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The benefits and potential risks of digital fiat currencies

June 2018

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from the British people

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1. Introduction

The release of bitcoin in 2008 triggered the rapid emergence of private digital currencies to disrupt and potentially challenge the efficacy of traditional financial systems. From Ethereum to Ripple, digital currencies and their underlying distributed ledger technology or blockchain can facilitate peer-to-peer (P2P) transactions between trustless counterparties that are faster, cheaper, convenient, and both more secure and efficient than traditional means of payment regulated by central banks (International Telecommunications Union (ITU), 2017: 10). It is for these reasons that digital currencies are considered as not simply competitors, but also potentially as substitutes for existing central bank sovereign fiat currency (Berger, 2016; Raskin & Yermack, 2016).

This potential for private digital currencies is, however, limited in a number of ways. Primarily, without the backing of a centralised authority or nominal anchor, digital currencies lack universal acceptance between buyers and all sellers as a valid means of exchange and unit of account. This is reinforced by the growing inefficiency of their payment verification systems that require connected digital devices to possess substantial computing power to complete "cryptographic proof(s) of work" that only process "between 7 and 10 transactions per second" (Barrdear and Kumhof, 2016: 6–7). This processing power is not only less than the current hundreds of thousands of transactions settled by major card payment processors per second; it is also relatively variable and capable of exposing merchants to counterparty risk (Barrdear and Kumhof, 2016). The volatility associated with its value additionally limits its usefulness as a store of value once verification processes are complete. The lack of consumer protection against these risks and against the potential for fraud consequently reduces their likelihood of achieving scale. Because of this, it appears that while private digital currencies may offer substantial gains to individuals, they are not necessarily capable of extending these benefits to the larger financial system.

In light of both the innovation and limitations of private digital currencies, central banks around the developed and developing world are now beginning to look into the possibility of introducing their own digital fiat currencies (DFCs) into circulation. These DFCs would be capable of both benefiting from existing technology, while overcoming the challenges faced by private alternatives. More importantly, if implemented correctly, central bank-backed DFCs have the potential to significantly transform both the accessibility and usage of financial services in respective economies and deepen financial sector development.

This may be achieved through the potential of DFCs to (i) enhance the efficiency of national payment systems, (ii) ease the convenience of payment processes through mobile phones as primary financial service instruments, and (iii) encourage the broad digitisation of traditionally cash-based societies. By doing so, digitised financial systems stand to benefit from more targeted monetary policy that has greater control over national liquidity flows. Lower transaction costs can be achieved by central banks through their reduced need to print, distribute and destroy physical cash from circulation, as well as by commercial banks who may save on costs associated with cash-handling and payment reconciliation processes that eventually translate into high consumer banking charges.

These cost savings, in turn, may result in greater net seigniorage[1] revenue received by central banks through reduced marginal costs to produce physical currency, and the improved uptake of more accessible, affordable, efficient and secure financial services on mobile devices.

These gains to financial market development and inclusion are, however, subject to DFC implementation that is considered and idiosyncratically tailored to a given context where, if hastily applied, could risk exposing consumers to cyber-attack, financial instability and even national payment system failure if proper enabling infrastructure and regulatory frameworks are not ensured. As DFCs are likely to impose substantial disruptions to national financial systems in these instances, it is important for central banks that are considering the implementation of DFC to do so with not only an eye on its benefits but also a sober understanding of its potential risks. This concept note aims to provide a brief assessment of both the benefits and risks of implementing DFC, as well as recommendations to assist central banks in optimising the value of this technology for the upgrading of national payments systems into the 21st century and beyond, and the promotion of economic development that is both digitally and financially inclusive.

[1] Seigniorage refers to the income that central banks receive from issuing currency, or, in other words, the profit derived from the creation of money. It is calculated as the market value of currency minus the costs incurred to either print notes or mint coins. Seigniorage is created when the market value of currency exceeds its associated production costs. Monetary authorities also earn seigniorage because of their ability to fund assets cheaply via banknote circulation and sight deposit due to their banknote monopoly (Swiss National Bank, 2018).

2. Defining a fiat currency

2.1. Criteria of a currency

To evaluate the potential of DFC, it is important to understand what a fiat currency is. According to Camera (2016), a currency is any object that is widely circulated to facilitate payment. To do so effectively, it must satisfy three prevailing conditions. Firstly, it must be able to act as a means of exchange between a buyer and all sellers. Secondly, a currency must be able to provide a store of value. This implies that a unit of exchange cannot merely be accepted momentarily, but in perpetuity. The purchasing power of currency should therefore not be based on intrinsic value, but rather on faith in its long run value (Camera, 2016). The achievement of this status enables a currency to act as a unit of account. This refers to the ability of a currency to act as a trusted measuring tool for the value of any good or service.

2.2. Fiat status

The accreditation of a currency to the status of "fiat" implies the validation of its three criteria by the authority of a sovereign government. In most countries, this status implies that its sole creation, issuance and distribution are conducted by, or under the auspices of, a central bank on behalf of a sovereign state. Fiat currency is consequently identified as the legal tender of a country by linking its value to the patronage of a government rather than the value of the instrument material. This provides fiat currency with the unique ability, which no other currency can claim to have in a given territory without the authority of the State, to "legally discharge financial obligations" (Camera, 2016). All private digital currencies today, such as bitcoin, do not function as legal tender or as fiat currency. This significantly impedes their ability to act as true currencies or compete with national fiat currency. This impediment, however, also presents central banks with the unique opportunity to take ownership of digital currency and define it in ways that enable the DFC to act as legal tender while preserving the inherent benefits of digital currencies.

