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CBDCs: Innovation Transcending Public Money

*Mihnea Constantinescu**

Abstract

This article provides a brief overview of the main characteristics of the existing two-tier public money payment architecture while emphasizing the numerous trade-offs that are necessary to achieve the second-best arrangement currently in use. Reforming this arrangement requires taking into account many of the old economic and legal constraints while considering the benefits of new available technologies. Some possible avenues for the joint *development of central bank digital currencies (CBDCs) and cryptocurrencies and assets are outlined. Particular attention is paid to the role and function of money in a digital, data-driven economy.*

A The Background

The inception of the current wave of innovation in decentralized finance (DeFI) and cryptocurrencies can be traced back to 2008, with the emergence of Bitcoin. This seminal moment was marked by the publication of a 'Whitepaper'[1] that spanned a mere nine pages, in which an unknown entity known as 'Satoshi Nakamoto' proposed a pioneering messaging system that functions without a central relay server and facilitates the coordination of an online digital ownership ledger. This event is widely considered to be the birth of cryptocurrencies, giving ample momentum also to the technology that underpins them. Cryptocurrencies are digital assets that exist exclusively in an anonymous and trustless online environment, robust to the possibility of malicious activity in manipulating the content and structure of the digital ledger. They are designed to be exchanged using private and public keys. However, the groundwork for such exchanges was laid before the publication of the Whitepaper.[2]

Contrary to popular belief, central banks have been at the forefront of innovation in the field of payments even before the recent wave of technology-driven enthusiasm. For instance, the Bank of Finland proposed a decentralized peer-to-peer payment clearing solution in 2007.[3]

* Mihnea Constantinescu, (https://orcid.org/0000-0002-2700-2589), University of Amsterdam and National Bank of Ukraine, email: m.constantinescu@uva.nl. Disclaimer: The views expressed in this paper are solely those of the author and do not necessarily reflect those of the National Bank of Ukraine.

1 https://bitcoin.org/bitcoin.pdf.

2 A. Narayanan & J. Clark, 'Bitcoin's Academic Pedigree', *Communications of the ACM*, Vol. 60, No. 12, December 2017, pp. 36-45.

3 L. Harry, 'E-settlement: Soon a Reality?' *in* S. Millard, A. Haldane & V. Saporta (Eds.), *The Future of Payment Systems*, 2007, pp. 206-229.

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There is disagreement among scholars about Bitcoin's main source of popularity and longevity. While some attribute it to the new technology (i.e. blockchain), others attribute it to its status as private money. For a long time, state money was exclusively the domain of kings, governments and, in more recent times, central banks. It is likely that both of these features have played a role in the success of cryptocurrencies to different degrees over time. However, the failures of the past, both from the early days[4] and more recent, have demonstrated that technology alone is insufficient to guard against malpractice and theft. Cryptocurrency exchanges, which have introduced some centralization elements to reduce inefficiencies in peer-to-peer trading, have succumbed to the same issues as their historical counterparts. Cryptography alone is no match for greed, unreliable processes or fragile and untested technical configurations. The need for efficiency eventually gives way to various degrees of functional centralization.

Private money, which lacks a government anchor,[5] has rarely achieved the critical mass or long-term stability required to challenge state money. Throughout history, it has been difficult to achieve and maintain network effects without the explicit fiscal support of a sovereign conducting monetary policy in a transparent and accountable manner.[6] Furthermore, the law, which is another exclusive privilege of kings and governments, has helped state money maintain its rock star status despite occasional underperformance. More than once, historical events have taken centre stage, leaving governments with little choice but to debase their currency. Too frequently, fiscal deficits have been financed by pushing the central bank far beyond its seigniorage capacity.

Seigniorage, which initially was the difference between the face value of money and the cost of producing it, is also present in many cryptocurrencies' monetary designs. It is not limited to one actor but can potentially be distributed among several, with governance priorities encoded in the algorithm. Taking things one step further, transactional conditionalities embedded into algorithmic promises of future repayments paved the way for smart contracts. These software components, designed to enhance a cryptocurrency's payment function, facilitate transparent and rapid contract performance assessment. The democratization of money creation and contracts is a significant driver of the initial adoption of many cryptocurrencies. However, their lack of regard for the historical lessons that led to the current state of money systems poses a significant obstacle to their further development.

