nbc.org.kh

[108] UNESCAP. (2017, November). *Digital and Virtual Currencies for Sustainable Development*. Retrieved from https://www.unescap.org/resources/digital-and-virtual-currencies-sustainable-development

[109] Bank of Canada. (2020, February 5.) *Contingency Planning for a Central Bank Digital Currency*. Retrieved from https://www.bankofcanada.ca/2020/02/contingency-planning-central-bank-digital-currency/

[110] *Id.*

[111] Monetary Authority of Singapore. (2019, May 2). *Central Banks of Canada and Singapore conduct successful experiment for cross-border payments using Distributed Ledger Technology* [Press release]. Retrieved June 5, 2020, from https://www.mas.gov.sg/news/media-releases/2019/central-banks-of-canada-and-singapore-conduct-successful-experiment-for-cross-border-payments

[112] *Id.*

[113] *Id.*

[114] Yang, Y. (2019, November 25). What is China's digital currency plan? Retrieved June 4, 2020, from https://www.ft.com/content/e3f9c3c2-0aaf-11ea-bb52-34c8d9dc6d84

[115] Cheng, J. (2020, April 20). China Rolls Out Pilot Test of Digital Currency. *Wall Street Journal*. Retrieved August 4, 2020, from https://www.wsj.com/articles/china-rolls-out-pilot-test-of-digital-currency-11587385339

[116] Magas, J. (2020, July 19). Digital Yuan CBDC Momentum Grows as More Chinese Firms Get to Testing. Retrieved August 4, 2020, from https://cointelegraph.com/news/digital-yuan-cbdc-momentum-grows-as-more-chinese-firms-get-to-testing

[117] *Id.*

[118] Shome, A. (2020, April 1). Chinese Central Bank Finishes Basic Development of CBDC. Retrieved June 4, 2020, from https://www.financemagnates.com/cryptocurrency/news/chinese-central-bank-finishes-basic-development-of-cbdc/

[119] Wu, J. (2020, June 23). *Blockchain as an Infrastructure: A Deep Dive into China's DLT Strategy*. Retrieved from https://cointelegraph.com/news/blockchain-as-an-infrastructure-a-deep-dive-into-chinas-dlt-strategy

[120] Yatsui, T. (2020, November). *Implications of China's Digital Yuan Initiative*. Retrieved from https://www.mitsui.com/mgssi/en/report/detail/__icsFiles/afieldfile/2021/01/07/2011c_yatsui_e_1.pdf

[121] European Central Bank. (2020, October). *Report on a digital euro*. Retrieved from https://www.ecb.europa.eu/pub/pdf/other/Report_on_a_digital_euro~4d7268b458.en.pdf

[122] *Id.*

[123] *Id.*

[124] *Id.*

[125] Sveriges Riksbank. (2018, October). *The Riksbank's e-krona project* (Report 2). Retrieved from https://www.riksbank.se/globalassets/media/rapporter/e-krona/2018/the-riksbanks-e-krona-project-report-2.pdf

[126] Sveriges Riksbank. (2017, September). *The Riksbank's e-krona project* (Report 1). Retrieved from https://www.riksbank.se/globalassets/media/rapporter/e-krona/2017/rapport_ekrona_uppdaterad_170920_eng.pdf

[127] *Id.*

[128] *Id.*

[129] Sveriges Riksbank, 2018, *supra.*

[130] Sveriges Riksbank. (2020, February). *The Riksbank to test technical solution for the e-krona.* Retrieved from https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/notices/2020/the-riksbank-to-test-technical-solution-for-the-e-krona/

[131] *Id.*

[132] Palmer, D. (2019, December 13). "New Risks": Swiss Government Skeptical on Central Bank Digital Currency. Retrieved June 4, 2020, from https://www.coindesk.com/new-risks-swiss-government-skeptical-on-central-bank-digital-currency

[133] *Id.*

[134] *See, e.g.,* PYMNTS, (2019, May 3). *Cash is Here to Stay in the UK.* Retrieved from https://www.pymnts.com/news/payment-methods/2019/cash-uk-currency-treasury/

