The New Money: The utility of Cryptocurrencies and the need for a New Monetary Policy

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Abstract

Since its inception in 2008, cryptocurrencies are gaining adoption globally. Even though its utility may vary, the primary purpose of cryptocurrencies is to provide some form of payment (or medium of exchange) in the digital world. As more use cases arise from the industry, cryptocurrencies and blockchain are no longer a niche topic. Educational institutions are introducing it into their curriculum, and governments are talking about it in parliament. In particular, governments are keen to determine if the underlying technologies can form the fundamentals to issue a Central Bank issued Digital Currency (CBDC). Will these forms of currency become the "New Money"? This paper sets out to explore the utility of cryptocurrencies and CBDC, their implications on the economy and the government's ability to use monetary policy. We examine and compare the approaches to CBDCs suggested by various governments.

Keywords: Central Bank Digital Currency, Cryptocurrency, Payment System, Distributed Ledger Technology, Monetary Policy, DCEP, Libra.

1. Introduction: From digital payments to digital cash

The rise of the Internet, PC, and companies like Amazon and Alibaba for the past 20 years has made e-commerce a part of everyday life. As new technologies emerge, we are entering a digital era with numerous digital footprints and digital payments, playing an increasingly important role. Traditional digital banking and payment technologies have been successful in the past, but perhaps not in the future. These electronic payment systems were dependent on bank deposits, credit cards or stored-value facilities; these payment intermediaries increased the costs and complexity of electronic payments, making it inefficient and expensive.

To support the growing e-commerce sector, make full use of the digital footprints and increase payment efficiency, truly digital cash is in high demand. Digital cash shall serve as the digital replacement of physical cash, meaning that it should fulfil criteria such as to provide a store of value, a unit of account, a medium of exchange, as well as anonymity and transferability to the users, but it is more than that – digital cash should also be able to handle small transactions efficiently. On a technical level, digital cash needs to address the double-spending problem, the risk that it can be spent twice. These criteria are hard to satisfy, and the compromise usually results in high overheads, making the digital payment method inefficient and expensive. Many digital payments methods also do not meet the criteria of anonymity, and most forms of digital payments are traceable.

The invention of Bitcoin in 2008 seems to provide a potential solution, or at least a direction. It is truly peer-to-peer and offers built-in pseudo-anonymity[1]. Decentralisation allows Bitcoin to remove the need to trust centralised middlemen and have no single point of failure. Incentive mechanisms were then incorporated to ensure that the interests of the participating economic agents of Bitcoin are aligned. Most importantly, ensuring transactions are correct and valid. The creation of Bitcoin also pioneered a new category termed "cryptocurrencies".

As the world gets more digital and financial institutions adopting technology to innovate on financial services, cryptocurrencies (and blockchain) are becoming mainstream and widely recognised. While searching for new and sustainable growth areas, governments have included blockchain into various national initiatives. In Kshetri and Voas (2018), the authors explain how the US-based platform for real-estate registration, Bitland, uses a blockchain-based land registry system in Ghana, where 78 per cent of land is unregistered, and how the platform is expected to guarantee property rights and reduce corrupt practices. Geospatial applications involving blockchain can potentially unlock economic values.

[1] Bitcoin is anonymous by design such that owners' identities are unknown to other network users unless they choose to reveal it. However, the patterns of usage or other information may reveal the identity through modern tracing using AI algorithms or via links with third parties.

Similarly, in China, the use of fake export invoices to disguise cross-border capital flows has been pervasive. The government is relying on provenance, traceability, and transparency characteristics of blockchain-based systems to thwart such scandals and assist financial institutions in battles against fraud, money laundering and illegal activities. Governments (such as Kenya in Africa, China in Asia and Argentina in Latin America among many others) have also discussed issuing digital currencies of their own using blockchain technology to facilitate lower cross-border transactions, financial inclusion, reliable and provided end-to-end traceability with smart contracts (Raskin & Yermack, 2018). Could cryptocurrencies or national digital currencies become the "New Money"? Will we see the end of paper money? This paper will explore this topic and discuss the implications on monetary policy and the issuance of Central Bank Digital Currency (CBDC). But first, we start by providing a brief introduction to cryptocurrencies and its economics.

2. Cryptocurrencies

2.1. What are cryptocurrencies?

As the name implies, cryptocurrencies are currencies based on cryptography. Most cryptocurrencies consist of a distributed network of validators where each validator holds a replicated copy of the ledger of transactions. Tokens (or currency) are minted via entries in the ledger, and this can be done with rules embedded in the code for validation (such as Bitcoin mining) or on a one-off or ad-hoc basis. The ledger (or blockchain) is constructed using cryptography to make it almost impossible or very costly to change or reverse entries.

Bitcoin is the first cryptocurrency of such kind and it introduces the idea of blockchain. Features of decentralisation and immutability allow it to be a form of digital cash which can be moved peer-to-peer without an intermediary and will enable it to have no central control. These features also make it different from current digital payments, and many consider it to be the chief ingredient to create the future of the digital (crypto-token[2] and sharing[3]) economy.

Tokens in the Bitcoin network are represented by ledger entries, since there are no physical bitcoins. The token creation mechanism was designed to create a capped money supply (a fixed increase in its amount until the cap is reached). This mechanism is built into the code and cannot be changed without the agreement of a majority of the network. There had been various attempts to change this code and

[2] Token Economy refers to the system of incentives based on cryptocurrencies that reinforce and build desirable behaviours the in blockchain ecosystem.
[3] An economic system in which assets or services are shared between private individuals, either free or for a fee, typically by means of the Internet.

this led to hard forks (derivative currencies) as majority consensus cannot be reached (Atik & Gerro, 2018). There are also instances that offline governance was heavily influenced by core developers that we saw community rolling back to an earlier version of the network voluntarily such as the 2013 Bitcoin fork from version 0.8 back to 0.7 (Narayanan, 2015).

Since the inception of Bitcoin, various forms of cryptocurrencies were introduced[4] - some have differing designs from Bitcoin such as the methods to create the money supply, and some offer alternative technologies that claim to work better. Cryptocurrencies or crypto-tokens can be grouped into five general categories, (1) Transactional, (2) Utility, (3) Platform, (4) Application, (5) Asset-backed.

Transactional cryptocurrencies function like Bitcoin, and their main aim is to provide a form of payment. Newer versions have enhanced privacy features and can scale better than Bitcoin. One such example is Dash[5], a cryptocurrency based on Bitcoin but with built-in privacy functions that include those providing privacy of the transactions with shielded ledgers. Its tamper-proof instant transactions, accompanied by a well incentivised secondary peer-to-peer network, make it a stable medium of exchange (Duffield & Diaz, 2018).

Utility cryptocurrencies are tokens designed to facilitate transactions for custom blockchain networks. These can be purpose-built blockchain networks such as those for supply chain traceability or decentralised finance.

Platform cryptocurrencies facilitate the operations of smart contract enabled blockchains. Such blockchain allows users to create smart contracts that form the basis for decentralised applications.

Application cryptocurrencies are used for decentralised application use cases, which are built on blockchain smart contract platforms.

Asset-backed cryptocurrencies are linked to real-world or virtual assets such as gold, fiat currency or property. These can be used to create a fractionalised investment for assets that may require a large outlay. They can also be used to provide a stable medium of exchange which can then be used for payments.

[4] As of February 2020, around 5000 of such cryptocurrencies exist
[5] Dash is an open source cryptocurrency forked from the Bitcoin protocol and also a decentralized autonomous organization (DAO) run by a subset of its users, which are called "masternodes". Other privacy coins are Zcash (ZEC), Zcoin (XZC), Monero (XMR), TeleCoin (TELE), Incognito (PRV), and PivX(PIVX).

Many investors in the cryptocurrency market buy cryptocurrencies or crypto-tokens not for the functions, but for speculative purpose. One of the notable earliest use cases for issuance of tokens was for fundraising. Projects (usually with a blockchain angle) would issue tokens to investors in return for funds (usually in the form of other cryptocurrencies). These tokens would eventually get listed on a cryptocurrency exchange. These are known as ICOs (Initial Crypto-Token Offerings). The success of such projects depends largely on its perceived value. Being speculative in nature, there were many ICO scams wherein the fundraisers had no intention of bringing the project to fruition. This prompted many governments to impose regulation or even outright banning this form of fundraising. We will discuss more about the economics, finance, and challenges of cryptocurrencies in the following sections.

2.2. The economics and finance of cryptocurrency: Network, Incentives and Markets

Unlike a centralised system where there is one sole authority that decides what is stored in the database, distributed networks are made up of multiple connected computers/digital devices (or nodes) working towards a common goal. In the case of cryptocurrencies such as Bitcoin, the distributed network needs to synchronise[6], validate token transactions and record them in a replicated database. The key challenge of such a distributed network is to get the nodes to agree on the transactions that they are recording. The creators of Bitcoin designed incentives in the distributed network such that the network can achieve consensus on the validity of the cryptocurrencies transactions that are broadcasted and recorded onto the blockchain (or distributed ledger). In distributed networks, such incentive mechanisms are known as consensus protocols. The best-known example in cryptocurrencies is Proof of Work (PoW), which is also known as Bitcoin mining.

In Bitcoin mining, servers on the network commit computational resources to solve a cryptographic puzzle which is related to the set of transactions that are being verified as discussed in Nakamoto (2008). In return, the first server to find the answer to the puzzle wins a mining reward. Bitcoin mining is probabilistic in nature and the change of winning increases with the computational power committed. Servers have an incentive to ensure that the transactions are valid if they want to keep the reward they win. This type of consensus protocol has a few problems.

First, as the network grows and becomes more competitive, it consumes large amounts of electricity making it harmful to the environment. According to Stoll, Klaaßen and Gallersdörfer (2019), electricity consumption required by Bitcoin is more than the entire country of Jordan. Amassing computational power also leads to incremental chances of winning the mining reward, and this results in 65% market

[6] The internet is inherently asynchronous in the sense that there is no global clock and each nodes may receive messages that carries transactions' information in different sequence. This has been a major research topic in the area of distributed network involving network engineering and fault tolerance.

share being held by major mining companies such as Bitmain, Ebang and Canaan and only 8% of the market held by small scale miners. Second, since one can accumulate computation power (or machines) to gain an unfair advantage in bitcoin mining, this leads to less decentralisation and ultimately results in strategic mining behaviour where miners with high computation power game the outcomes to their advantage.

The decentralised nature of cryptocurrency networks means that such consensus protocols are necessary as the servers that participate in the network are untrusted. Incentive mechanisms need to be in place such that the servers will act in the best interest of the network. Other than PoW, there are a plethora of other consensus protocols which are designed to address some of the issues with PoW. One popular alternative to PoW is Proof of Stake (PoS). PoS requires the servers to stake cryptocurrencies ("freeze" the coins in a wallet) for a chance to be selected as the verifier/miner. It trades computer resources in exchange for the time value of the cryptocurrency stake. Proof of Stake was first introduced in Peercoin, and is designed to be better in terms of energy consumption and it also better aligns the incentives between stakeholders (Ren, 2014). Chepurnoy, Duong, Fan and Zhou (2017) discuss Twinscoin, a cryptocurrency that uses both PoW and PoS. Each time a new protocol is introduced, there will a trade-off and another weakness, and the design thinking is to ensure that whichever consensus is used, it will provide safety[7] and liveness[8] for the distributed network.

Consensus protocols control the creation of new cryptocurrency. In Bitcoin, new coins are created on the blockchain with each new block to provide for the mining reward. Bitcoin mining rewards started with 50 bitcoins and are halved every four years. In May 2020, rewards were reduced to 6.25. This halving will continue until a cap of 21 million coins is reached, as discussed in Nakamoto (2008). This is a conscious effort by Bitcoin's creators to "hard code" the coin supply and prevent any central authority from changing it. Essentially, in most cryptocurrency networks, code controls the supply. It is difficult to change the programming, as the entire network needs to agree to upgrade code. This pre-programmed supply and cap create scarcity.

However, this is only one determinant of the market supply. Even though the creation of coins is pre-programmed, the circulation of coins is in the hands of human beings. The built-in coin creation and cap creates an expectation of future scarcity, and this causes hoarding of coins in anticipation of a higher price. This drives prices up and encourages further hoarding, making cryptocurrency mining a lucrative industry. Some coins take this further by offering "dividends" to coin holders. The choice of consensus

[7] Safety means that the consensus must never achieve agreement on a state of the ledger when nodes have not actually agreed on that given state to ensure the integrity of the ledger.
[8] Liveness means that consensus cannot stall, even in case of a tie, the consensus algorithm must always make progress

protocol may also amplify this, for example, Proof of Stake coins organically controls supply with its staking requirements. In other cases, the creators of the cryptocurrency network pre-create or pre-mine the cryptocurrencies, essentially making them the majority owners and controllers of the coins in circulation.

One of the major challenges faced by cryptocurrencies is price volatility as current use cases are speculative in nature. Many buy and hoard cryptocurrencies in anticipation of higher future value. Athey, Parashkevov, Sarukkai and Xia (2016) find that Bitcoin is mostly used for investing (or store of value), and its value is linked to beliefs about the future rather than exchange rates to current fundamentals. Demand for cryptocurrencies is largely speculative in nature. Sovbetov (2018) finds that (for five major cryptocurrencies) the cryptocurrency market beta, trading volume and volatility are significant both the short- and long-run. Liu, Tsyvinski and Wu (2019) also find that cryptocurrency market size and momentum capture the cross-sectional expected cryptocurrency returns. During bull runs, the cryptocurrency market is very attractive as it is much more volatile as compared to traditional investments.