3. Digital fiat currency (DFC)

3.1. Definition

A DFC can be broadly defined as standard fiat currency that resides in a digital or algorithmic format (Raskin and Yermack, 2016). According to a 2016 Bank of England (BOE) discussion paper, DFC is a universally accepted "24x7" accessible bearer instrument that is denominated on a one-to-one basis in the national currency and distributed exclusively by a Central Bank as legal tender for all public and private transactions (Barrdear and Kumhof, 2016; Bordo and Levin, 2017). This implies that DFC is seamlessly interchangeable with physical sovereign currency, and inherently adopts all three of its key features as a unit of account, store of value and costless means of exchange between transacting parties. The latter characteristic is particularly important, as it provides a distinction between DFC that citizens can use for retail purposes as a substitute or complement to physical cash, and DFC that the central bank and/or financial institutions can use to facilitate wholesale transactions on platforms such as Real-Time Gross Settlement (RTGS) systems (Bech and Garratt, 2017). This distinction is illustrated by the "money flower" diagram below (Figure 1), which shows both a clear distinction between wholesale and retail DFC, as well as the latter's distinction from other mediums of exchange that are either electronic, universally accepted, central-bank issued or capable of facilitating non-intermediated peer-to-peer transactions (Bech and Garratt, 2017). This diagram highlights retail DFC (hereafter referred to simply as DFC) as being seamlessly interchangeable with physical sovereign currency and inherently characterised by all three currency criteria as a unit of account, store of value and costless means of exchange between transacting parties.

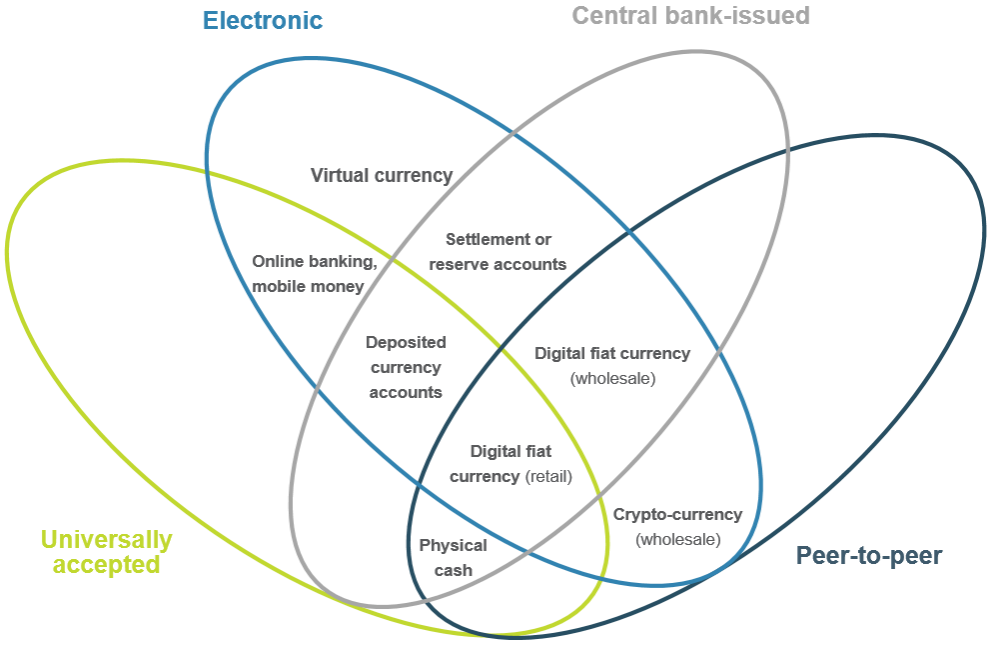

Figure 1: Digital fiat currency "money flower" taxonomy

Source: Adapted from Bech and Garratt (2017)

3.1.1. Ledger technology

The costless and frictionless nature of DFC highlights its key distinction from traditional forms of electronic money exchange, such as internet banking or online shopping, that typically incur banking/reconciliation charges to transact. Like private digital currencies, the elimination of banking charges stems from the location and distribution of DFC via distributed ledger technology (DLT). The ITU defines a DLT as a "secure database or ledger for keeping track of who owns [a] financial, physical or electronic asset[s]" that is replicated across multiple sites (or nodes), countries or institutions with no centralised controller (ITU, 2017). Each node represents a string of P2P transactions, each with its own unique private user key that has been verified, validated and resultantly linked to a "blockchain" in the absence of trust between transacting parties. This process of validation through some form of consensus among participants removes both the need for numerous intermediaries to settle and clear transactions, and the resultant charges for bank customers. The form and structure of this process of validation, however, will depend on the type of ledger technology utilised and the level of participation granted (Accenture Consulting, 2017).