[135] Bank of England. (2020, March). *Central Bank Digital Currency: opportunities, challenges, and design.* Retrieved from https://www.bankofengland.co.uk/-/media/boe/files/paper/2020/central-bank-digital-currency-opportunities-challenges-and-design.pdf?la=en&hash=DFAD18646A77C00772AF1C5B18E63E71F68E4593

[136] *Id.*

[137] Carney, M. (2019, August 23). *The Growing Challenges for Monetary Policy in the current International Monetary and Financial System* [Press release]. Retrieved from https://www.bankofengland.co.uk/media/boe/files/speech/2019/the-growing-challenges-for-monetary-policy-speech-by-mark-carney.pdf?la=en&hash=01A18270247C456901D4043F59D4B79F09B6BFBC

[138] Ponce, J. (2018, June 7). Central Bank Digital Currency: A central banker perspective [Slides]. Retrieved from https://www.bis.org/events/eopix_1810/licandro_pres.pdf

[139] SUERF, Gnan, E., & Masciandaro, D. (2018, February). *Do We Need Central Bank Digital Currency?* Retrieved from https://www.suerf.org/docx/s_cf0d02ec99e61a64137b8a2c3b03e030_7025_suerf.pdf

[140] *Id.*

[141] *Id.*

[142] Digital Dollar Foundation, & Accenture. (2020, May). *The Digital Dollar Project: Exploring a US CBDC.* Retrieved from https://static1.squarespace.com/static/5e16627eb901b656f2c174ca/t/5ecfc542da96fb2d2d5b5f15/1590674759958/Digital-Dollar-Project-Whitepaper_vF.pdf

[143] *Id.*

[144] The BAA was initially introduced by House Democrat Maxine Waters, Chairwoman of the Financial Services Committee. *See* Brett, J. (2020, March 23.) *Coronavirus Stimulus Offered by House Financial Services Committee Creates New Digital Dollar.* Forbes. Retrieved July 14, 2020, from https://www.forbes.com/sites/jasonbrett/2020/03/23/new-coronavirus-stimulus-bill-introduces-digital-dollar-and-digital-dollar-wallets/#65c497834bea

[145] Brett, J. (2020, March 24). *Digital Dollar And Digital Wallet Bill Surfaces In The U.S. Senate.* Forbes. Retrieved July 24, 2020, from https://www.forbes.com/sites/jasonbrett/2020/03/24/digital-dollar-and-digital-wallet-legislation-surfaces-in-the-us-senate/#7b2adf8d3866

[146] JD Supra. *Digital Dollars: Amid the COVID-19 Crisis, Support for a U.S. Digital Currency Emerges*. (2020, March 13). JD Supra. Retrieved July 14, 2020, from https://www.jdsupra.com/legalnews/digital-dollars-amid-the-covid-19-58028/

[147] For the academic paper on which the legislation was based, *see* Ricks, M., Crawford, J., & Menand, L. (2020, July 16). FedAccounts: Digital Dollars. *George Washington Law Review*. Retrieved August 19, 2020, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3192162

[148] JD Supra, *supra*.

[149] Brett, J., March 24, 2020, *supra*.

[150] *TreasuryDirect Factsheet*. (2020, March 26). TreasuryDirect. Retrieved July 14, 2020, from https://www.treasurydirect.gov/news/presskit/presskit_td.htm

[151] Foohey, P., Jiménez, D., Odinet, C. K. *Cares Act Gimmicks: How Not to Give People Money During a Pandemic and What to Do Instead*. (2020, April 11). The National Law Review. Retrieved July 14, 2020, from https://www.natlawreview.com/article/cares-act-gimmicks-how-not-to-give-people-money-during-pandemic-and-what-to-do

[152] JD Supra, *supra*.

[153] De, N. U.S. Fed Chair Says Private Entities Should Not Help Design Central Bank Digital Currencies (2020, June 17). Retrieved August 4, 2020 from https://www.coindesk.com/us-fed-chair-says-private-entities-should-not-help-design-central-bank-digital-currencies.

[154] Brainard, L. (2020, August 13.) An Update on Digital Currencies. *Federal Reserve Board an Federal Reserve Bank of San Francisco's Innovation Office Hours*, 2-3.