The cryptocurrency exchange industry is a fragmented one, and there are more than 250 cryptocurrency exchanges that are tracked on CoinMarketCap (a cryptocurrency tracking platform). These exchanges operate in a number of markets and offer exchange of fiat currencies to cryptocurrencies and also among cryptocurrencies. This increases arbitrage opportunities and the speculativeness of the market. Cryptocurrencies are also commonly thought of as alternative investments, providing a hedge against the market (Lee et al., 2018)). Dyhrberg (2016) suggests that cryptos and gold have similar hedging capabilities and can be used to hedge against the FTSE index. Chan, Le and Wu (2019) examine the hedging capabilities of Bitcoin, and demonstrate that while it does provide a hedge against the market, the actual amount of that hedge depends on the index and time period studied. Bouri, Gupta and Vo (2020) show that various cryptocurrencies respond to geopolitical risk, and during periods of heightened geopolitical uncertainty, investors can move to Bitcoin as a shelter. In regions prone to political instability and hyperinflation, cryptocurrencies are being adopted as the currency of choice for payroll and payments.

When the trust in the financial system is low, the demand for cryptocurrencies increases, leading to higher prices. In 2015, with harsh capital controls restricting the flow of bank deposits, Greeks were looking to turn physical cash into stores of value. That change in perception that fiat currency was not as reliable as previously thought, enticed a rally of 37% in bitcoin price with the thesis that bitcoin was a store of value, could be purchased with cash and had similar properties to money.

In another episode during the 2018 Venezuela hyperinflation, the volume of transactions increased with many crypto exchanges, crypto wallet and gift cards. Aid flowed in via alternative crypto payment system. Though the actual size relative to the population of both countries are small, it still attracted the attention of international organisations in viewing underlying technology, not necessarily cryptocurrency, to be of benefits during a financial crisis caused by a loss of confidence or trust. Clearly, the collapse in the Letter of Credit services among banks during the 2008 Global Financial Crisis that led to more than 30pc drop in international trade disrupting the supply chain is still fresh in the central bankers' mind.

Another determinant of a cryptocurrency's demand is its utility. Bitcoin's main utility is for payments (and its use to pay for transaction fees), other cryptocurrencies like Ethereum are used to fuel the processing of smart contracts. Blockchain networks with well-defined use cases (such as supply chain) can provide strong utility for its cryptocurrency, forming a strong internal demand which supports the cryptocurrency price and makes it more stable. Supply-demand fundamentals such as the total number of bitcoins and the number of unique bitcoin addresses used per day have a significant impact on bitcoin price (Ciaian, Rajcaniova & Kancs, 2016). Cryptocurrency prices could also be determined by its cost of production. As found in Hayes (2016) & Hayes (2019), the marginal cost of production (mining and consumption of electric power) plays an important role in explaining bitcoin prices. The pricing model leads us to expect that during periods of excess demand (aka a price bubble), either the market price will fall and/or the mining difficulty will increase to resolve the discrepancy.

Market sentiment about the cryptocurrency and its associated blockchain networks also play a role. The trustworthiness of the cryptocurrency's blockchain and the adoption of the blockchain drive prices in the long run (using data for five major cryptocurrencies) (Bhambhwani, Delikouras, & Korniotis, 2019). Bitcoin returns were found to be driven primarily by its popularity (Google search & number of newspaper articles), the sentiment (tone) expressed in newspaper reports on the cryptocurrency, and the total number of transactions (Polasik et al., 2015).

Incentives, social scalability[9], consensus, utility, and governance of the network have deep implications on the price of a cryptocurrency. When designing a cryptocurrency, one needs to consider the purpose of the coin and what best fits that purpose. Every choice can affect the volatility of the cryptocurrency

[9] According to Szabo (2017), "*Social scalability is about the ways and extents to which participants can think about and respond to institutions and fellow participants as the variety and numbers of participants in those institutions or relationships grow. It's about human limitations, not about technological limitations or physical resource constraints. One way to estimate the social scalability of an institutional technology is by the number of people who can beneficially participate in the institution. Another way to estimate social scalability is by the extra benefits and harms an institution bestows or imposes on participants, before, for cognitive or behavioral reasons, the expected costs and other harms of participating in an institution grow faster than its benefits*."

price. One may argue that private entities (designing and creating the coin) may not have interests that are aligned to the users of the coin. Lai and Lee (2018) described the design thinking, tradeoffs and implementation and adoption of a blockchain system.

For example, the issues in the Bitcoin blockchain sparkles lots of discussions. In fact, over the decade since the Satoshi paper in 2008, various schools of thought have emerged in the cryptocurrency and blockchain space. These range from the Bitcoin purists to believers of the Permissioned Enterprise Blockchain[10]. However, we also see a convergence in these schools, as experimentations with different applications reveal certain requirements. Hybrid solutions are a key emerging trend in blockchain applications where permissioned blockchain networks rely on a large public blockchain to provide data immutability and security. Many now agree that there will be multiple blockchain networks in operation and the ability to interoperate is key for a blockchain-based world. These requirements also prompted technology to evolve in an attempt to address the problems with the original Bitcoin design. The main issues with the technology revolve around scalability, interoperability and privacy. Projects such as Ethereum 2.0, EOS, Hedera Hashgraph, Zcash and Monero (just to name a few) aim to address these issues.

DeFi (or Decentralized Finance) is an emerging trend in blockchain/fintech, and the term was coined to refer to the class of tools and applications built on blockchain to facilitate a financial ecosystem. DeFi tools can come in the form of digital assets, protocols, smart contracts, and dApps (decentralised applications). Applications can be found in the area of asset tokenisation, stablecoins, decentralised exchanges, alternative savings, lending and payments, and more. The aim of DeFi is to create an open financial ecosystem where one can build financial tools and services on top of this ecosystem by combining, modifying and integrating current applications. Cryptocurrencies will facilitate the DeFi ecosystem, and this will have implications on the real-world economy as the applications grow.

However, at the current stage of maturity in the industry, real-world use cases have yet to see mass adoption beyond spurts of financial speculation and fundraising activities such as token creations, Initial Token Offerings (ITO)[11], DAOs and DAICOs[12] using smart contracts. Many of these adoptions

[10] What sets enterprise blockchains apart from public blockchains is the permission required to participate in the network and interact with it. Unlike Open Blockchain, a node must be specifically permissioned to join the Permissioned Enterprise Blockchain.
[11] Includes Initial Crypto-Token Offering (ICO), Initial Exchange Offering (IEO), Security Token Offering (STO), Initial Mining Offering (IMO).
[12] DAICO is a word association between the Decentralized Autonomous Organization (DAO) and the Initial Coin Offerings (ICO). A DAICO puts in place more stringent management rules and constraints for ICO projects to avoid certain risks for investors.

eventually led to frauds, scams and bugs that dampened the initial enthusiasm, clogging of the network, and with colossal volatility measured in fiat currency[13].

This also makes the original intended use case of payments infeasible, and to address this a solution generally known as stable coins has been proposed by the industry. For example, Berentsen and Schär (2019) discuss crypto-assets that are developed with the aim of minimising price volatility by embedding a stability mechanism. In general, three methods are now used to create stable coins: Fiat-collateralized, crypto-collateralised and non-collateralized. **Fiat-collateralised** stable coins refer to asset-backed tokens. These assets such as fiat currency or precious metals need to be centrally held and managed by a trusted authority. Custodian costs would be incurred in this situation and there is a need for regular audits to ensure full collateralisation. There are two modes of fiat-collateralisation. The first is single asset-backed, this is usually in the form of currencies like the USD or gold. This means that the operational costs cannot be recovered from asset appreciation and needs to be provided through other means. The second is multi asset-backed, this is usually a basket of interest-bearing assets that are selected to cover the operational costs. These assets will need to be managed by professionals, which leads to a further increase in costs. **Crypto-collateralised** stable tokens are backed by another cryptocurrency. To handle the volatility of the cryptocurrency, usually this type of coin is over-collateralised. This requires the collateralising cryptocurrency to maintain a certain value and also creates a large opportunity cost to the issuer. **Non-collateralized** stable coins generally use algorithms (smart contracts) to manage the supply of the token (by issuing or destroying coins) which in turn keeps the price stable. Al-Naji, Chen and Diao (2017) show how Basis, an algorithmic stablecoin, actually implements price stability using expansion and contraction in its three-token system. This is similar to central bank operations but decentralised. There must be perceived value and a demand-side for such methods to work.

The methods mentioned are used by private entities for the issuance of stable coins. A derivative of Fiat is Libra Coin to be created by Facebook-led project involving 100 Libra Association members[14]. Libra has proposed to create a stable coin backed by a basket of currencies in its initial proposal and floated the idea of single-currency-backed Libra in the revised white paper[15]. Governments have also been exploring the possibility of issuing similar digital currencies - these are also known as Central Bank Digital Currencies or CBDC.

[13] In the crypto economy, volatility and stability can be measured using a benchmark based on highly traded cryptocurrencies such as bitcoin and ether, rather than fiat currencies.
[14] Libra White Paper retrieved from https://libra.org/en-US/white-paper/
[15] A white paper in cryptocurrency is a document which includes an outline of a problem that the project is seeking to solve, the solution to that problem as well as a detailed description of their product, its architecture and its interaction with users.

Cryptocurrencies are usually deployed on open and public networks where anyone can join as a node on the network. These networks are also known as permissionless, as no permission is required to join. In such networks, specially designed incentive mechanisms in the form of consensus protocols such as Proof of Work are required as the network participants are not trusted (or known). Permissioned blockchain networks on the other hand are controlled, and only known parties that are given permission can join the network. Every participant in this sort of network needs to be trusted and agree on the governance of the network. This sort of network is a popular choice for CBDC. The central bank can have control over the supply and the parties that form the network. Thus, one can manage monetary and government policies using CBDCs and this will be explored next.

2.3. Monetary policy considerations in the presence of non-sovereign cryptocurrencies

As cryptocurrencies creep into everyday life and are used for digital payments, governments inevitably need to consider how it would affect the circulation of central bank issued money and the effectiveness of monetary policy. Money has existed in digital or electronic form for a few decades now, and those technologies have not reduced the effectiveness of monetary policy. Would cryptocurrencies be any different?

The main difference to note is that a cryptocurrency has its own price and can be used in replacement of a national currency. Oh (2018) suggests that if a new cryptocurrency becomes commonly used in a country, it can cause a rise in the money supply, a fall in the interest rate and an overall rise in the exchange rate. Cryptocurrencies have demonstrated their potential for capital mobility in countries with capital restrictions, thus providing a cheap currency substitute. Relatively stable currencies such as the USD, JPY and CHF have been traditionally used as a currency substitute, and cryptocurrencies now present an alternative. Engel (2019) presents a framework for foreign exchange to examine the impact of the cryptocurrencies. In the paper, Engel suggests that the digital currency market is not a major concern for monetary policy currently as their holdings are small relative to other forms of liquid assets (in August, 2019, the market capitalisation of digital currencies was approximately $260 billion, which by comparison is less than 2 per cent of U.S. Treasury debt held by the public). He also discusses the problem of currency substitution and where consumer prices are set in the new currency, and transactions that take place using the new currency. If currency substitution occurs, inflation targeting by the central bank will lose its effectiveness.

Raskin, Saleh and Yermack (2019) present an alternative point of view that a private digital currency may, in fact, improve welfare in a country. As mentioned in the paper: “Although private digital currencies have not replaced the dollar, their mere existence may have a counterfactual impact in that they exist as a check on both fiscal and regulatory policy.” Modelling an emerging economy with a

private digital currency, the authors present three key findings. First, the existence of the private digital currency imposes discipline upon monetary policy and thereby generates welfare gains for citizens. Second, a private digital currency increases local investment within an emerging market economy, as the private digital currency serves as a hedge asset. Third, citizen welfare that is increased from permitting digital currencies enables the government to raise tax rates, which in turn increases government revenue. Thus the existence of the private digital currency in an emerging economy could benefit the economy overall. The paper highlights that private digital currencies should not be analysed as a replacement for traditional money but rather as an important alternative asset.

As discussed in the previous section, non-collateralized stable coins are being designed to mimic monetary policy. Could such coins eventually substitute the central bank? We can design such algorithms to provide a counter-cyclical monetary policy, however it is still a long way before it can administer policy on a discretionary basis. Thus, one middle ground that taps onto the technical advantages of cryptocurrencies, while providing central banks with the discretionary power could be CBDC.

3. Central Bank Digital Currencies (CBDC)

Government control of money can be traced back to ancient Egypt (more than 4000 years ago), and money innovations have never ceased throughout history. Sveriges Riksbank is the oldest central bank in the world and has been managing the monetary system of Sweden since 1668. But it was the Dutch's Wisselbank that lay the foundation for the contemporary central bank model. A critical role of central banks is to provide risk-free money and safe means of payments to the financial system. This includes retail and wholesale, or more specifically households and businesses. Despite its relatively young status of 50 years, fiat money has evolved from simple cash and banknotes to broader money that provides for bank deposits, credit cards, and now electronic money. The financial institutions that provide the third-party trust and the creation of money have secured a premium for centralised trust services and the whole web of complex payment systems. However, the competing interest and complicated landscape among the different stakeholders have overshadowed the original risk-free and safety purposes.

More recently, the emergence of fintech companies with new payment methods has created opportunities to overcome these pain points, but they come with some risks. This separation between

the wholesale payment system[16] and retail payment system[17] will almost surely be re-defined, and some have even suggested merging both with new players and technologies. In particular, there are new proposals from the central bankers and academics, especially in the design and structure of the Central Bank Digital Currency or CBDC using Distributed Ledger Technology (DLT) or Blockchain.