3.1.2. Type of ledger technology

In the unique case of DFC, processes of payment validation and confirmation via the underlying blockchain technology critically differ from private digital currencies. Specifically, rather than mined and validated by miners, a DFC DLT is coded and regulated by a central bank as a trusted third party whose involvement in payment validation and distribution may differ depending on the type of permission and validation set for the DLT. According to proofs of concept developed by various central banks, and analysis from the private sector. DFC may be operationalised via three different types of blockchains that differ by permission, validation, access and level of user privacy: centralised, decentralised and a hybrid between centralised and decentralised. These are outlined in Table 1 on the next page:

Type of DLT	Level of permission	Validation	Access	User privacy	Examples
Centralised DLT	Access restricted to either only the central bank as the sole participant and holder of the ledger, or financial institutions Not replicated across sites	Provided by the Central Bank alone Commercial bank reserves with the Central Bank held in cryptocurrency rather than traditional electronic money	Licensed issuers Supply of DFC fixed according to the central bank	Peer-to-peer anonymity All private-user information known to the central bank only	Proposed by the Central Bank of Russia; Bank of Canada CAD-Coin
Decentralised DLT	Central bank acts as regulator over commercial banks and other financial institutions as participants	Digital ledger procedures overseen by participants such as validation, governance, issuance of user keys and ensuring KYC compliance	Participating financial institutions responsible for distributing DFC Users transact directly with each other rather than via banks as third-party intermediaries Supply of DFC dependent on market forces	Users issued with a private-user key linked to their financial information Peer-to-peer pseudo-anonymity with only the public address made known to other participants	Proposed by the Bank of England RSCoin
Hybrid	Central bank acts as regulator over and other financial institutions as participants	Decentralised validation of transactions via participants	Distribution decentralised among participants. Supply centralised and fixed by the central bank	Financial institutions act as traders of DFC	Proposed by Fedcoin and eKrona

Table 1: Potential variations of digital fiat currency

Source: Adapted from Accenture consulting, 2017; Bech and Garratt, 2017

3.2. DFC functionality

In addition to variations in ledger systems, DFC can differ by distribution. Bordo and Levin (2017) outline the potential for a token-based DFC distribution or an account-based distribution. A token-based DFC operates similarly to private digital currencies such as bitcoin in that DFC tokens circulate within the economy via a DFC wallet, which holds digital representations of bank deposit money. An account-based system implies the creation of DFC accounts held either at the central bank, or in "specially designated accounts at supervised depository institutions" (Bordo and Levin, 2017: 6). Commercial bank accounts and central bank accounts are linked under this approach and enable the instantaneous use of DFC from the central bank as a direct transformation of existing electronic money into DFC via the blockchain.

4. Benefits of DFC

DFC presents many opportunities to enhance financial-sector development and to promote greater financial inclusion.

4.1. National payment system efficiency

The distribution of DFC implies the removal of third-party intermediaries and the multitude of step-wise clearing and settlement procedures that typically protract P2P transactions over multiple days before achieving settlement (Bech and Garratt, 2017). This process is inefficient and typically exposes transactions to settlement and counterparty risks. It further acts as a barrier to the use of formal channels to remit small but frequent values across borders to individuals in immediate need, such as migrants (Ratha et al, 2011). Through DLT, however, payment of any kind is capable of encompassing systems of clearing, settlement, verification and reconciliation across multiple organisations, all in one step (Bordo and Levin, 2016). This enables faster settlements and longer trading hours when time-bound intermediaries are excluded from payment processes.

The minimisation of payment error and risk exposure can further enhance the resilience of national payment systems (NPSs). This resilience will be key given the need for NPSs to be interoperable with various digital devices as the primary mechanism through which DFC is exchanged. This degree of interoperability will, in turn, enable consumer-centric approaches of frictionless DFC payment services to the formally unbanked but digitally connected.

4.2. The digitisation of cash economies

DFC has the potential over time to digitise the entire payments value chain, from the first to the last mile, through universal uptake. Unlike private digital currencies or mobile money, this potential derives from its fiat status as a unit of account, store of value and, most importantly, a universally accepted medium of exchange that can promote adoption through network effects. Its speed, costlessness and safety as a digital currency that is backed by a trusted central bank may further instil public confidence in using DFC as a direct substitute for physical currency in P2P transactions. This substitution has the potential to act as a stepping stone towards the improved access and uptake of a wider array of financial services among the unbanked, following the accessibility and convenience of mobile-phone-based financial products such as mobile money, credit and saving. The use of digitised proof of ownership, or “smart property”, may be especially useful in enabling banks to provide digital loans by linking credit to digital collateral in the form of asset deeds located on government databases rather than to paper documents that can be lost, destroyed or modified (ITU, 2017; Prasad, 2018). As this process of validation may further lend itself to the insurance market, it is possible that the digital uptake of DFC may not only foster greater financial inclusion among the previously excluded, but also financial-sector development when more individuals can access debt and mitigate risk (Berger, 2016).

Towards achieving these outcomes, Bordo and Levin (2016) propose the possibility of imposing a graduated schedule of fees on transfers between cash and DFC to incentivise this substitution and eventual obsolescence of the former. The effectiveness of this approach, however, depends on the national level of mobile penetration, cash reticulation and digital literacy among low-income households in particular, who may not be ready to fully transition from cash to digital. It will also depend on the extent to which all primary payment channels are digitised and reliable in terms of effectively facilitating fast and secure payments.