The radical nature of Bitcoin and Ethereum, as alternative *payment systems*, can be seen as a response to decades of work on cryptographic algorithms[7] and

4 https://archive.org/details/MTGox20140217Announcement.

5 F. Mishkin, 'International Experiences with Different Monetary Policy Regimes', 1999, *NBER Working Paper*, No. 6965.

6 J. Frost, H.S. Shin & P. Wierts, 'An Early Stablecoin? The Bank of Amsterdam and the Governance of Money', 2020, *BIS Working Paper*, No. 902, https://www.bis.org/publ/work902.htm.

7 D. Chaum, 'Blind Signatures for Untraceable Payments', *in* D. Chaum, R.L. Rivest, A.T. Sherman (Eds.), *Advances in Cryptology*, Boston, Springer, 1983, pp. 199-203.

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digital cash alternatives.[8] This 'overnight sensation', which took 40 years to come to fruition, was launched at the height of the 2007-2008 *credit crunch*.[9] However, why and how should payment systems and financial markets be reformed in response to a credit crisis caused by an overextended and poorly allocated lending boom? The profoundly decentralizing or, more precisely, anti-centralizing, ethos that permeates the work of the cypherpunk movement embodies frustrations with the broader balance of rights and responsibilities within the current monetary and economic system. This link between payments and credit will be examined at various aggregation levels (bank, industry, economy), with the overarching goal of highlighting the legal and economic complementarities between private and public money design and operation across all these levels.

This article provides a brief overview of the main characteristics of the existing two-tier public money payment architecture (i.e. central bank and commercial banks) while emphasizing the numerous trade-offs that are necessary to achieve the second-best arrangement currently in use. Reforming this arrangement requires taking into account many of the old constraints as well as some new ones. Some possible avenues for the *joint* development of central bank digital currencies (CBDCs) and cryptocurrencies and assets are outlined, with a focus on the associated correlated economic and legal challenges.

B What Is Money, and Why Does It Matter?

The definitions of money appear deceptively simple, yet they conceal extensive intellectual labour in various fields, such as economics, law, history and sociology, with few commonalities beyond the agreement on the shape of a coin. While the *functional answer* that 'Money is what money does' may be more well-known, a simple binary test of its components will lead us into a labyrinth of conceptual and practical difficulties. According to this dictum, something is considered money when it fulfils three primary functions: a medium of exchange, a unit of account and a store of value. However, the categorization of money is not straightforward, as demonstrated by the casual objections raised regarding, for example, the definition of a 'medium of exchange'.

Medium of exchange for all transactions? For some transactions, one may find higher utility in the use of cash (central bank money) rather than in the use of a bank account (commercial bank money). That may be due to ease and availability, such as a small payment of a long-forgotten debt while hiking with a friend in a remote area. It may also be due to the need for anonymity, such as taking a pregnancy test under social constraints. The casual objections raised in identifying a good 'medium of exchange' bring forward the need for privacy and the role of information conveyed in multiparty transactions. These will be essential in the present article. They provide the thread connecting the design of digital state

8 D. Chaum, A. Fiat & M. Naor, 'Untraceable Electronic Cash', *Advances in Cryptology*, 1988, pp. 319-327, https://dl.acm.org/citation.cfm?id=88969.

9 The genesis block contains the following reference: 'The Times 03/Jan/2009 Chancellor on Brink of Second Bailout for Banks', https://sourceforge.net/p/bitcoin/code/133/tree/trunk/main.cpp#l1613.

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money and associated monetary objectives for an economy fuelled by user data and high value-added digital products and services.

Medium of exchange all the time? The Carrington Event (the 1859 solar storm) interfered with telegraph services and, in some cases, disrupted them altogether. Although a counterfactual example, should a similar event occur in our electricity-hungry world, payments within a tech-dependent infrastructure would not be possible. Having a low-tech solution, such as cash, can provide a modicum of functionality that may prove essential in such situations. The simple examples above, related only to the medium-of-exchange function, indicate that a clear-cut categorization is not straightforward. Furthermore, this example indicates that the fulfilment of one or more functions is dependent on the technical specifications and broader context of the transaction.