It is challenging to have a precise definition but less debatable to simply define CBDC[18] as a digital form of money issued by the central bank. It has been called a digital fiat currency or digital base money to signify its similarity with fiat money. However, an expanded definition is that CBDC is a digital payment token that includes a class of digital bits and bytes which is simply treated as money by government regulation, monetary authority or legislation. The main distinction between fiat currency and digital token in our bank accounts is how they are issued. Commercial banks and some permitted financial institutions hold electronic fiat currency in the form of reserves that can create money. The consumers have access to money through the commercial banks, and they, in return, have to fulfil reserve requirements by the central bank. CBDC, on the other hand, allows the possibility for households and businesses to make payment to others directly and store value using an electronic form of central bank money, thereby bypassing the commercial banking system.

Many central banks are considering it, and some have started piloting CBDCs. Given the speed of innovation in central banks in devising new money, our discussions will focus on the design thinking of a few critical directions and its associated risks. Many but not all of the proposed CBDC are blockchain or DLT-based, and the debates on the benefits of using this nascent technology are still ongoing. In other words, the digital currency can be modelled either as non-cryptocurrency or as a form of crypto-token.

To define CBDC in a broader sense, one should include innovations that are evolving in Asia. Some examples are China's newly proposed CBDC and Singapore's Project Ubin. China has termed its cryptography-based money as Digital Currency/Electronic Payment (DCEP) and it emphasises the asset side of currency and its P2P payment functionalities. Singapore has different phases for Project Ubin[19] and intends to enhance the functions and capabilities of its newly proposed payment system using DLT. While the DCEP allows for the possibility of P2P payments, Singapore's model is a tokenised form of

[16] A wholesale payment system is a funds transfer system through which large-value and high-priority funds transfers are made between participants in the system for their own account or on behalf of their customers. (BIS, 2003).

[17] A retail payment system is a funds transfer system which handles a large volume of payments of relatively low value in such forms as cheques, credit transfers, direct debits, ATM and EFTPOS (Electronic Funds Transfer at Point of Sale) transactions (BIS, 2003).

[18] BIS (2018) defines CBDC as a new form of central bank money. That is, a central bank liability, denominated in an existing unit of account, which serves both as a medium of exchange and a store of value.

[19] The details of different phases are given in Appendix 2.

government securities that can be used for payment and as a store of value for wholesale banks. But with DLT, the possibility of P2P payments without the banks as intermediaries is real.

The Bank of Thailand (BOT) has developed a tokenised version of the Thai Baht and evaluated the impact of a tokenised Real-Time Gross Settlement (RTGS)[20] in its first phase of Project Inthanon[21]. Project Inthanon-Lionrock is a joint DLT initiative for cross border payments between two central banks: BOT and the Hong Kong Monetary Authority (HKMA). Cambodia, Japan, Hong Kong and Canada have all taken different approaches to design their digital currency. The table below is a summary of recent use cases by central banks, as discussed in Shiral (2019) and Bech and Garratt (2017).

Fiat is a currency issued by the government and is legal tender. Within the monetary system, money consists of the central bank and private sector money. Central bank money has two components, namely, Retail Cash and Wholesale Reserve Deposit. Traditionally, private sector money has only Retail Bank Deposit. But with CBDC, this new eMoney in the form of Crypto Tokens or eAssets will introduce several benefits and risks into the monetary system, the impact of which is still not fully known. But the benefits are clear as CBDC can manage anonymity, is easily accessible to the public, is traceable, offers online and offline peer-to-peer payments, is available 24/7, and can be designed to pay interest, among others. Neither cash nor bank deposits have all these characteristics.

Table 1 : Recent Use Cases by Central Banks

Target	Technology	Country(s)	Current Discussions
General Public or Retail	CDBC without DLT	**Sweden** 1. An account-based retail CBDC is the issuance of a digital currency to the general public by directly providing an account at the central bank. 2. A value-based retail CBDC is the issuance of a digital currency for which the prepaid value can be stored locally on a card or in an eWallet.	1a. Will commercial banks suffer a loss in retail deposits? 1b. Should there be a lower interest rate for CBDC in account-based? 1c. Will there be a rush to safety from bank deposits during a crisis? 2. In a value-based account with partial anonymity, should a limit be placed and is that implementable?

[20] Real Time Gross Settlement System will be discussed in more detail in Section 5.4.

[21] Thailand's Project Inthanon is named after Thailand's highest mountain. The second phase involves the tokenization of bonds and the project targets coupon payments, interbank trading, bond redemption, and interbank repos (short term collateralized lending between banks). In the third phase, the Bank of Thailand explores interoperability with legal systems and other platforms, including cross border transactions.

General Public or Retail	CBDC with DLT	**Uruguay, Senegal, China, Tunisia, India, Israel, Lithuania, the Marshall Islands** DLT here refers to using some or all of the features of cryptocurrency. In the case of China, UTXO[22] or unspent transaction output from bitcoin transactions are used to balance the ledger. This is not popular among developed countries, according to Cœuré (2018), but it is popular in developing economies. Contrary to the assessment, this may allow the emerging economy to leapfrog as it solves many pain points for developing economies such as payment, trading and financing.	1. Can developing economies enhance financial inclusion? 2. Can developing economies bypass the traditional International Payment or remittance system to lower overall cost? 3. Can household activities and illiquid be tokenised and be integrated with CBDC in the form of utility and asset tokens?
Financial Institutions or Wholesale	CDBC for wholesale	**Canada, Singapore, Thailand, South Africa, Eurozone, Japan** This is the most popular proposal that can integrate the traditional payment system and banking models.	1. Are there benefits beyond efficiency improvement with the use of Reserve Deposits, Crypto Tokens or Assets? 2. How does the payment system integrate with other financial instruments and processes such as Delivery and Payments for securities, supply chain financing, and cross country remittances?

Source: Shiral (2019), Bech and Garatt (2017) and Authors

3.1. What problems can CBDC solve?

[22] In cryptocurrencies, an unspent transaction output is an abstraction of electronic money with a ledger that can only append entries. Each UTXO represents a chain of ownership implemented as a chain of Digital Signatures where the owner signs a message transferring ownership of their UTXO to the receiver's Public Key. Public Key Infrastructure (PKI) is a set of requirements that allow (among other things) the creation of digital signatures. Through PKI, each digital signature transaction includes a pair of keys: a private key and a public key. Digital signature is used in Bitcoin to provide a proof that one owns the private key without having to reveal it (so proves that one is authorized to spend the associated funds).

There is a demand for CBDC with more than 70% of governments in the world researching the topic. One primary reason is to ward off the challenge of stable coins such as Libra which has the potential to scale globally and weaken the central banks that are not on board. Other reasons are (1) supporting competition efficiency and innovation in payments; (2) meeting future payment needs in a digital economy; (3) improving the availability and usability of central bank money; (4) addressing the consequences of a decline in cash; (5) acting as a building block for better cross-border payments; and (6) supporting a resilient payments landscape. However, it is the potential use of the CBDC that is interesting, and we summarise the specifics here:

(1) To allow offline transactions of eMoney similar to physical cash.

Near Field Communication enabled technology will lessen the reliance on the Internet/mobile network and reduce the risk of disruption of services.

(2) To allow for more general value transfer via eWallet without the need of an account, or any link to financial institutions or cards for eMoney.

At the most basic level, a simple downloading of application software replaces the complicated, inconvenient, and costly onboarding process for users. CBDC will then function similar to physical transactions using cash. It eradicates the intermediary and counterparty risk. The breakdown in trust among licensed payment institutions during crises are bottlenecks for central banks' efforts in distributing money to the ultimate beneficial parties. CBDC may mitigate the risk of the break in the supply chain financing and trade financing during crises.

(3) To ensure efficiency and security of the payment system without going through a clearinghouse or real-time gross settlement system while retaining monetary sovereignty.

This bypassing of trusted third parties will mitigate the risk of a breakdown in any centralised system or clearinghouse system.

(4) To ensure a more accurate representation of economic activities currently excluded from the calculation of national accounts statistics.

A lot of small transactions take place without going through the banking or financial system, but they are essential economic activities. The use of CBDC for retail will capture all payments associated with primary activities currently not reflected in the national accounts.

(5) To ward off the challenge of non-fiat eMoney replacing fiat money, thus weakening the fiscal policy sovereignty, which includes tax collection.

With eMoney and eCommerce, payments using other alternative currencies may lower tax revenue as traceability may be an issue for tax authority when the goods and services traded are in digital form.

(6) To reduce the cost of reliance on physical notes and coins.

CBDC will eradicate the cost of issue, printing, storage, exchange of old notes with new ones, fraud, counterfeit, carrying, and lead to an overall improvement in hygiene.

(7) To maintain privacy protection and yet have the ability to manage anonymity to prevent money laundering, terrorist financing, tax evasion and criminal activities.

The central authority will have full information if the individual agrees to reveal that information or that transaction amount or frequency exceeds the threshold set by the body. AI and data analytics can identify patterns of money laundering and other illegal activities.

A tier system for onboarding has several advantages. The most basic level of directly downloading an app will reduce the cost of onboarding, and thus increase social scalability beyond the country of issue. The second tier that allows for a larger amount of transactions and storage will require the opening of a bank account or linking with a credit or debit card. The third tier will require one to present physically for identification at a designated license entity. CBDC will empower the central bank in big data analysis and at the same time, lessen the control and privacy invasion at the financial institutions level.

(8) To allow for digital or smart contracts to be implemented.

Digital agreements are useful when trusted parties are needed to provide trust, and when the transactions are small, decentralised digital enforcement codes (or more commonly known as smart contracts) can be executed automatically without a trusted third party. Smart contracts reduce the cost of trust. In many areas with an imperfect justice system and a weak enforcement environment for a legal agreement, smart contracts will address the pain point of non-performance of a deal and therefore may stimulate more investment. It is also possible to have a two-tier system to improve efficiency and allows the intermediary to implement decentralised apps, consistent with centralised governance and third party trust outside the network.

(9) To stimulate growth in the underserved, under-recorded, and under-represented sectors.

GDP national accounts do not capture many lowly traded, minute transactions, illiquid assets and unrecorded economic activities. Tokenisation can allow tracking of household services, livestock trading, and many other unrecorded and unreported activities. By capturing the excluded economic events in the national accounts, it will lead to better policymaking for sustainable growth. In aggregation, these essential omitted statistics of primary economic activities can be substantial in agriculture and less developing economies.

The key is then to retain the desirable characteristics of cash, manage anonymity, make it easy to use, keep it secure and yet balance the need for enforcement for illegal activities. The secondary benefit of CBDC is to capture those excluded essential economic activities and devise a better sustainable growth policy. The last point is the most attractive proposition and presents the most potential to the developing economies that have yet to be entangled in a complex economy dominated by the financial sectors.

3.2. Why do we need CBDCs?

There are features of CBDC that are not available in traditional cash and notes. Some features are present in the DLT or blockchain-based CBDC. These features will be able to complement the existing roles performed by the monetary system. In particular, if the intention is not just to digitise money but also to have sustainable growth, well designed DLT and blockchain-based CBDC may be able to smooth the pain points and provide cost-effective solutions. CBDC can be viewed as a new form of financial design to achieve objectives such as financial inclusion, lower remittance charges, a fuller measure of GDP, and facilitating transactions with more moderate or zero cost of trust -

(1) Traceability and Immutability: This will simultaneously allow for privacy protection (from intermediaries) and yet facilitate the use of big data analytics to recognise the patterns of illegal activities, while not allowing data to be easily changed by any party.

(2) Smart Contract: This will allow for low-value transactions to take place where the cost of third party trust is high. It will also allow for the non-human intervention of low-value Peer-to-Peer (P2P) as well as Machine to Machine (M2M) transactions which are too costly to track and execute at the moment. Smart contracts will bring a lot of economic activities back to the calculation of GDP. Smart Contract may also become an autonomous money creation algorithm that allows money creation using CBDC if certain conditions are met (Rashkin & Yermack, 2018), creating a parallel to the existing fractional banking system based on bank reserves.

(3) Tokenisation: This will allow the trading of goods and services and therefore release the value of illiquid assets and household services.

(4) Fractionalization: This will allow for assets, livestock and durables to be divided into a smaller piece of assets. The democratisation of fungible[23], durable, livestock as an asset will lead to more liquidity and affordability.

[23] In economics, fungibility is the property of a good or a commodity whose individual units are essentially interchangeable, and each of its parts is indistinguishable from another part. Commodities, shares, options and dollar notes are examples of fungible goods while diamonds, land, or a cow are not fungible because each of them has unique qualities that add or subtract value.

(5) Non-Fungibility: This will allow for non-fungible products and services to be tracked and assigned value for its components, weights or characteristics via a token swap or value transfer with low cost.

(6) Multi-Tier Registration system (MTRS): MTRS will allow for the proportionality and materiality principles[24] to be fully applied. Depending on the activities and the amount, different tier identifications may be needed. CBDC is unlike notes and coins that have a denomination. The lower the "largest denomination" of notes, the higher the cost for laundering large amount. However, CBDC has no "largest denomination" and carrying, storing, transferring and exchanging entails the same cost. A multi-tier registration system is an improvement as anyone trading, exchanging or transferring a significant amount will be subject to more stringent monitoring and reporting. At the same time, granting specific exemptions to those engaging in small transactions or designated activities may seem more appropriate. Any accumulated suspicious activities will be picked up by pattern recognition and an advanced surveillance system. MTRS can combine the use of phone number identification, credit card linkages, or in-person registration. MTRS will encourage innovation and allow the regulatory system to be more flexible, allowing for less regulation for small transactions or infrequent transactions. The cost savings can be substantial for regulators, intermediaries and the end-users.