4.3. Lower transaction costs

A more efficient and interoperable NPS offers significant cost savings for all participants currently inside and outside the payment system:

4.3.1. Commercial banks and business

Commercial banks and businesses have the potential to save costs that relate to bulk cash management, cash distribution and logistics. A recent study by Raskin and Yermack (2016) estimates savings relating to bookkeeping and operational processing to amount to between 50% and 80% of total operational costs. The efficiency of instantaneous and seamless payments without intermediaries is additionally estimated to reduce reconciliation costs in securities clearing and settlement by as much as 50% (Mainelle and Milne, 2016). Immediate interbank clearing and settlement of transactions further imply less costly operational processes and lower operational risk associated with multiple-day settlement lags (Bech and Garratt, 2017). A study by Santander InnoVentures (2015) estimates that USD15 billion to USD20 billion could potentially be saved annually by the broader banking industry as a result of these lowered reconciliation costs. Further shared savings could also be made by businesses through their ability to extract ledger information for efficient tracing, consumer recourse, data maintenance and hedging of data risk. This will enable more cost-effective and informed governance, compliance, accounting and auditing practices that are easier to implement and monitor over time. In addition to reduced maintenance costs of remote bank branches and ATMs, commercial banks and businesses may also benefit from lower costs associated with cash-in-transit robberies and the lives of security personal lost as a result. This cost may be substantial in some developing countries such as South Africa, where a rise in cash-in-transit heists by at least 104% has been observed between 2016 and 2017 (BBC, 2017).

4.3.2. Central banks

Potential costs-savings may be amplified for central banks as significant handlers of large volumes of cash in terms of producing, issuing, managing, storing, counting and destroying physical cash. These cost savings will be especially significant for cash-based economies such as those in the developing world. This is affirmed by an Indian Finance of Ministry report that estimates saving on cash handling in developing economies at between 5% and 7% of the gross domestic product, and at 1% to 2% in developed countries" (Berger, 2017). These gains are likely to be even greater in countries where physical money not only dominates transactions, but particularly where it is sufficiently well reticulated and costly to both produce and exchange. The resultant savings from enhancing digital transactions and

streamlining national payment systems may further allow for gains in capital investment as well as financial-sector development (ITU, 2017).

4.3.3. End-user

The most substantial savings on transaction costs are likely to accrue to the end-user as a result of reducing costs faced by both commercial and central banks (Fung and Halaburda, 2016). In terms of monetary costs, the use of DFCs will enable bank customers to avoid costly ATM cash withdrawal fees that typically range upwards from 2% to 5% of the withdrawal value (Bordo and Levin, 2017:7). These cost savings could additionally apply to online transactions fees, which may be lowered following the removal of layers of electronic settlement from payment procedures. This may incentivise the digitisation of prevalent cash-based transactions by individual, both within and outside the financial system.

This streamlining of payment processes may therefore particularly benefit individuals who make cross-border payments given the potential for DLT to eliminate the role of various intermediaries in the international money transfer market, such as foreign correspondent banks (Raskin and Yermack, 2016). By doing so, the typically high average cost of formal international money transfers may be significantly reduced to incentivise their optimal usage by the most vulnerable and excluded, such as migrants and refugees. Although an ITU (2017) study estimates this cost reduction to be as much as 75% based on a number of private digital currency projects, this value likely underestimates the true savings offered by DFC given its potential to overcome volatile and subjective currency conversion rates provided by money transfer operators (Fung and Halaburda, 2016).

DFC would also save on non-monetary transaction costs. These costs refer to the time and effort that would have been spent on travelling to ATMs to withdraw cash for exchanges, to remit money across borders through informal means such as bus drivers and to simply transfer money electronically when requirements exist for the acquisition and input of counterparty banking details before payments can even be initiated. (Fung and Halaburda, 2016). It is the reduction of these non-monetary frictions in P2P payments, in addition to those that are monetary, that will facilitate the wider effective footprint of DFC as a common medium of exchange and enable the scale of benefits for both users and financial service providers.

4.4. Monetary policy efficiency

The exclusive issuance of DFC by central banks offers substantial efficiency gains for monetary policy and the transmission mechanism. By using smart contracts to trigger the automatic adjustment of money supply according to an “algorithmic rate of money creation”, central banks will able to perfectly dictate not only the amount of liquidity within a given system, but also where this liquidity flows to within the country (Raskin and Yermack, 2016). This capability enables central banks to accurately meet money demand with money supply and to target intervention precisely towards regions or demographics that were previously cash-dependent and unaffected by interest rate adjustments. This level of knowledge may consequently allow central banks with the mandate of price stability to target prices directly, as opposed to inflation. Fernández-Villaverde and Sanches (2016) state that this level of digital currency control by central banks, and their use of DFC as a monetary instrument, may be more socially optimal compared to the existence of private digital currencies, given their profit-maximising motive to infinitely supply money.

The allocative efficiency of DFC is a particularly strong selling point for central banks in developed economies such as the United States where liquidity traps exist. In these economies, monetary policy has become ineffective at stimulating demand when consumers are incentivised to hoard physical money, as opposed to spending it, when interest rates fall to zero. The circulation of DFC rather than physical cash, however, enables central banks to not only overcome this behaviour by maintaining access to all liquidity on the DLT as money outside of closed-looped wallets, but to also use this liquidity to facilitate intermediation and the overall optimality of the money multiplier (Berger, 2017). This implies the enhanced capacity of monetary authorities to both stimulate economic growth, as well as incentivise more cost-effective loan disbursement by commercial banks to both banked and unbanked populations (Prasad, 2018).