[155] *Id.* at 3.

[156] *Id.* at 3-4.

[157] Condon, C. (2021, February 22). *Yellen Signals Interest in Backing Digital-Dollar Research*. Bloomberg. Retrieved from https://www.bloomberg.com/news/articles/2021-02-22/yellen-signals-interest-in-backing-digital-dollar-research

[158] Reghuveera, N. (2020, June 18). *Central bank digital currency can contribute to financial inclusion but cannot solve its root causes*. Atlantic Council. Retrieved July 14, 2020, from https://www.atlanticcouncil.org/blogs/geotech-cues/central-bank-digital-currency-can-contribute-to-financial-inclusion-but-cannot-solve-its-root-causes/

[159] Allen, M. (2020, June 12). *Central bank digital currency (CBDC) and financial inclusion*. Cenfri. Retrieved July 14, 2020, https://cenfri.org/publications/central-bank-digital-currency-cbdc-and-financial-inclusion/

[160] Reghuveera, *supra*.

[161] Calabia, *supra*.

[162] Reghuveera, *supra*.

[163] Haig, S. (2020, March 8). *Central Bank Officials: DLT Can Improve the Global Financial System* [Press release]. Retrieved June 5, 2020, from https://cointelegraph.com/news/central-bank-officials-dlt-can-improve-the-global-financial-system

[164] Mancini Griffoli et al., *supra*.

[165] *Id.*

[166] *Id.*

[167] KPMG, Seibold & Samman, *supra*. "Consensus Mechanism" has been described in a variety of ways. *See, e.g.,* Policy Department for Economic, Scientific and Quality of Life Policies, Houben, R., & Snyers, A. (2018, July). *Cryptocurrencies and blockchain: Legal context and implications for financial crime, money laundering and tax evasion*. Retrieved from https://www.europarl.europa.eu/cmsdata/150761/TAX3%20Study%20on%20cryptocurrencies%20and%20blockchain.pdf ("a predefined specific cryptographic validation method that ensures a correct sequencing of transactions on the blockchain.")

20

[168] R3 & Rutland, E. (2017). *Blockchain Byte*. Retrieved from https://www.finra.org/sites/default/files/2017_BC_Byte.pdf

[169] Dentons & Molino, *supra.*

[170] World Bank Group, *supra.*

[171] He et al., *supra.*

[172] Federal Reserve Board, *supra.*

[173] Goldberg, 2005, *supra.*

[174] Investopedia, *supra.*

[175] Goldberg, 2012, *supra.*

[176] World Bank Group, *supra.*

[177] European Parliament, *supra.*

[178] European Central Bank. (2015, February). *Virtual currency schemes- a further analysis*. Retrieved from https://www.ecb.europa.eu/pub/pdf/other/virtualcurrencyschemesen.pdf; Green, S., Fox, D., & Carr, D. J. (2019). *Cryptocurrencies in Public and Private Law*. Oxford, United Kingdom: Oxford University Press.

[179] Green, S., Fox, D., & Carr, D. J. (2019). *Cryptocurrencies in Public and Private Law*. Oxford, United Kingdom: Oxford University Press

[180] CryptoCurrency Facts. *The Difference Between Fiat Currency and Cryptocurrency*. (2020, March 27). CryptoCurrency Facts. https://cryptocurrencyfacts.com/the-difference-between-fiat-currency-and-cryptocurrency/

[181] Texas State Securities Board. *Fiat v. Virtual Currency*. (2020, January 14). Texas State Securities Board. https://www.ssb.texas.gov/fiat-v-virtual-currency

[182] CryptoCurrency Facts, *supra.*

[183] Texas State Securities Board, *supra.*

[184] World Bank Group, *supra.*

[185] Del Río, C. A, *supra*, at 1-13.

[186] World Economic Forum & Lannquist, *supra.*

[187] World Bank Group, *supra.*

[188] Bacon, Michels, Millard & Singh, *supra*, at 1-106.

[189] ITU-T Focus Group Digital Financial Services & Perlman, *supra.*

[190] *Id.*