(7) Data Privacy Protection: In a DLT network, the payment and settlement system may store a single copy and thus avoid the situation of a single point of failure. While secret sharing[25] or fractional filing system have not been exploited, zero-knowledge proof[26] that shields the ledger has been used in Project Ubin. Cryptography can be used to safeguard data privacy to comply with the "need to know" basis among the nodes or participating financial institutions. Other techniques such as Secure Multi-Party Computing[27] can create methods for nodes to jointly compute a function over their inputs while keeping those inputs private, thus promoting collaboration while not violating data privacy law for regulated entities.

3.3. Risks

[24] The principles seek to right-size regulations to be fit-for-purpose; for both traditional as well as new business models, according to the risks the activity poses.

[25] Secret sharing is a cryptography algorithm where a ledger, in this case the secret, is copied multiple times and then each copy is divided into parts, giving each participant its own unique part of a copy. To reconstruct the original ledger, a minimum number of parts is required and so no single node can have knowledge of the whole ledger.

[26] In cryptography, a zero-knowledge proof or zero-knowledge protocol is a method by which one party (the prover) can prove to another party (the verifier) that they know the value of X in the ledger, without conveying any information apart from the fact that they know that X exist.

[27] Secure multi-party computation is also known as secure computation, multi-party computation (MPC), or privacy-preserving computation). The cryptogrphy protects participant's privacy from each other and creating methods for parties to jointly compute a function over their inputs while keeping those inputs private. Beyond the traditional cryptographic tasks of ensuring security and integrity of communication or storage and the malicious elements, this sub-field of cryptography protects participants' privacy from each other. For a need-to-know-basis interbank system, this is one vaiable solution.

CBDC is not without risks and warrants a careful analysis before the implementation of any new designs. Full-reserve banking requires banks to have 100 per cent cash reserve for deposits other than demand deposits to be ready for an immediate demand for withdrawals. Fractional-reserve banking, on the other hand, allows the bank to lend out the short-term deposits except for the fraction (retained as cash) that is needed to meet potential demand for withdrawal. CBDC is digitised cash and can be withdrawn instantaneously by the transfer of the private key if it resembles a cryptocurrency. If the whole amount is removed, the bank will have no deposits to lend, or in the worst case, the bank has to recall all the loans at once.

Contemporary discussions have centred on (1) whether there should be an upper bound for the conversion of deposits into CBDC; (2) whether there would be interest payment for CBDC deposit; (3) whether interest rate should be different for different tiers; (4) whether the interest rate on CBDC should be below bank deposits, and (5) whether the floor is zero or negative for CBDC; (6) whether the CBCD system is a full-reserve, fractional reserve, or a dual system. While the foundation of finance is the fractional reserve banking system, there are arguments and proponents[28] for a full-reserve system (Mayer, 2019). In 2018, the Switzerland Sovereign Money Initiative proposed a full reserve banking as a prominent component of its proposed radical reform of the Swiss monetary system. Even though the proposal was overwhelmingly rejected (Bacchetta, 2018), the idea will likely to be revisited with a new interest in CBDC.

There were some discussions among the central bankers and academics[29,30] and we have summarised their findings on the significant risks of CBDC as follows[31]:

(1) Facilitation of Money Laundering

There may be more money laundering with CBDC. The cost of money laundering is lower with CBDC than cash. Specific restrictions on the frequency and size of conversion of CBDC for bank deposits and a limitation in usage may be needed for prevention purposes. The saving grace is that a digital trail will be left behind, unlike that with cash. So, there may need to be a suitable set of restrictions on CBDC based on the kind of business activities separating high risk from low-risk economic activities to prevent complicated layering to avoid audit or detection.

(2) Risk of a Bank Run on Banks with Low Credit Rating

[28] The chief Economist of Deutsche Bank and the former Governor of the Spanish central bank have both mentioned about the 100 per cent CBDC system and "safe money" in Mayer (2019) and Fernández Ordóñez (2018).
[29] Long (2019) discussed about risk prevention in the practice of central bank legal digital currency (in Chinese) especially in reference to DCEP. Barrdear, B. & Kumhof. M. (2016) discussed in detailed about the macroeconomics of Central Bank issued digital currencies.
[30]Klein, Gross and Sandner (2020) discussed about the digital Euro and the role of DLT for CBDC.
[31] The material in this section is entirely drawn from Long (2019) with the authors' inputs.

The possibility of a run on the bank as an event may trigger a preference for lower-risk CBDC over bank deposits. CDBC has lower risk than bank deposits, and during a credit crisis, it may be the root cause of a bank run as more people convert their bank deposits to CBDC. CBDC is classified as M0 and it is a liability of the central bank. Bank deposits are classified as M1 / M2, which is a liability of commercial banks. Holding CBDC subject one to sovereign risk whereas holding bank deposits has an additional risk of a bank default. Therefore, there is a strong incentive to convert deposits to CBDC during a period when a bank is known to have a credit crisis. The central bank may impose limited conversion from bank deposits to CBDC. But any such measures will defeat the purpose of having CBDC, which is to have a lower risk while having more convenience.

(3) Systematic Risk of the Banking System

A unique event at one bank may trigger a run on the whole banking system. A bank run can be instantaneous, given that it is in electronic form. The race to CBDC can spread within a short period from a single bank to the entire banking system. The order and magnitude of the run on the banking system may be much larger than a single bank run and can happen instantaneously.

(4) Risk of Deleveraging of Banks Without a Diversified Portfolio

A bank without a diversified liquid asset portfolio can become illiquid in a very short period. According to regulatory requirements, all deposit liabilities of banks need to be supported by corresponding assets, and the asset requirements corresponding to different currency types of deposits are different. Cash reserve does not generate interest and is a form least preferred but kept simply to meet the needs of users. Unlike the 100% requirement of cash reserve, general deposits only require a partial reserve. Assuming that the deposit reserve rate is 10%, one unit of a commercial bank's reserve in the central bank can create a ten-fold deposit currency. When the reserves of commercial banks in the central bank are insufficient, commercial banks can borrow reserves from the central bank by collateralising their liquid assets to the central bank. The size of a commercial bank's liquid assets constrains its ability to create a deposit currency.

Commercial banks create deposit currency through loans, however, the scale of commercial banks' liquid assets limits the size of credit creation. Similar to cash reserves, CBDC requires a 100% reserve. Therefore, the switch from retail bank deposits to CBDC forces banks to transfer deposits of equal size from partial reserves to 100% reserves, which will quickly consume liquid assets held by commercial banks. The tighter liquidity will seriously shrink the amount and increase the pricing of credit, especially for banks without a large portfolio of diversified assets. The money multiplier will decrease. When the bank runs out of liquid assets, it cannot support the conversion of the user's deposit to CBDC, and the bank is forced to recover the loan assets at a discount. Banks may quickly become insolvent.

(5) Risk of a Bank Run Caused by Interbank Payments

Interbank payment of CBDC may cause a bank run when conversion depletes reserves. When there is a deleveraging happening by banks depositing CBDC as reserves and when there is a transfer of CBDC to another bank, the payee bank has to use 100% backing to settle through RTGS. That in itself is a deleveraging process as the payee bank needs to recall loans to reduce lending to 100% reserve. This may create a deposit run because the bank reserves may have to be converted to CBDC reserve that requires 100% backing. Previous, there is a limited supply of cash and therefore there is a limit of how much cash can be deposited. However, CBDC is a circular flow and if there is no physical or strict limit of the conversion of CBDC into deposits, the circular flow ends in a rapid deleveraging of the monetary system. Assuming that the entire non-banking sector needs more CBDC, and that the entire banking sector has run out of reserves to exchange for CBDC, it still cannot meet the demand. Banks need to sell / mortgage eligible assets to the central bank to obtain reserves to exchange for CBDC. Given the scale of interbank payment, the banking sector may quickly deplete its qualified assets.

The central bank may have to expand the list of qualified collateral or even completely remove the collateral requirement for large-scale unsecured loans. Therefore, the credibility of this guarantee depends on the central bank's commitment as the lender of last resort. Given the potential scale of liquidity requirements, it may bring unprecedented risks to the central bank's balance sheet. There is a strong case to "set appropriate mechanisms to restrict" the conversion of bank deposits to CBDC.

Not only do we need to restrict the exchange of bank deposits to CBDC, but we also need to prohibit the free conversion of reserves to CBDC. Under the current currency issuance system, commercial banks can borrow reserves from the central bank's mortgaged national debt. The Bank of England study also recommended that commercial banks use qualified collateral to exchange CBDC with the central bank. A two-tier reserves system separating into one with CBDC that pays lower or no interest, and the other as the existing fractional bank reserves may be a solution.

(6) The Risk of Inconsistency

Under the premise that neither reserves nor bank deposits can be freely exchanged with CBDC, it will bring challenges in maintaining the consistency of CBDC and their face value. The central bank needs additional mechanisms to achieve this goal. The Bank of England's 2018 research report recommended the setting up of the CBDC exchange, which sold/purchased treasury bonds to the central bank in exchange for CBDC, and exchanged bank deposits with the household and corporate sectors for CBDC. As long as the central bank promises to pay 1 unit of CBDC for bonds worth 1 unit of "deposit currency", there is an arbitrage mechanism in the market that drives the difference between the face value of CBDC and deposits to zero.

This will call for a limit or cap on wholesale CBDC accounts to limit the volume both in terms of size and the number of small transactions. Central bank scholars Gürtler, Nielsen, Rasmussen and Spange (2017) point out in their paper that the setting of the cap of the CBDC account is an art rather than a science. If the cap is set high enough, it cannot effectively limit the wholesale payment function and may cause bank deposits to run to CBDC. If the cap is set too high, it will damage the effectiveness of CBDC as a payment tool and may cause parity risk.

(7) The Issue of Competition

The advantage of CBDC is convenience. It has the additional benefits of lower risk, offline payment and partial anonymity. As a result, the interest rate of bank deposits can be viewed as a risk premium. Those who hang on to CBDC view convenience premium higher than the risk premium and vice versa. If the interest rate is near zero, the risk premium will not be enough to cover the inconvenience, and therefore there will be a tendency to hold CBDC. In the event of economic downturn or market panic, holders will be more concerned about asset security than financial income, and more bank deposits will be switched to CBDC. At this time, the interest rate instrument will become more ineffective. This will then have a counter effect of expansionary monetary policy.

(8) The Risk of Ineffective Monetary Policy

If the CBDC supply exceeds the demand for various reasons, the central bank will not be able to recover CBDC liquidity at zero interest rates. Traditional physical cash has similar problems but has no real impact, because (1) physical cash accounts for only 5% of the M2 supply, and (2) physical cash flow efficiency is much lower than bank deposit (the reasonable assumption is one-tenth of the deposit). Therefore, physical cash contributes less than 1% to the overall social liquidity, and the central bank only needs to control the liquidity supply of bank deposits.

But CBDC will be very different because (1) CBDC is not only a substitute for physical cash, but also a substitute for bank deposits and it is reasonable to assume that CBDC will account for 20% of the M2 supply; (2) The circulation efficiency of CBDC is higher than bank deposits. In 2016, the Bank of England's research by Barrdear and Kumhof (2016) showed that CBDC's turnover efficiency is twice that of bank deposits. Therefore, CBDC contributes nearly one-third to overall social mobility.

In the case where CBDC's impact on social liquidity is comparable to bank deposits, if the supply of social liquidity is excessive, the central bank will lack effective monetary policy tools to recover the CBDC liquidity. The central bank traditionally used interest rates and open market operations tools to regulate liquidity, but now nearly one-third of liquidity is not affected by interest rate instruments, which in turn will significantly weaken the effectiveness of existing interest rate instruments. The direct consequence of excess liquidity is inflation.

3.4. Challenges of Digital Money

It is essential to return to the basics to understand the concerns of central banks. The four primary functions of money or eMoney are that it is a medium of exchange, a store of value, a unit of account and a means of deferred payments. Other vital attributes that enhance the function of money include Portability, Durability, Divisibility, Verifiability, Fungibility, and Limitations in Supply. The table below outlines the disadvantages of fiat and the technological bottlenecks and pain points of digital money in terms of its functions and attributes.