4.5. Economic growth stimulus

The adoption of DFC via digital devices is expected to expand the size of the formal economy and positively affect economic growth as a result of the benefits mentioned above. According to a 2016 Bank of England (BOE) working paper, using a pre-crisis US economy as the benchmark scenario, the issuance of interest-bearing DFC amounting to 30% of GDP, against the equivalent in government debt, is estimated to permanently raise GDP by about 3% through reductions in the real interest rate, distortionary taxes and money transaction costs. Countercyclical DFC price or quantity rules are also expected to substantially improve the central bank's ability to stabilise business cycles as a second monetary policy instrument.

Business cycles could, however, additionally benefit from the establishment of new business activities that were previously deterred by high operational costs. The heightened velocity of money triggered by the speed and low-cost of DFC payments may also support these activities by promoting greater consumer demand, loan creation and company profitability (Barrdear and Kumhof, 2016; Franco, 2015). This would enable DFC to act as a pull factor for international business and partnerships through its provision of cost-effective and efficient exchange through smart contracts between distant and trustless partners.

Greater resulting economic activity, and improved databases to both identify and track transactional flows, may consequently allow for improved tax collection. By the same token, this implies the preserved or strengthened ability of the government to fund fiscal deficits or stimuli (Bordo and Levin, 2017). The capability to fund fiscal policy is conversely constrained when closed-looped private digital currencies are used and prohibit State access to "inside" private liquidity flows (Prasad, 2018). This exclusion consequently undermines the State's ability to redirect available funds to productive uses as the national financier of the real economy (Bordo and Levin, 2017). The use of DFC, however, ensures that all liquidity flows are "outside" private markets and are readily available on the DLT for government authorities to use towards financing economic policy. This capability may be an essential prerequisite for strengthening and deepening of financial-sector markets.

4.6. Improving the safety of transactions and stored wealth

One of the most appealing features of cryptocurrency is the level of security associated with transactions made through decentralised ledger systems (Yanqing and Xintong, 2018). Unlike centralised single systems, decentralised ledgers ensure that the history of all transactions, as well as their associated private user information, do not reside at one site but rather be

replicated across many sites or participants on the ledger (Accenture Consulting, 2017). This implies the invulnerability of stored wealth in the form of decentralised DFC to attack or the failure of any one node on a ledger (Wen, 2018). By distributing one's wealth across all network nodes in this way, DFC effectively eliminates the risk of systemic banking failure and the threat of cyber-hacking when the number of nodes on a DFC ledger is high enough and continuously active throughout the day (Yanqing and Xintong, 2018).

Depending on the level of permission granted and the extent to which private user information is centralised, DFC may have the added security benefit of enabling Central Banks to collect substantial data on financial transactions that take place on its ledger. This is enabled through the cryptographic algorithm embedded within each transaction that make transfers not only highly trackable, but also date and time-stamped (Berger, 2017). This implies greater powers of surveillance by central banks to lower risks of money laundering, tax evasion and other fraudulent activities. This level of information particularly allows for investigations into illicit flows and money laundering to become more efficient than those that typically require information from multiple sources across numerous single system banks. The consequence of deeper insights into transactional level data is an improved speed of forensic accounting and auditing which underpins an enhanced supervisory capability of a central bank to protect the value of its fiat currency. This capability may, in turn, promote the resilience of the financial and real economy as a key perquisite in promoting trust among banked and unbanked populations that may be sceptical of the value in adopting DFC.

4.7. Environmental sustainability

Account-based DFC may be significantly less energy-intensive than private digital currencies such as bitcoin. The computational process of mining or distributing bitcoin (which involves solving intentionally complex cryptographic puzzles) is a significant and a relatively wasteful use of CPU cycles and electricity according to research by Gupta, Lauppe and Ravishankar (2017). O'Dwyer and Malone (2014) estimate that the total electricity consumption of bitcoin during early 2014 was comparable to that of Ireland (roughly 5GW) in the same year. Deetman (2016) further estimates that at its current growth rate in computing efficiency and uptake, the bitcoin network could potentially consume as much as 15GW by 2020. This is similar to the consumption rate of Denmark in 2014.

Account-based decentralised DFC may require less computational capacity than bitcoin, and therefore less electricity. If decentralised, as proposed by Fedcoin, central banks will primarily control money supply through a decentralised set of authorised nodes (commercial banks) to verify transactions and prevent double spending. Under this regime, Gupta, Lauppe and Ravishankar (2017) indicate that DFCs will not require the expensive proof-of-work that is demanded by cryptocurrencies such as bitcoin. The central bank would rather act as a trusted third party for the verification and validation of payments, as well as a body with the sole right to add or modify node entries (Raskin and Yermack, 2016). This implies less computing power required than those of competing miners for bitcoin, as well as DFC usage that is more inclusive and accommodating to the needs of low-income and/or energy-deficient populations.

5. Potential risks associated with DFC

Although DFC offers crucial benefits to financial-sector development and inclusion, these gains may be threatened or undermined by a number of potential risks that this technology may additionally introduce to the system:

5.1. Security threats

Despite the inherent benefits of a decentralised blockchain with no single point of failure, there are security risks in storing all forms of wealth electronically. This is especially true for DFC given its digital representation of physical currency that is typically held by individuals as safety nets or stocks of wealth against financial crises. By placing this wealth under the direct supervision of the central bank, however, individuals risk giving central banks the "immense power to observe and potentially to control an individual's finances", according to Raskin and Yermack (2016). Although this ability may be useful for intervening in cases of fraud or money laundering, it could undermine privacy or even security of an individual's wealth if there is risk of central banks siphoning or manipulating public DFC for its own or fiscal debt policy agenda.