Table 2: Technological Bottlenecks and Pain Points of Digital Money

eMoney Functions	**Explanation**	**Central Bank Digital Currency Non-DLT Based**	**Non-Central Bank Digital Currency DLT Based**
Medium of Exchange	eMoney functions as a reference value to facilitate trade.	Digitising coins and notes to have minimal impact on the fractional reserve system.	Limited Supply, low acceptance, low circulation, low transaction per second, high energy consumption for PoW, congestion, high storage cost, high transaction fees, no finality, governance issues.
Store of value	eMoney is an asset that can be saved, retrieved and exchanged at a later time, and be predictably useful when retrieved, and it also maintains value without depreciating.	No different from the existing system.	Illiquidity, universally recognizable, readily exchangeable for other assets, fluctuates in value
Unit of Account	eMoney allows different things to be compared to each other.	May be able to digitise other goods and services not traded frequently.	Not a standard measure for trade in goods and services, Not a benchmark to measure the value

Standard of Deferred Payments	eMoney is a widely accepted way to value debt, thereby allowing goods and services to be acquired now and paid for in the future	New products on digitised goods and services.	Inflation and deflation, no recourse in case of counterfeit, instability and loss of purchasing power.
Attributes	**Requirements**	**Advantages**	**Disadvantages**
Portability	Money is mobile and can be exchanged with ease with other currencies	More portable than cash and notes with possible 24/7 exchange.	In reference to fiat currencies, there needs to be a regulated exchange.
Durability	Money is immutable and can withstand continuous use by a large number	Forgery is more complicated and there is no wear and tear.	May lose its value if there is a loss of trust with attacks or bugs
Divisibility	Money has small increments for the exchange of things of varying value	eMoney can have more than two decimals.	Divisible up to 10^-8
Verifiability	Money is impossible to forge and easily identifiable as legitimate	eMoney is comparatively more traceable, authenticated and verified.	Double spend and subject to malicious attack if there are fault or bugs
Fungibility	Money is interchangeable that two equal units have to be equivalent and indistinguishable	Fractional eMoney can have many digits and is an advantage of its fungibility.	It is possible to trace the transaction history and the individuals who use them.
Limits in Supply	Money can retain its value	If backed and conditional on fiat, it is relatively stable.	Can be created with no limits

Source: Authors

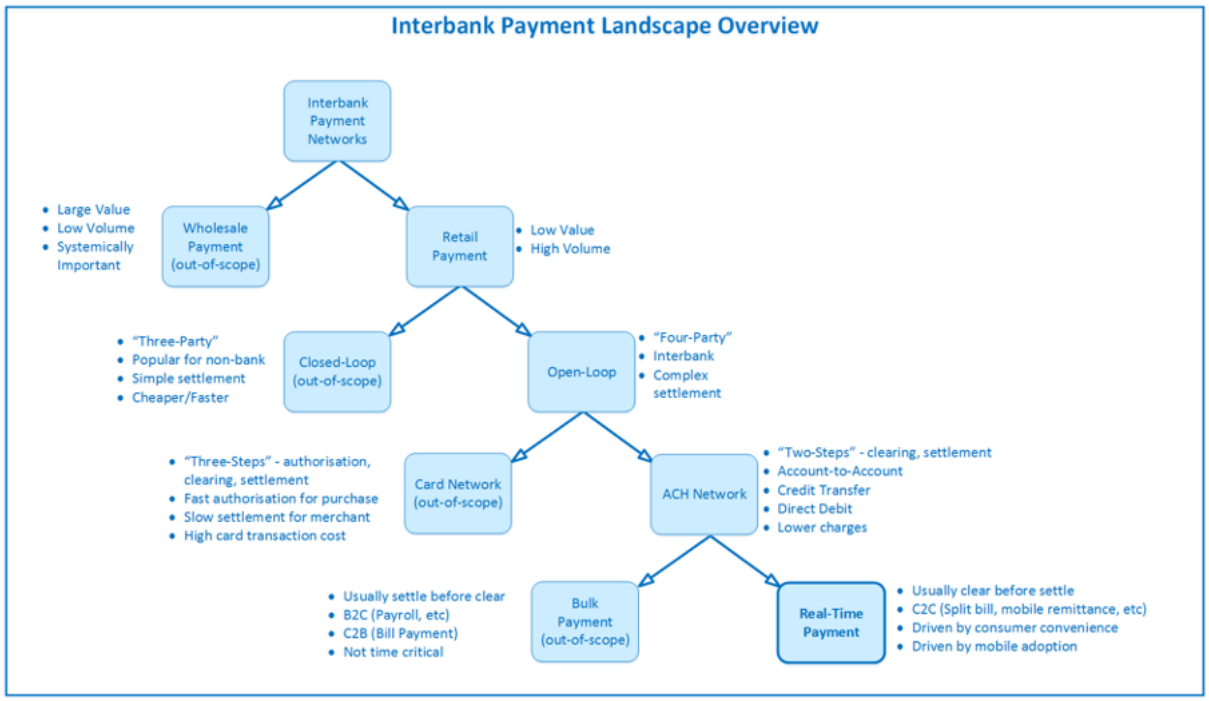
Much of the literature focuses on the extension of fiat money and its mechanism, partly because they fear that innovative money instruments may not fit in with century-old regulation, legacy systems and existing stable systems. The discussion tends to be centred on the approach of comparing physical and

electronic form, as well as comparing peer-to-peer and trusted third party. The creation of the asset and the smooth functioning of the exchange mechanism are the foundations of the monetary system. Naturally, the concerns are the response of the current system to the innovation, and whether there exists a systematic risk. From our discussions above, the general form of CBDC does have significant systematic risks beyond single bank risks, among other concerns such as the diminished role of the traditional banking business models.

3.5. Interbank Payment Network

Let us have an overview of the interbank payment landscape in relation to M0 and M1. Figure 1 below maps out the interbank payment landscape.

Figure 1: Interbank Payment Landscape Overview



Source: Lai (2018)

Lai (2018) discusses in detail the Interbank Payment Network (IPN). A payment system consists of a set of instruments, banking procedures and, typically, interbank funds transfer systems that ensure the circulation of money (BIS, 2003). In any country, either a wholesale payment system or a retail payment system is used as the IPN.

3.5.1. Wholesale Payment

A country's central bank usually operates a wholesale payment system (also known as large-value payment systems) for the transfer of systemically important, low volume, and high-value funds among banks and large corporations. There are generally two types of wholesale payment systems:

(1) A **Real-Time Gross Settlement (RTGS):** This system is used for settling funds between accounts on a per transaction basis in real-time.

(2) A **Deferred Net Settlement (DNS):** This system is used for the settlement of funds between accounts at designated times of the day on a net basis, usually done by consolidating a batch of transactions between accounts. Instead of settling them individually, only the net positions are settled after offsetting the batches.

However, most wholesale systems are hybrid and employ special techniques to minimise liquidity risks and credit risks. Given that these are centralised system, there are scopes for central banks to use DLT to achieve better efficiency as discussed in the Monetary Authority of Singapore's Project Ubin. The stages of references are given in Appendix 2.

3.5.2. Retail Payment

The **retail payment system**[32] (also known as **low-value payment systems**) is used for processing non-urgent, low-value and high volume transactions such as consumer payments. Retail payment systems can exist in two forms: closed-loop and open-loop.

3.5.2.1 Closed-loop

A **closed-loop system**, also known as the "three-party" payment system, requires both payer and payee to be on the same platform. It is usually adopted by non-bank entities for end-to-end, simpler, cheaper and faster transactions. Settlement can be achieved in one step via internal book-transfer as the transactions are managed by one entity.

3.5.2.2 Open-loop

An **open-loop system**, also known as a "four-party" payment system, is used to facilitate the transfer of funds between a payer and payee belonging to different banks. Since it involved a network of banks, settlements are more complex. Therefore, the banks have to appoint a licensed and trusted centralised third party to process and coordinate the transactions. There are two types of open-loop network: Card Payment (CP) and Automatic Clearing House (ACH).

[32] A retail payment system is a funds transfer system which handles a large volume of payments of relatively low value in such forms as cheques, credit transfers, direct debits, ATM and EFTPOS (Electronic Funds Transfer at Point of Sale) transactions BIS (2003).

a. Card Payment (CP) Network

A **Card Payment** network is an open-loop electronic fund transfer point-of-sale system (**EFTPOS**) for international payments between a payer and payee belonging to different banks. Notable examples are Visa and Master Cards. Here, the merchant holds an account with its bank to receive payments. The entire payment process involves authorization, clearing and settlement. The network usually has high transaction cost, slow settlement for the merchant and fast transaction for the purchase.

b. Automatic Clearing House (ACH) Network

An **Automatic Clearing House** network is another open-loop retail payment system that facilitates domestic fund transfer directly between banks (also known as **Account-to-Account** or **A2A** transfer). The original purpose of an automatic clearing house was to provide clearing and settlement services for paper checks between banks. The ACH is account-to-account credit transfer or direct debit with lower charges.

i) Bulk Payment

ACH batch payment systems operate only during normal working days. A specific clearing window of the day known as the outward clearing window is open for banks to submit payment instructions from their account holders to the ACH for validation and processing.

ii) Real-Time Payment

One of the most commonly publicised examples of RTPS is the UK's Faster Payment System (FPS) that was implemented in 2008. It has most of the characteristics of what most countries will expect out of having an RTPS. In 2014, FPS handled more than 1 billion transactions worth over $1 billion.

Naturally, with such complex and critical systems in place, it is natural to proceed with great care. Table 3 looks at how the existing system can accommodate the innovation of CBDC. In particular, in row 6, the Non-DLT Electronic Substitutes that focus on centralised ledgers may be more comfortable for adoption. The payment system infrastructure is an extension of the existing system with an emphasis on (1) Centralised Interbank Payments, (2) Bi-lateral Payments, and (3) Peer-to-Peer exchanges with third party trust. DLT Electronic Substitutes (in row 7) may be a form too innovative for the existing regulation and system to digest and accommodate.

Table 3 : Attributes of Various Forms of Money				
1. Private Physical Substitutes	Tokens and Notes	Non-Legal Tender	Private Money Physically Held	1. Peer-to-Peer, B2C or via Peer-to-peer Exchanges 2. No infrastructure needed

2. Physical Fiat	Cash and Notes	Legal Tender	From Central Bank and can be physically held, in Central or Commercial Banks	1. Through Central Banks, B2C or Peer-to-Peer 2. No infrastructure needed
3. Electronic Fiat	Bank Deposits	Legal Tender eMoney	In Central Bank	1. Centralized Interbank Payments 2. Bi-lateral Payments
4. Electronic Fiat	Deposits	Legal Tender eMoney	In Commercial Banks	1. Centralized Interbank Payments 2. Bi-lateral Payments
5. Electronic eMoney	eMoney in other forms including Credit and Debit Cards	Legal Tender eMoney	In Commercial Banks	1. Centralized Interbank Payments 2. Bi-lateral Payments 3. Peer-to-peer exchanges with third party trust
6. Non-DLT Electronic Substitutes	New Form of Central Bank eMoney	Digital Currencies	Centrally Issued and in Centralised Ledgers	1. Centralized Interbank Payments 2. Bi-lateral Payments 3. Peer-to-peer exchanges with third party trust
7. DLT Electronic Substitutes	eMoney	Crypto-currencies	By algorithm or decentralised organisations and on the DLT	**1. Centralised Interbank Crypto and Fiat Payments** **2. Bi-lateral Payments** **3. Peer-to-peer exchanges with third party trust** **4. Peer-to-peer decentralised exchanges**

Sources: BIS and Authors

We defined four types of new infrastructure settings for the systems described in the table:

(1) Centralised Interbank Crypto and Fiat Payments;

(2) Bi-lateral Payments;

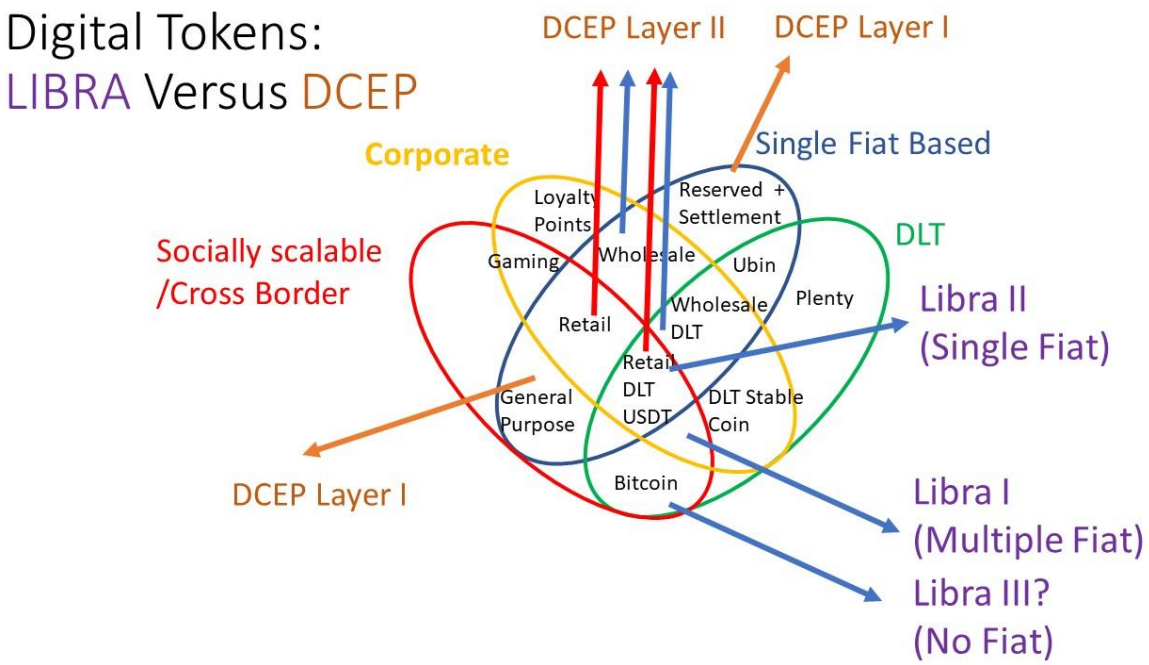
(3) Peer-to-peer exchanges with third party trust;

(4) Peer-to-peer decentralised exchanges.

All these new infrastructures will have implications for the existing system. Given the complexity of legacy issues, the inertial cost of the central bank to transform is higher for matured financial centres than merging markets or agriculture-based economies with lower linkages with international payments. It will be interesting to see if countries with similar characteristics such as Cambodia or Marshall Island will have a first-mover advantage and leapfrog their economies through digitalisation. The inertia cost associated with the possibility of the instability in the banking system and the inefficacy of monetary policy may slow down the transformation process. The more advanced and more internationalised the financial sector is, the higher the inertia cost.

Figure 2 below presents the diagrammatic classification of currencies and looking at the possible paths of Libra coin and Chinese's DCEP within the payment and settlement system. The possible configuration of Libra in the future (Libra III) and the second layer of the DCEP are purely speculative and a natural extension of the current design.

Figure 2: Digital Tokens – Libra Versus DCEP



Source: Authors

But the crypto-exchanges are now trading with 5,500 cryptocurrencies with a trading volume of USD102 billion with the domination by Bitcoin of 66%. Tether (USDT) is usually the most heavily traded cryptocurrency with digital tokens designed to replicate the value of the United States Dollar. As of May 23 2020, Tether (USDT) which claimed to be backed by the US dollar, has a market cap of $8.92B and a 24-hour USDT volume of $36.93B. It has a market cap ranked of 3 behind Bitcoin and Ether with a circulating supply of 8,913,502,390. Tether is traded on 125 exchanges. Tether had an all-

time high of $1.1059 over two years ago. Over the last day, Tether has had 5% transparent volume and has been trading on 8,188 active markets. By markets, it means the number of fiat or crypto-token markets using USDT to trade.