This risk of theft may extend further to outside hackers according Meilejohn et al (2013), who suggest that the "pseudo-anonymity" of private key identities may not necessarily be any more secure than those of private digital currencies. This implies that DFC users could still be vulnerable to Ponzi schemes or fraudsters, thus exposing consumers to security threats and the central bank to reputational risk if attacks on DFC are successful (Barrdear and Kumhof, 2016). Although these risks may be more salient for DFC based on centralised ledgers with fewer nodes, their possibility highlights the critical need for central banks to maintain national payment systems that are resilient to cyber-attacks and infrastructural shortfalls as a prerequisite for DFC (Camera, 2016).

Resilience may critically hinge on the ability of underlying ledger technology to be agile to new technological developments such as quantum computing. According to Dr Bruno Huttner, a cryptocurrency specialist, the emergence of quantum computing within the next decade could pose significant risks to cryptocurrencies given its capacity to generate large numbers of outcomes in relatively short periods to potentially infiltrate multiple nodes on a decentralized decentralised ledger instantly and simultaneously (GIP Digital Watch, 2018). This reinforces sentiments by David Wen, co-founder of eCurrency and chair of ITU Focus Group on Digital Fiat Currency at International Telecommunication Union, that DFC cannot depend on data structure for security in the same way as Bitcoin does. Substantial hardware encryption of DFC will instead be required to hedge against attack and various unknown fragilities. These provisions will be essential to maintaining confidence in the value of DFC and the central bank as its trusted regulator.

5.2. Technology obsolescence systemic risk

As with any innovation, DFC has the potential to significantly disrupt existing technological systems. A key danger in this regard is the potential for systemic risk in cyber fraud as a result of low technological interoperability and obsolescence. In other words, in the absence of preceding efforts to update existing technological systems to ensure their interoperability and capacity to manage large flows of DFC, loop holes in oversight and management may create payment vulnerabilities capable of being exploited by cyber attackers (Prasad, 2018). Backward interoperability, as opposed to its upfront reform, is a key problem that has exposed recent technological innovations such as bitcoin to fragmented uptake and security breaches (Prasad, 2018). As banking and P2P become more electronic, this danger of system incompatibility is likely to become systemic and destabilising to the entire financial system. The avoidance of this scenario may therefore require substantive efforts to both harmonise existing technological systems as well as to ensure its interoperability. This process would need to, however, focus on the interoperability and technological neutrality of existing participants within the payment system if DFCs are to operate on existing payment rails rather than necessitate entirely new infrastructure (Wen, 2018).

5.3. The obsolescence of fractional reserve banking

A popular concern raised on the implementation of DFC regards the role of commercial banks and intermediation (Accenture, 2017; Raskin and Yermack, 2016; Berger, 2017). This refers to the fear that if a central-bank-issued DFC became the central medium of exchange in an economy, it would imply the cryptographic storage of liquidity and the effective obsolescence of commercial banks as "custodians of deposits" (Raskin and Yermack, 2016). Relative to DFC wallets, the storage of wealth in accounts at commercial banks would be inconvenient, costly and insecure (Berger, 2017). This new reality may, in turn, limit the ability of commercial banks to accumulate central bank reserves and contribute to the money multiplier as primary intermediaries of credit. By doing so, sceptics warn of the possibility for DFC to endanger the stability of the banking system and trigger bank runs if its implementation is not gradual and considered.

However, while it is true that the introduction of DFC should be graduated, its contribution to the removal of commercial banking is unlikely. Although it is true that value would be stored cryptographically, the access of banks to these funds should not be any different from current methods of electronic intermediation. The absorption of disintermediation duties from commercial banks by the central bank would not only be cumbersome, but it would also defy the mandate of central banks across the world. Furthermore, DFC is a direct representation of physical currency – not a tool for intermediation by commercial banks – and therefore should not be engineered as such (Prasad, 2018). Limitations on DFC functionality may therefore require greater supervision by central banks to monitor the incentives of commercial banks in their adaption and circulation of DFC for maintained financial stability. Investigations into the impact of DFC on commercial bank revenue generation may inform central bank understanding of these incentives given the potential for ledger technology to eliminate key banking activities that are currently key sources of economic rent such as correspondent banking and banking fees (Prasad, 2018).

5.4. Regulatory risks

The introduction of DFC has the potential to fundamentally alter both national and international payment systems. The effective implementation of this new medium of exchange may therefore imply risks to existing financial and payment regulation if an enabling regulatory environment is not created prior to the release of DFC.

On a national level, DFC could significantly challenge existing laws on the definition of legal tender, its supervision and the distribution of DFC as legal tender (Prasad, 2018). Financial and banking regulation may additionally need to be reformed to stipulate the role and functions of DFC, how it interacts with existing payment systems, as well as who can or may distribute and store account-based DFC on behalf of customers. In the absence of clear considerations on how to ensure the inclusion and interoperability of new and existing payment participants, asymmetric information and payment frictions could risk delaying adoption and undermine confidence. Lack of ownership and infrastructure neutrality considerations may further lead to capture of DFC by large banks and inhibit the interoperability needed to support the frictionless distribution of DFC.

On an international scale, national DFC presents substantial legal risks to the flow of cross-border payments. The legislation of a DFC in one territory may not necessarily align with the currency, payment or banking regulation of another (GIP Digital Watch, 2017). The absence of payment regulation harmonisation or informal agreements between countries could potentially impede international DFC transfers and impose transaction costs to undermine their efficiency. DFC could additionally challenge international interoperability standards necessary to ensure the capability of global payment infrastructure to receive and send values in this medium. If these considerations are not made, DFC may not only disrupt the payment of a single economy, but also catalyse global financial contagion.

5.5. Crowding out of private digital currencies

According to sceptics, the ability of DFC to achieve scale implies the potential crowding out of existing private digital currencies, such as Ripple, who currently compete with fiat currency as a medium of exchange. This development risks both inhibiting competition as well as innovation in cryptocurrency. This is particularly concerning for Fung and Halaburda at the Bank of Canada (2016) who doubt whether central banks possess the necessary comparative advantage to develop and implement DFC. Although central banks may recruit expertise from the competing private sector, Fung and Halaburda (2016) are sceptical on the likelihood or success of this plan. This scepticism, however, rests on the assumption that external recruitment would take place rather than the outsourcing of DFC development. By adopting the latter, central banks will be able to preserve and stimulate private-sector competition (Prasad, 2018). Innovation in both private and fiat digital currencies may therefore improve and offer greater benefits to consumers who may choose one or both currencies.

5.6. Environmental risks

The conservation of energy by DFC depends critically on whether it is account-based and can be distributed without processes of mining unique tokens. It also depends, however, on the size of the DFC ledger and the number of participating nodes. While electricity may be

conserved when DFC is account-based and centralised, token-based DFC on a decentralised system may consume equal, if not more, power than private digital currencies. This distinction suggests that in order to conserve energy, countries adopting DFC may have to forgo the high level of security associated with decentralised ledgers. To ensure the viability and sustainability of DFC, especially in power-constrained developing countries, appropriate technology will be required to develop clean and efficient DFC distribution mechanisms that do not undermine their cost-effectiveness or security of transactions. This may require hybrid derivations of DFC to be developed to suit the needs of individual economies.

6. Recommendations for DFC implementation

DFC has the potential to produce substantial payment efficiencies, economic gains and financial inclusion for all participants along the payment value chain through fast, cost-effective, proximate, convenient and secure P2P transactions. To ensure, however, that these benefits not be undermined by the suggested associated risks of DFC, a number of prerequisite conditions may need to be considered by central banks prior to the establishment and roll-out of this new cryptographic innovation.

6.1. A resilient financial system

A consequence of near instantaneous transactions between individuals and financial institutions is the significantly reduced time that regulators, policymakers and market participants will have to react and manage payment disruptions or threats. The immediacy of interventions highlights the need for regulators to ensure the resilience of future financial ecosystems before the unbundling of their current form (Stewart, 2017). This will mean the building of new technical capabilities and organisational structures by market participants to monitor and manage decentralised DFC blockchain transactions for monetary and financial stability (Berger, 2017). Current RTGS systems may need to become more robust during the transition from electronic to DFC transactions to accommodate larger volumes of transactions and potential hacking activity (Scorer, 2017). Cyber-security safeguards will additionally need to be a key consideration to ensure that DFC user information can be sufficiently protected before its adoption.

Blockchain or derived technology processing the eventual volumes of P2P and P2B transactions will require a high degree of robustness to manage rapid flows at a national level to be fit for purpose in retail applications. This implies obtaining a significant amount of computing capacity by central banks and/or other market players as the key infrastructure to support and maintain DFC capacity. Although DFC should not be as energy-intensive as digital currencies such as bitcoin, it may nevertheless require a sufficient amount of reliable power generation across diverse sites. This requirement, in addition to sufficient security to offset potential vulnerability to cyber-attack, will be essential to avoid shut-downs of DFC. DFC that is not supported by a large and diverse computing array in respect of security will require additional safeguards inter alia robust cryptography, detection and isolation functionality.

6.2. Consumer and business privacy controls

Privacy is a key differential attribute possible with DFC that would lend it to higher consumer acceptance than with private crypto-currency offerings. The extent of protection of consumer privacy will determine the rate and degree of acceptance.

Legislators, regulators and central banks will need to implement strict safeguards on the privacy of user transaction and account data to ensure that access to DFC by participants is not constrained, threatened or manipulated by external forces (Stewart, 2017). This implies the need for precise, deliberate and effective regulation to protect the privacy of users from not only malicious forces, but also state institutions such as the central bank and national authorities that may seek financing or evidence of illegal activity respectively. These regulations should, however, not undermine but rather strengthen anti-money laundering/counter-financing of terrorism efforts by financial intelligence authorities. Regulatory reforms should additionally occur before the implementation of DFC to allow for its seamless and frictionless roll-out.

A key step towards this would be the promulgation of legislation and/or regulation that subjects formal access to user information to strict substantive legal processes. This could be achieved through the application of special judicial warrants to grant access to DFC transactional data. To preserve consumer trust and usage, such a special judicial warrant should not be administrative nor routine in nature, but rather exceptional and very specific in extent and always granted by a sitting judge in chambers upon solid factual evidence of a prima facie case. Furthermore, any such warrant should not provide precedent for other access nor additional areas of enquiry. It is also recommended that consumer information acquired in any other method than a special judicial warrant be declared void for all current and future legal or state proceedings and derivatives thereof. The possession or dealing with such information in any unauthorised instance should be declared a serious crime. In all other instances, DFC private user transaction data should be protected by cyber-security safeguards and the level of idiosyncratic “permission architecture” designed into the DFC blockchain of a given economy. Barrdear and Kumhof (2016: 10) suggest that the optimal design of this architecture may exist through a blockchain that is distributed, to preserve the efficiency and resilience of the payment system, but permissioned to limit public access to private user key information.