While there are close to 200 centralised exchanges, there are also decentralised exchanges (DEX) that operated without a central authority that allows P2P trading of cryptocurrencies. DEX does no rely on third-party services to hold customer's fund. Despite the small trading volume as compared to USD daily volume of USD5.1 trillion, the distributed nature of the payments and settlement network is interesting. The decentralized exchange network will change the way metals and other commodities are traded and funded, just as how they will stimulate M2M trading and settlement. While they are far from making an impact, the potential of decentralised exchanges will facilitate barter and minute trades when goods and services are tokenised and fractionalised. This innovation has future implications on the demand for fiat currencies and the CBDC.

3.6. The Europe and Asia Perspective

3.6.1 The Europe Perspective

Given the risk that we mentioned above about a general class of CBDC, it is not surprising that the focus of the developed economy is more towards maintaining stability and the effectiveness of its monetary policy. For example, the decrease in cash usage has led to the push for e-payments in Europe. Still, the existing regulations, the system of fiat money, and channels dictate the innovation of digital currency and payment systems. Some interesting discussions are in Mersch (2017), Bank of England (2020); Ward and Rochemont (2019), and BIS (2015, 2018, 2020a and 2020b).

The adoption of abovementioned infrastructure requires a considerable leap in mindset and a revamp of the entire payment system. Instead of worrying about the transition that can disrupt critical services, Switzerland financial regulator Finma was the first to issue two Crypto Bank Licences to Sygnum[33] and SEBA[34] with guidelines on payment on blockchain and rigorous approach to combating money laundering on the blockchain[35]. These entities can perform the functions of both traditional banking services as well as crypto-token related services, which mainly is a form of private key custody and involves a whole new set of crypto compliance. As computation law and crypto governance evolve, we will see more decentralised exchanges while such "banks" will be providing the infrastructure for open APIs and dApps. While trust cannot be distributed, there are new centralised entities to take on the role private keys custodian of tokenised goods and services, while disrupting the traditional commercial bank model that thrives on bank deposits.

[33] https://www.sygnum.com/
[34] https://www.seba.swiss/
[35] https://www.finma.ch/en/news/2019/08/20190826-mm-kryptogwg/

FINMA recognises the innovative potential of the "shift in trust" and applies the relevant provisions of financial market law in a technology-neutral way. It does not allow crypto banks to circumvent the existing regulatory framework, especially the rules for combating money laundering and terrorist financing, where the inherent anonymity of DLT and blockchain technology present increased risks. Financial Action Task Force (FATF) guidance on financial services in the context of blockchain technology must be closely followed. Institutions supervised by FINMA are only permitted to send cryptocurrencies or other tokens to external wallets belonging to their own customers whose identity has already been verified and they are only allowed to receive cryptocurrencies or tokens from such customers. SEBA Crypto AG registered in Zug and Sygnum AG registered in Zurich will offer services for institutional and professional customers only. While restrictive, it is considered a giant leap in Europe. However, in Asia, the regulations, innovation and experiments are moving at an even faster speed that has surprised many observers.

3.6.2. The Asia Perspective

The People's Bank of China (PBOC) was the first central bank to initiate a research group on cryptocurrency on the prospects for the introduction of a CBDC in 2014. We have summarised notable announcements by various agencies and associated news in Appendix 1.

However, Singapore was one of the first to launch the open-source code for a tokenised digital currency under the Project Ubin proposal which involved several international banks such as Bank of America Merrill Lynch, Credit Suisse, Hong Kong and Shanghai Banking Corporation (HSBC) Limited, JP Morgan, Mitsubishi Financial Group, two local Singapore banks and several other blockchain companies (R3) in 2016. The associated timeline of Project Ubin and Acts are summarised in Appendix 2.

In 2017, Japan recognised Bitcoin and other digital currencies as legal property under the Payment Services Act[36]. Japan's Financial Services Agency confirmed bitcoin and several cryptocurrencies as legally accepted means of payment in the country.

Subsequently, in the same year, the Bank of England initiated a global discussion on the prospect of the introduction of a CBDC. In 2018, the International Monetary Fund began examining the potential innovative nature of digital coins (crypto assets) and supported CBDC proposals publicly. Finally, in 2019, the tokenised debt was issued by the World Bank. Other initiatives by International Agencies and the USA are summarised in Appendix 3.

[36] http://www.japaneselawtranslation.go.jp/law/detail/?id=3078&vm=02&re=02

The three fundamental aspects of digital currency design are the asset, the payment, and the utility. Most of the discussion focuses mainly on the first two aspects except PBOC that has mentioned the use of DCEP for tokenisation of currently untraded services and goods.

Even though CBDC and DCEP can generally be classified by most as fiat money, there is a distinct difference. The Chinese have so far refrained from calling the DCEP as digital fiat yuan but only refer to it as digital money. One purpose of DCEP is to stimulate the trading of services and goods, China has given the DCEP enough flexibility to facilitate the selling of products and services that are currently not actively traded in the market. Some of these critical components of economic activities are excluded from the calculation of the actual GDP statistics but may constitute a large part in economic activities. Examples are time-based services or a stable asset token with underlying value. The timeline of the development of the Chinese DCEP can be found in Appendix 1.

While the earlier discussions of CBDC were centred around the payment functions, recent talks have switched to fiat currency in the form of digital tokens and assets. From the simple idea of money for transaction, speculative and precautionary motives, the studies have extended towards tokens as a form of money that serves as a unit of account, a store of value, a medium of exchange, and a standard of deferred payments. Money must be durable, portable, divisible, and difficult to counterfeit. PBOC has extended the discussion to tokenising services and illiquid goods.

The potential innovations associated with digital currency designs refer to both the tokenisation of the asset and services, as well as the P2P payment aspect. Any asset and services can be tokenised as an asset-bearing token, and whose liability is backed by the physical asset, legal entity, an object, or just an everyday service. The digital currency or token can be designed to be automatically created as an asset and yet not a liability of any party. The P2P payment allows for transfers between parties without the involvement of trusted third parties. Still, some other designs aim to create a network that works in isolation from (or with only a marginal connection to) existing payment systems. The model can cater to value-based applications that directly open accounts in a distributed ledger with payments of such tokens native to the network.

The only connection with the existing payment system would be the exchanges and trading platforms, where the digital tokens would be exchanged for sovereign currency, and where transaction fees are charged and the exchange rates determined by demand and supply. The earlier discussions were focused on efficiency improvement for existing regulated entities such as the banks in setting up a decentralised payment mechanism between payment service providers to improve back-office clearing and settlement processes. From end-users being unaware of digital currencies and distributed ledgers to a whole new mechanism that changes the way assets are stored, and payments are executed. These will change the way the society views currency and existing activities not captured in GDP calculations to be explicit

prices and trade. These latest discussions are certainly deviating from the earlier norm that distributed ledgers could be re-engineered and adopted to existing payment systems without involving the issuance of digital currency. This is a much broader mindset than the distributed ledgers which are simply used with a sovereign currency. PBOC has deliberately left the layer II architecture, beyond the level I creation of DECP, to the private sector, awaiting them to innovate and work hand in hand with the central bank. While this is true, not all central banks think like the PBOC research team.

3.7. A General Framework

There are two-tier considerations for CBDC. The first is the approach to the currency issue, i.e., how the digital currency will be issued. The second is the payments methods among wholesale banking and retail. The central bank can centralise the decision for the approaches, or they can relax the control on the payments once the digital currency is in circulation.

The major pain point for cash or M0 is the high costs associated with the issuance, print, withdrawal and storage of physical money in the form of notes and coins. Physical cash lacks portability, traceability and anonymity. It is vulnerable to counterfeit, money laundering, terrorism, and unknown criminal use. Meanwhile, existing non-cash payment tools such as credit and debit cards, Internet and app payment cannot replace M0 as they are dependent trusted third-party payment services. Furthermore, these other payments are dependent on institutions accounts that fail to support offline and anonymous payment services.

The main advantage of using the bitcoin UTXO (Unspent Transaction Output) is the possibility of offline payment, managed anonymity, and P2P payment without a centralised ledger. The design can be viewed as M0.5 as it retains the P2P offline Anonymity characteristics of M0, and yet traceability is similar as in M1. Unlike cards and institutional dependent payments, M0.5 can replace M0 with the added advantage of managed anonymity. However, this M0.5 concept is lacking in most central banks' design except China.

M0.5 combines the best features of a distributed system such as blockchain with the central bank's central management. As in Lee (2017), there is no conflict between decentralised ledger technology with central bank's centralised management. Although the technical characteristics of blockchain are not dependent on centralised institutions, they do not necessarily run contrary to the purpose of effectively integrating distributed operations with centralised governance and control. If appropriately designed, blockchain and DLT can effectively integrate distributed operations and better achieve centralised control of CBDC. There is no inevitable conflict between the two. For example, China utilised a three-layer general framework to understand and design their CBDC.

Layer 1 decision: The issuance of CBDC

Layer 2 decision: The Core-Satellite payment system that links the user

Layer 3 decision: The authentication, registration and query functions

In the first layer, the decision regarding the digitisation has to be made of how CBDC is issued. There is a choice between a centralised or distributed technology to sign and issue the encrypted digital string of money guaranteed by the central bank. Only the central bank is allowed to issue and burn the digital money or tokens created. However, these coins can be created and burned on a single or multimode blockchain or DLT where the central bank controls this core node.

Layer 2 refers to the underlying payment system. The core node of the system can be controlled by the central bank and other nodes can be either directly managed by the retail or there can be delegated nodes of commercial or wholesale banks. One design is to have central bank core deposits the CBDC on the core that can be a dedicated node on the private cloud or independent core node, which can be viewed basically as the central bank's cash operation management system. The satellite nodes or the user nodes can have their payments on the core node or have their own CBDC's dedicated cloud node. There seem to be no reasons why there cannot be two tranches, those that are designed as 100pc reserves account needs to designate 100pc CBDC holding and the fractional CBDC can create new credit.

The third layer consists of three clients: tokenisation, registration and analytics. Tokenisation or certification is to ensure that supply is limited and whether the underlying is an asset or just created as a balance sheet item.

To entice usage of CBDC, eMoney must be more convenient and less risky than the current payment system. Here are the critical designs behind a new breed of CBDC:

1. CBDC is guaranteed by the Government and retains its fiat currency legal tender status. Not all digitised fiats are legal tender and CBDC has to be directly backed by the Government to ensure universal usability.

2. The usage and deposit of CBDC do not take on corporate and credit risks of licensed entities or financial institutions. Not all digitised fiat are of the same risk, and therefore there are issues of bank runs and freedom of usage across different platforms.

3. Public-Private sector collaboration is essential in designing a new CBDC. There are a lot of considerations and no one party can claim to have the solution for scalability, both technical and social. So for cross border remittances and exchange, it becomes important to leave room for innovation amidst the tight regulatory environment.

The Board of the Bank for International Settlements (BIS) has established BIS Innovation Hub with central banks in Switzerland, Hong Kong SAR, and Singapore to foster international collaboration on innovative financial technology within the central banking community and the following[37]:

(1) identify and develop in-depth insights into critical trends in technology affecting central banking;

(2) develop public goods in the technology space geared towards improving the functioning of the global financial system; and

(3) serve as a focal point for a network of central bank experts on innovation.

Central banks are sharing their findings and open-source of their pilot programs to ascertain what would be the acceptable designs for a decentralised system for banks. As a new wave of private payment solutions arrive, the urgency is felt as these innovations may potentially leave incumbent financial institutions obsolete. Both China and Singapore are involving more private sector participation.

It is interesting to note that the structure and restrictions of CBDC, the payment system, and how complex the monetary system, will all affect the speed of adoption and experimentation. China is in a unique position because it is the second-largest economy in the world, and yet it is very isolated from complex financial instruments. Its fairly close system without exposure to international instruments trading, as well as more trading that will be done in RMB gives an added advantage and added urgency for it to adopt CBDC, since less complexity and lower risks mean fewer outcome uncertainties, unlike many central banks. Another important fact is that since China internationalised its currency, it needs to exert certain control over the direction of the RMB and hence its reserves. Matured financial centres and many central banks do not have the luxury or appetite for testing the resilience of using a CBDC as the cost of disruption is much too high for international standing.

At the end of the day, it is about a balance between legality and convenience, innovation and a one-size-fit-all regulation, substance and cosmetics, and cost and security. There is an opportunity to improve international payment systems with CBDC and banking regulation would have to keep pace with the use of DLT and Blockchain. There is not much time left before many central banks are left behind with ineffective payment and monetary systems.

The concerns of central banks are about private sector issuers taking advantage of their unique positions to possibly increase fees and lending rates, and privacy invasion if the public relies entirely on private money. The purpose of a central bank is to provide a fair, safe, liquid payment system equally to both the retail and wholesale sector. COVID-19 may trigger further financial crises and bankruptcies, and the public will suffer losses as well as interruptions in payments and settlements as seen in the global

[37] BIS to set up Innovation Hub for central banks.

financial crisis. The collapse in the letter of the credit system that caused three months of severe shrinkages in trade and disruption in the supply chain was an important lesson for international payment and related financing activities.