6.3. Consumer protection and recourse

Recourse mechanisms should be in place to enable consumers to retrieve or recoup their funds if security and regulatory measures fail to protect value against theft, misappropriation or value lost during transactions. In the case of escheat losses, or untraceable fund loss, guidelines will need to be established for the investigation between the regulator and the consumer. The loss of traceable or hacked funds will also need to be accounted for through the establishment of a reconciliation process. This process should accept reimbursement requests via due process, but at some cost to the consumer to fund investigation procedures and deter moral hazard effects. This mechanism will be essential to promoting consumer trust and adoption of DFC (Berge, 2016).

6.4. Financial literacy

The widespread adoption of DFC, in developing countries in particular, will require a sufficient level of financial literacy within the population to understand the value of digital currency and how to use it (Stewart, 2017). Stewart (2017) advises the initiatives to expand public knowledge on how DFC and paper money are created. This may be established within schools or through public–private initiatives (Stewart, 2017). However, in regions such as sub-Saharan Africa where more than half of the population is financially excluded, it may be

useful to not only promote the existence of DFC, but also its usefulness and cost effectiveness relative to the pervasiveness of cash (Elixirr, 2017). Acceptance would require readily accessible points of conversion to paper currency sequenced with wholesale and retail value chain digitisation to provide value chain demand and physical cash equivalence use cases.

6.5. Digital and financial inclusion

Access to connectivity and the cost of mobile data present a serious hurdle to low-income individuals to adopting and using digital devices for financial services (Stewart, 2017). To incentivise their utilisation of DFC will therefore require improvements in digital connectivity infrastructure to enhance the speed of connectivity, especially in rural geographies, and reduce the cost of optimal mobile phone usage. Overcoming this divide between the "superconnected" and the disconnected will be crucial to reducing the perceived cost of DFC, enabling broader financial inclusion to additional mobile services such as money credit and insurance (Stewart, 2017).

The increased potential market scale possibilities for DFC can provide some scope for digital handset financing and distribution. DFC will likely reach scale in connected urban areas and move outwards to more rural areas that have more compelling use cases but less concentration of wealth. The adoption of DFC could also be improved among poorer unstructured supplementary service data (USSD) mobile phone owners by utilising mobile money operators as intermediaries to translate mobile money into DFC and vice versa. This may overcome compatibility constraints between powerful internet-based DFC applications and antiquated feature mobile phones, but risk mitigation measures, inter alia, enhanced wallet class structures would be required. Subsidisation of DFC network connectivity costs by central banks, such as in Ecuador, may be a further solution to overcoming digital inequality (Lervik, n.b.).

6.6. Efficient cash reticulation

The gradual and natural transition away from physical currency towards the uptake of DFC, as foreseen by Bordo and Levin (2017), will initially require an efficient cash reticulation system to operate adjacent to DFC systems. This implies the need for circulation of cash within an economy at such high velocities that the increasing expense of handling cash incentivises the adoption of DFC by businesses and consumers as the relatively more cost-effective and convenient payment option. This system, in addition to potential imposition of monetary penalties on the use of cash for large frequent transfers, may encourage the eventual digitisation of the economy (Bordo and Levin, 2017). This new state would additionally reduce the drag of cash on the money multiplier as an effective leakage of liquidity from the financial system. Economies where physical cash distribution is inappropriately priced due to regulation or where the market competition has resulted in the mispricing of cash by the setoff of the cost of cash against credit product margins, would struggle with DFC adoption. In those instances, either cash would need to be repriced or financial institutions would need to drive adoption to reduce their internal cost structures.

7. Conclusion

The successful development and introduction of DFC could imply substantial spill-over effects for national economies through the provision of a fast, cost-effective, secure and convenient P2P and P2B medium of exchange. Through its national adoption, DFC use may translate into enhanced monetary policy and money multipliers, the digitisation of payment systems that are more efficient and resilient, lower transaction costs to stimulate optimal spending and cross-border payments, improved financial inclusion and economic growth based on circulated currency that is secure and environmentally sound.

By realising that these benefits from DFC may be associated with significant risks to consumer privacy and financial stability, however, it is clear the success of this positive and innovative technology cannot materialise unless necessary safeguards and prerequisites are in place. These should include a clear regulatory framework and mandate on the issuance of DFC as a form of national currency, the enforcement of DFC as legal tender; appropriate consumer privacy regulation, cyber-security programs, robust infrastructure, and currency and payment systems that are both efficient and resilient in respect of the transition from cash to digital. In identifying these considerations for successful implementation, however, it is important to note that these are not exhaustive. On the contrary, further research should be conducted to more robustly identify real and substantive risks to DFC than have currently been identified in a recent, albeit limited, literature. This research will be essential to ensuring that the introduction of DFC disrupts rather than destroys existing financial architecture, and it is able to effectively provide the impetus for enhanced and inclusive e-commerce (Berger, 2017).

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