3.8. Comparing different central bank approaches to issuing digital currency

Banque or bank Gold or Banco was conceptualised in the early 1940s by John Maynard Keynes and E.F. Schumacher (1943). The value of any currency is inherently related to the demand and supply based and that in turn is based on the demand for international trade. Similar to the 1940s, the interest rate may not have enough policy potency to solve unemployment in the coming years. A unit of trade account may eventually be back in fashion, and this time, it is a unit of e-account to track the international flows of assets and liabilities. These may not be necessarily be tracked by an International Clearing Union, but instead through DLT of blockchain technology. While Keynes's idea was replaced by establishing the United States dollar as a reserve currency convertible to gold at a fixed price on demand by other governments previously, Libra and China may revive the idea. Libra Association, if successful, may resemble the Banco proposal with coins backed by the volume of trades. China, on the other hand, may execute the idea.

Keynes's Banco proposal has been revived several times since the GFC by Zhou Xiaochuan, the former governor of the People's Bank of China. He proposed the adoption of the International Monetary Fund (IMF) special drawing rights (SDRs) as a global reserve currency. His view was echoed by the United Nations and the International Monetary Fund during the same period. To simultaneously meet the demand for reserve currency and the twin goal of domestic monetary policy goals, there were calls for the reform of the existing system. Zhou Xiaochuan subsequently set up the Digital Currency Research Institute in Beijing with the view that digital payment systems and CBDC can compete with each other, and innovation can take place in private sector's infrastructure under the guidance and supervision of the government. We may just see a new DCEP system evolving together with BRI[38] modelled after the Banco, starting with a few fiat currencies.

Coincidentally, International Swaps and Derivatives Association (ISDA) has devised many standards for smart contract exploring issues of legal and regulatory uncertainty as market participants seek to apply new technologies, such as smart contracts and DLT, to derivatives trading. Legal guidelines for Smart Derivative Contracts from Master agreement, collateral, Equities, to Interest Rate Derivatives have been presented in a series of whitepapers and contracts since 2019[39]. Such ideas and established standards can be extended to tokenising commodities and services by China. DCEP is in the process of internally tested in four large cities — Shenzhen, Suzhou, Chengdu and Beijing satellite city Xiong'an.

[38] Zhou Xiaochuan (2009)'s speech on 23 March 2009.
[39] https://www.isda.org/2019/10/16/isda-smart-contracts/

Blockchain Service Network (BSN), ChinaChain, has now launched globally. ChinaChain, architected in part by Red Date Technology, launched an internet of interoperable blockchains that includes Ethereum, Hyperledger, and EOS. ChinaChain or Blockchain Service Network (BSN) will connect 128 cities in China to seven countries. McDonald, Starbucks and Subway have been named together with 16 other retail firms & restaurants to experiment and transact in DCEP[40].

Meantime in the UK after Brexit, the two purposes of liberalising the pounds by the Bank of England originally are made known publicly, especially the second one. First, the BoE is to regain its regulatory power that seems to have been given to the third-party payment units. Second is to revive the sterling as a universal currency so as to challenge the dollar hegemony. The second reason was voiced by the former Bank of England governor in the United States on August 23, 2019. These two reasons are perhaps expressed and pursued by many other central bankers. European nations have exported medical supplies to Iran as part of a mechanism set up to circumvent US sanctions on Tehran, ending their struggle over the past year to establish the INSTEX[41] barter system[42]. The creation of the INSTEX mechanism has enabled the export of medical devices from Europe during the COVID-19 Pandemic, and the arrangement would allow many other transactions to proceed. The USD dominant position is not automatically guaranteed.

Furthermore, CBDC resembles the controversial 1920's "100 percent reserve" idea of English Nobel prize winning chemist Frederick Soddy and later presented to US president Franklin Roosevelt by the Chicago School's Frank Knight and Henry Simons at the end of the Great Depression. The idea of "100% Money" was popularised by Fisher's book published in 1935 on the same title after receiving a summarised letter from Henry Simon that sparked his interest (William, 1993). The essential effect is to separate the money lending function from the money-creation function, thus allowing control of the size of the money stock being solely a government function. CBDC is undoubtedly a revival of the original ideas linked to Sovereign Money System, Full-reserve banking, Plain Money, and 100 per cent money. None of these ideas has taken root before. With technology, coupled with social and political pressure from inequality, governments may eventually be incentivised to adopt and accelerate these "unconventional" proposals. With a full reserve system, the idea of tontines and mutual aid on a blockchain can potentially be revived as a new approach to banking and to reach the financially excluded.

[40] https://medium.com/coinmonks/chinas-chinachain-launched-globally-starbucks-mcdonald-s-subway-to-test-china-s-dcep-12742832d778

[41] The Instrument in Support of Trade Exchanges (INSTEX) is a European special-purpose vehicle (SPV) established in January 2019.

[42] https://www.dw.com/en/europe-and-iran-complete-first-instex-deal-dodging-us-sanctions/a-52966842

The BoE has commented that DLT is not necessary for CBDC, as they may have been focusing solely on the importance of transaction purposes and regulating. They may have missed the empowerment by the distinct features of blockchain and associated cryptography techniques such as fractionalisation of ownership, data privacy, programmable currency, and multiparty sharing and computing. The convergence of blockchain technology with the Internet will be the future that no central bank should ignore. The idea of having an Internet of many blockchains[43] aided by other technologies such as IoT with external data verification with oracles is perhaps the ultimate infrastructure of the central bank in transforming the economy.

Most of the discussions outside China seem to have shied away from discussing the function of programmable money, smart contracts, oracles, Internet of Blockchain, and Convergence of Technology. CBDC can perform a more prominent role and solve the pain points of the currency economies, which presently rely on QE Infinity to prevent the economy from sliding. The long term solution can only be available if central banks are willing to broaden the discussion beyond transactionality and supervision objectives. Open comprehensive design for CBDC based on blockchain may be an exciting opening to a journey with a steep learning curve for all stakeholders. With Sovereign Wealth Fund such as Temasek Holdings[44] becoming a member of Libra Association and China venture into DCEP with many stakeholders, no governments can afford to be complacent, and rigidity is no more in the vocabulary.

4. Conclusion: what would likely happen in the future?

The suspension of the gold window in 1971 saw the end of the conversion of the metal to USD at a fixed exchange rate of at $35 per ounce. That led to the Bretton Woods system being replaced by the current freely floating fiat currencies since 1973. Since then, the monetary system has been driven by the fractional reserve system with USD acting as a global reserve currency. Besides, USD also serves as the default trading currency for commodities trading and in particular crude oil. Since 2008, the USA field production of crude oil has increased from 5 million barrels a day to a record of more than 12 million in 2020[45]. Demand for the USD has been growing over time. Continuous quantitative easing (QE) and the asset allocation strategy of Risk-Parity fuelled further demand for the USD and US debts.

[43] Polkadot and Cosmos are predicated on the thesis that the future will have multiple blockchains that need to interoperate with each other rather than individual blockchains existing in isolation. https://polkadot.network/ and https://cosmos.network/

[44] https://www.reuters.com/article/facebook-cryptocurrency-temasek/singapore-state-investor-temasek-joins-facebooks-libra-project-idUSL8N2CX07V

[45] https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpus2&f=a

It is not coincidental that Satoshi Nakamoto launched the Bitcoin Network in 2009 immediately after the global financial crisis.

The value of gold-backed currencies was rooted in the trust in gold. Free-floating fiat shifted the trust to the issuing Government in providing stability for the exchange system. Bitcoin, however, is viewed as a hedge against the collapse in the trust of the monetary system. Its value has a negative coherence with stability and trust in the fiat system. During a crisis of confidence, the trust in a Government may shift to the use of bitcoin as a medium of exchange, a store of value, and a unit of account, which is essentially the trust in the Community or Cryptography. While the loss in trust in the global system is unlikely, the loss in trust in a country monetary system happens frequently. However, the launch of bitcoin is a direct challenge to the notion of USD being the reserve currency of the world and therefore a replacement candidate for the entire fiat system. It is unlikely that it will happen but cryptocurrencies, like many other alternative forms of currencies during unstable times, are likely to be in existence for a long time, given that several countries have declared some of these cryptocurrencies as legal tender or part of the legal payment system.

Even as China begins regulation on cryptography and software, potentially making codes legal entities, there are still a lot of challenges for international law and governments to define cryptography, computational networks and code. Thus, it is difficult to have an international agreement on how to regulate cryptocurrencies. With cryptocurrencies making up a small composition of the monetary system, it is unlikely to destabilise the fiat system in the near term.

A more direct challenge to the fiat currency system and in particular the USD reserve system will be the non-fiat stable coin. Stable coins issued by non-government entities such as technology giants may stand a good chance of destabilising the USD based monetary system if regulation fails to keep up with technology development. On top of this, countries with limited resources may turn to the technology provided by these private entities (such as the Libra project) to create digital versions of their currency. With wide adoption, a country or a group of countries with massive trade and capital accounts collectively may exert pressure on the USD reserved based system in a very short period. That is a very likely scenario that we may see soon.

The fiat-backed corporate-issued stable coin may be less of a threat as these coins are likely to be heavily regulated even though they have a vast user base. However, as the use cases of these technology corporations grow, this may change. As mega apps emerge from tech giants with their own social platforms, telecom network, online broadcast, mobility, proptech, telemedicine and eCommerce with a large volume of trades, corporate-based stable coins may play a much more significant role than we can imagine at this moment. With its reputation and financial muscle, a fiat-baked corporate stable coin can

transform into a coin based solely on the trust of the corporation. A cross-border community based monetary and payment system may evolve and may pose a threat to the blockchain or DLT payment system initiated initially by governments.

5. Appendices

Appendix 1: The Timeline of Chinese Study of the CBDC

Central Policy Statement 中央政策声明		
Date	**Content**	**Source**
2014	央行就成立了发行法定数字货币的专门研究小组，论证央行发行法定数字货币的可行性 The central bank set up a specialised research group to issue and demonstrate the feasibility of the central bank digital currency	中国人民银行 People's Bank of China
Oct 2016	《中国区块链技术和应用发展白皮书（2016）》 China Blockchain Technology and Application Development White Paper (2016)	中国工信部 China Ministry of Industry and Information Technology
Dec 2016	国务院印发《"十三五"国家信息化规划》，首次将区块链技术列入国家级信息化规划内容 The State Council issued the "13th Five-Year Plan" National Information Action Plan, and for the first time included blockchain technology in the national informatisation plan	中国国务院 State Council of China
Jan 2017	中国人民银行正式成立数字货币研究所 The People's Bank of China officially established the Digital Currency Research Institute	中国人民银行 People's Bank of China

Jun 2017	中国人民银行引发了《中国金融业信息技术‘十三五’发展规划》：积极推进区块链、人工智能等新技术应用研究 The People's Bank of China has initiated the "13th Five-Year Plan" for the development of information technology in China's financial industry: actively promoting the application of new technologies such as blockchain and artificial intelligence	中国人民银行 People's Bank of China
Sep 2017	国内数字货币交易所被勒令关停，对加密货币持禁止态度；监管当局决定关闭中国境内虚拟货币交易所 Domestic digital currency exchanges ordered to shut down and cryptocurrencies banned; Regulators then decided to close virtual currency exchanges in China	中国人民银行、中央网信办、工业和信息化部、工商总局、银监会、证监会、保监会 People's Bank of China, Central Cyberspace Office, Ministry of Industry and Information Technology, General Administration of Industry and Commerce, China Banking Regulatory Commission, Securities Regulatory Commission, Insurance Regulatory Commission
Aug 2018	官方出台《关于防范以“虚拟货币”“区块链”名义进行非法集资的风险提示》 The official released of the "Reminder on Preventing Risks of Illegal Fundraising in the Name of 'Virtual Currency' and 'Blockchain'"	银保监会、中央网信办、公安部、人民银行、市场监管总局 Banking and Insurance Regulatory Commission, Central Cyberspace Office, Ministry of Public Security, People's Bank of China, General Administration of Market Supervision
Jan 2019	官方出台《区块链信息服务管理规定》以明确责任、规避安全风险，2019 年 2 月 15 日实施 Officially issued "Regulations on the Management of Blockchain Information Services" to clarify responsibilities and avoid security risks, which would be implemented on February 15, 2019	国家互联网信息办公室 Cyberspace Administration of China

Mar 2019	《关于发布第一批境内区块链信息服务备案编号的公告》 First batch of licenced blockchain service providers was released (197 licences)	国家互联网信息办公室 Cyberspace Administration of China
Aug 2019	央行将推进中国法定数字货币研发归入2019年下半年八项重点工作之一；央行有关负责人在公开场合表示正在进行数字货币系统开发，“数字人民币时代”即将到来；央行出台《金融科技（FinTech）发展规划（2019-2021年）》 The central bank decided to promote the development of China's legal digital currency as one of the eight key tasks in the second half of 2019; relevant officials of the central bank stated in public that the digital currency system development was underway, and the "digital yuan era" was to be launched - FinTech Development Plan (2019-2021)	中国人民银行 People's Bank of China
Sep 2019	中国人民银行行长易纲表示数字货币研究目前取得了积极进展，但数字货币推出目前没有时间表 People's Bank of China Governor Yi Gang said that digital currency research had made positive progress, but there was no timetable for the launch of digital currency	中国人民银行 People's Bank of China
Oct 2019	《关于发布第二批境内区块链信息服务备案编号的公告》 Second batch of licenced blockchain service providers was released (309 licences)	国家互联网信息办公室 Cyberspace Administration of China

Oct 2019	中共中央政治局就区块链技术发展现状和趋势进行第十八次集体学习，习近平强调区块链技术的作用 The Political Bureau of the Central Committee of the Communist Party of China conducted the 18th group-study lesson on the current status and trends of blockchain technology. President Xi Jinping emphasised the role of blockchain technology	中共中央政治局、中共中央总书记 Political Bureau of the CPC Central Committee, General Secretary of the CPC Central Committee
Oct 2019	第十三届全国人民代表大会常务委员会通过了《中华人民共和国密码法》 The Standing Committee of the 13th National People's Congress passed the "Cryptography Law of the People's Republic of China"	中央委员会 Central Committee
Nov 2019	《中国产业结构调整指南目录》拟稿中加入的加密货币挖矿（包括比特币挖矿）已移除，从 2020 年起将其从要禁止的行业清单中删除 Cryptocurrency mining (including bitcoin mining) added to the draft "Guide to the Catalog of China's Industrial Structure Adjustment" and will be removed from the list of industries to be banned from 2020	中国国家发展和改革委员会（发改委） National Development and Reform Commission (NDRC) of China
Dec 2019	深交所发布深证区块链 50 指数 Shenzhen Stock Exchange released the Shenzhen Stock Exchange 50 Index	深圳证券交易所、深圳证券信息有限公司 Shenzhen Stock Exchange, Shenzhen Securities Information Co., Ltd.

Jan 2020	央行、国务院等多个部门机构公布了 11 则促进区块链与各领域结合的政策信息 The central bank, the State Council and other departments announced information on 11 policies to promote the integration of blockchain and various fields	中国人民银行、国务院、银保监会、交通运输部、国家外汇管理局、广电总局、司法部等 People's Bank of China, State Council, Banking Insurance Regulatory Commission, Ministry of Transport, State Administration of Foreign Exchange, State Administration of Radio, Film and Television, Ministry of Justice, etc.
Feb 2020	央行发布、多家机构参与的《金融分布式账本技术安全规范》 "Technical Security Specifications for Financial Distributed Ledgers" issued by the central bank and involving multiple institutions	中国人民银行；由中国人民银行数字货币研究所负责起草，由中国人民银行科技司、中国工商银行、中国农业银行、中国银行、中国建设银行和国家开发银行等 20 余家机构参与 Drafted by the People's Bank of China Digital Currency Research Institute, with the participation of more than 20 institutions including the Science and Technology Department of the People's Bank of China, Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank and China Development Bank

Apr 2020	《关于发布第三批境内区块链信息服务备案编号的公告》 Third batch of licenced blockchain service providers was released (224 licences)	国家互联网信息办公室 Cyberspace Administration of China

Important Reports on Central Bank Digital Currency

Date	Content	Source
2016	《中国金融》I 专题：央行数字货币研究与探讨 "China Finance" Special Topic: Research and Discussion on Digital Currency of Central Bank	《中国金融》、巴比特网站 China Finance, 8BTC Website
2019	中国研发央行数字货币这五年 Five years of China's central bank digital currency R&D	《环球》 Global Times
2020	央行数字货币已开始内测；法定数字货币专利助力我国数字金融发展 The start of China’s DC/EP piloting; Patents related to CBDC would aid the development of digital finance in China	新华社 Xinhua News

Local Government

Date	Content	Source

Feb 2020	全国已有 22 个省(自治区、直辖市)将区块链写入 2020 年政府工作报告；更多地方政府有关区块链政策信息 22 provinces (autonomous regions, municipalities) included blockchain in the 2020 government progress report; more local government information on blockchain policy.	Various
Apr 2020	北京已开始使用区块链技术进行行政审批 Beijing's administrative approval process driven by blockchain technology.	国家互联网信息办公室 Cyberspace Administration of China

Corporate Development		
Date	**Content**	**Source**
Feb 2020	互联网巨头和传统金融机构均开始涉足金融科技 Internet giants and traditional financial institutions are both getting involved in fintech	Various

Appendix 2: MAS Timeline of Project Ubin, Digital Bank Licenses and Payment Services Act		
Date	**Phase**	**Source and Content**
Initiated: 16 Nov 2016 Concluded: 9 March 2017	Phase 1: Tokenised SGD	https://www.mas.gov.sg/schemes-and-initiatives/Project-Ubin https://www.mas.gov.sg/-/media/MAS/ProjectUbin/Project-Ubin--SGD-on-Distributed-Ledger.pdf MAS announced on 16 November 2016 that it would partner with R3 and a consortium of financial institutions on a proof-of-concept project to experiment with inter-bank payments using Blockchain technology.

Initiated: 5 Oct 2017 Concluded: 11 Nov 2017	Phase 2: Re-imaging RTGS	https://www.mas.gov.sg/-/media/MAS/ProjectUbin/Project-Ubin-Phase-2-Reimagining-RTGS.pdf?la=en&hash=02722F923D88DE83C35AF4D1346FDC2D42298AE0 MAS and The Association of Banks in Singapore (ABS) successfully developed a software prototype of three different models for decentralised interbank payment and settlements with liquidity savings mechanisms.
Initiated: 24 Aug 2018	Phase 3: Delivery versus Payment (DvP)	https://www.mas.gov.sg/-/media/MAS/ProjectUbin/Project-Ubin-DvP-on-Distributed-Ledger-Technologies.pdf?la=en&hash=2ADD9093B64A819FCC78D94E68FA008A6CD724FF MAS and Singapore Exchange (SGX) announced on 24 August 2018 that it was collaborating to develop Delivery versus Payment (DvP) capabilities for settlement of tokenised assets across different blockchain platforms. This would allow financial institutions and corporate investors to carry out simultaneous exchange and final settlement of tokenised digital currencies and securities assets, improving operational efficiency and reducing settlement risks. Three companies, Anquan, Deloitte and Nasdaq were appointed as technology partners for this project. They would leverage the open-source software developed and made publicly available in Project Ubin Phase 2. The successful conclusion of the DvP project was announced on 11 November 2018. The project demonstrated that DvP settlement finality, interledger interoperability and investor protection could be achieved through specific solutions designed and built on blockchain technology.

	Phase 4: Cross-border Payment versus Payment (PvP)	https://www.mas.gov.sg/-/media/MAS/ProjectUbin/Cross-Border-Interbank-Payments-and-Settlements.pdf?la=en&hash=5472F1876CFA9439591F06CE3C7E522F01F47EB6 https://www.mas.gov.sg/-/media/MAS/ProjectUbin/Jasper-Ubin-Design-Paper.pdf?la=en&hash=437222C94FD39314FB4C685EA31FC3AAA5CA5DA1 The Bank of Canada (BoC), Bank of England (BoE) and the Monetary Authority of Singapore (MAS) jointly published a report on 15 November 2018 which assessed alternative models that could enhance cross-border payments and settlements. The report examined existing challenges and considered alternative models that could in time result in improvements in speed, cost and transparency for users. The report, Cross-border interbank payments and settlements: Emerging opportunities for digital transformation, provided an initial framework for the global financial community to assess cross-border payments and settlements in greater depth. Specifically, it discussed how a variety of payment models could be implemented, from both a technical and non-technical perspective. MAS and BoC subsequently linked up their respective experimental domestic payment networks, namely Project Jasper and Project Ubin, and announced on 2 May 2019 a successful experiment on cross-border and cross-currency payments using central bank digital currencies. MAS and BoC jointly published a report, Jasper-Ubin Design Paper: Enabling Cross-Border High Value Transfer using DLT, which proposed different design options for cross-border settlement systems.

	Phase 5: Enabling Board Ecosystem Collaboration	MAS announced on 11 November 2019 the successful development of a blockchain-based prototype that enabled payments to be carried out in different currencies on the same network. The prototype network, developed by MAS in collaboration with J.P. Morgan and Temasek, had the potential to improve cost efficiencies for businesses. The payments network would provide interfaces for other blockchain networks to connect and integrate seamlessly, and would also offer additional features to support use cases such as Delivery-versus-Payment (DvP) settlement with private exchanges, conditional payments and escrow for trade, as well as payment commitments for trade finance. The network was currently undergoing industry testing to determine its ability to integrate with commercial blockchain applications. Beyond technical experimentation, this phase of Project Ubin sought to determine the commercial viability and value of the blockchain-based payments network. The project report would be published in early 2020. The report would describe the blockchain use cases that would benefit from a blockchain-based payments network, and set out additional features that the network could provide. In addition, the technical specifications for the connectivity interfaces that were developed will also be released for public access under Apache License Version 2.0.
7 Jan 2020	Digital Bank Licences	https://www.mas.gov.sg/news/media-releases/2020/mas-receives-21-applications-for-digital-bank-licences https://www.mas.gov.sg/regulation/Banking/digital-bank-licence https://www.mas.gov.sg/regulation/payments/application-for-a-payment-service-provider-licence MAS announced on 7 Jan 2020 that it received 21 applications for digital bank licences as at the close of application on 31 December 2019. This comprised seven applications for the digital full bank (DFB) licences, and 14 applications for the digital wholesale bank (DWB) licences. Applicants included e-commerce firms, technology and telecommunications companies, FinTechs (such as crowd-funding platforms and payment services providers) and financial institutions. The majority of applicants were consortiums, with entities seeking to combine their individual strengths to enhance the digital bank's value proposition. This was in response to its announcement on 28 June 2019 that it would issue up to two digital full bank (DFB) licences and three digital wholesale bank (DWB) licences. These new digital banks were in addition to any digital banks that Singapore banking groups

		may already establish under MAS' existing internet banking framework. The digital bank licences would allow entities, including non-bank players, to conduct digital banking businesses in Singapore. These new digital bank licences marked the new chapter in Singapore's banking liberalisation journey, and ensured that Singapore's banking sector continues to be resilient, competitive and vibrant. A DFB would be allowed to take deposits from and provide banking services to retail and non-retail customer segments. A DWB would be allowed to take deposits from and provide banking services to SMEs and other non-retail customer segments.
28 Jan 2020	Payment Services Act	https://www.mas.gov.sg/news/media-releases/2020/payment-services-act-comes-into-force https://www.mas.gov.sg/regulation/acts/payment-services-act On 28 Jan 2020, MAS announced the commencement of the Payment Services Act (PS Act). The new PS Act would enhance the regulatory framework for payment services in Singapore, strengthen consumer protection and promote confidence in the use of e-payments. It was a forward-looking and flexible framework for the regulation of payment systems and payment service providers in Singapore. It was to provide regulatory certainty and consumer safeguards while encouraging innovation and growth of payment services and FinTech.

Appendix 3: Other Notable International Initiatives, Research and Recommendations		
European Central Bank	Digital Base Money: an assessment from the ECB's perspective	https://www.ecb.europa.eu/press/key/date/2017/html/sp170116.en.html Digital Base Money: an assessment from the ECB's perspective Speech by Yves Mersch, Member of the Executive Board of ECB, at the Farewell ceremony for Pentti Hakkarainen, Deputy Governor of Suomen Pankki – Finlands Bank, Helsinki, 16 January 2017

ADBI	Money and Central Bank Digital Currency	https://www.adb.org/sites/default/files/publication/485856/adbi-wp922.pdf This paper gave an overview of the concepts and features of central bank money and private sector money and focused on the actual performance of these types of money in selected advanced and emerging economies. In addition, digital coins (crypto assets), such as bitcoin, were newly emerged private sector money. Much attention was given to digital coins because the underlying distributed ledge technology (DLT) could enable a decentralized verification process while maintaining features similar to cash.
IMF	Designing Central Bank Digital Currencies	https://www.imf.org/en/Publications/WP/Issues/2019/11/18/Designing-Central-Bank-Digital-Currencies-48739 This was a technical paper on the optimal design of a central bank digital currency (CBDC) where CBDC could be designed with attributes similar to cash or deposits, and can be interest-bearing. It argued that the optimal CBDC design would trade off bank intermediation against the social value of maintaining diverse payment instruments. When network effects mattered, an interest-bearing CBDC would alleviate the central bank's tradeoff.
IMF	Central Bank Digital Currencies: 4 Questions and Answers	https://blogs.imf.org/2019/12/12/central-bank-digital-currencies-4-questions-and-answers/ This blog discussed the role of the IMF and addressed the issues of financial stability, legal foundation and regulation.
Financial Stability Board	Addressing the regulatory, supervisory and oversight challenges raised by "global stablecoin" arrangements: Consultative document	https://www.fsb.org/2020/04/addressing-the-regulatory-supervisory-and-oversight-challenges-raised-by-global-stablecoin-arrangements-consultative-document/ This consultation set out 10 high-level recommendations to address the regulatory, supervisory and oversight challenges raised by "global stablecoin" arrangements.
Federal Reserve System	Update on Digital Currencies, Stablecoins, and the Challenges Ahead	https://www.federalreserve.gov/newsevents/speech/brainard20191218a.htm Governor Lael Brainard speech on the Monetary Policy, Technology, and Globalisation Panel at "Monetary Policy: The Challenges Ahead," an ECB Colloquium Held in Honour of Benoît Coeuré, Frankfurt, Germany December 18, 2019

Federal Reserve System	The Digitalization of Payments and Currency: Some Issues for Consideration	https://www.federalreserve.gov/newsevents/speech/brainard20200205a.htm Governor Lael Brainard At the Symposium on the Future of Payments, Stanford, California February 05, 2020
US Congress	The draft legislation "Keep Big Tech Out Of Finance Act"	https://www.consumerfinancemonitor.com/wp-content/uploads/sites/14/2019/07/Facebook-crypto-bill-HFSC.pdf A proposed bill to prohibit large platform utilities from being a financial institution or being affiliated with a person that is a financial institution, and for other purposes. It was proposed on July 15, 2019 by the Democratic majority of the House Financial Services Committee targeting Libra.
US Congress	A draft bill titled "Stablecoins Are Securities Act."	https://financialservices.house.gov/uploadedfiles/bills-116pih-ssa.pdf To establish the treatment of managed stable coins under the securities laws, and for other purposes. It was proposed on Oct. 18, 2019. This legislation was meant to regulate stablecoins, a cryptocurrency that would work as a non-volatile, stable source of value, under the familiar Securities Act of 1933.

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