Moreover, money can be many more things than just a medium of exchange. As Kocherlakota shows, 'Money Is Memory.'[10] Under a set of assumptions about private information and the agents' transaction history, money provides the same service as a transaction ledger, much like what we call today a blockchain. The *information on past transactions* plays a significant role in this definition, as money is an anonymous indication of successful previous transactions. Using money removes the need to reveal the past chain of transactions. Whether this success was ethically or morally acceptable is another important question. Without money, an agent would try to settle an existing debt towards a counter-party, relying most likely on barter or another past debt outstanding towards her or him.

'Money Is Privacy!' Kahn, McAndrews and Roberds highlight the privacy benefit of money compared to credit-only settlement in an economic setting where moral hazard is present.[11] Money provides social value and increased efficiency in transactions where agents face imperfect enforcement of contracts.

Money splits and unites opinions, with lines at times heavily enforced by political inclinations, as Randall argues.[12] The definition of money rests on many implicit arrangements and the not-immediately-obvious split of responsibilities between the central bank, payment processors and commercial banks.

Should we be pedantic about what money is? As such, it is essential to understand the scope of the definition as improvements in the functioning of money and its associated markets are a delicate exercise crossing simultaneously political, economic and social boundaries. Enhancing the flow of money while further rendering its value solid without constraining economic actions or introducing distortions through unnecessary limitations is a crucial endeavour.

10 N.R. Kocherlakota, 'Money Is Memory', *Journal of Economic Theory*, Vol. 81, 1998, pp. 232-251.

11 C.M. Kahn, J. McAndrews & W. Roberds, 'Money Is Privacy', *International Economic Review*, Vol. 46, 2005, pp. 377-399.

12 W.L. Randall, 'Introduction to an Alternative History of Money', 2012, *Levy Economics Institute Working Paper*, No. 717.

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C Historical Legacies in the Current Institutional Setup

As per the evolution of payment infrastructure and processes, central banking was established to meet the markets' requirement for coordinated and predictable payment services while also catering to the governments' needs for managing their fiscal income and expenses. From 16th-century Venice to 19th-century Lombard Street, the significance of the payment infrastructure and its related processes has grown in parallel with the increasing levels of payment volume and complexity. As trade traversed borders and stretched over longer timeframes, contracts and settlement procedures co-evolved to accommodate new types of risks.

Efficiently settling debts within a village community over the course of a month can be achieved through the presence of a few witnesses, with trust and adherence to social customs serving as the primary mechanisms for enforcing such agreements. However, the need for commercial courts, such as those established during the Champagne fairs, arose with the advent of selling goods to previously unknown merchants and settling debts at annual markets. As trade expanded to encompass greater distances and unfamiliar counterparts, social pressure and trust were no longer sufficient to ensure contract compliance. To address this challenge, innovations in payment arrangements (such as net settlement) and legal institutions (such as public courts) emerged, enabling trade to take place over longer distances and periods of time.[13] Notably, the simultaneous evolution of both payment methods and legal frameworks facilitated the expansion of trade to more distant markets with unfamiliar customs and institutions, necessitating new approaches to risk-sharing in goods and payment delivery.

With the rise in trading volumes throughout the 19th century, financial market participants developed improved mechanisms to handle the increased complexity and new types of risks. This led to the establishment of clearing houses as a centralized point for reconciling trades and netting them, thereby reducing the overall number of transactions and associated costs. Over time, legislation in various jurisdictions began to recognize and formalize the role of clearing houses in financial markets, further solidifying their position within the financial system. The introduction of standardization in trading practices and transparency by clearing houses was also propelled by legal and regulatory adjustments. As financial markets became increasingly globalized, the necessity for and benefits of centralized clearing facilities became even more pronounced.

Clearing houses were not typically established by the sovereign but rather by private sector entities. These institutions were the response to the risks and inefficiencies associated with trade and financial transactions with multiple parties. However, despite their origins in the private sector, the operation and functioning of clearing houses have often been significantly influenced by state regulations over time. Initially, these entities were established by banks and exchanges as a self-regulatory measure to streamline the settlement process and reduce the risks

13 J. Edwards & S. Ogilvie, 'What Lessons for Economic Development Can We Draw from the Champagne Fairs?', *Explorations in Economic History*, Vol. 49, No. 2, 2012, pp. 131-148, https://doi.org/10.1016/j.eeh.2011.12.002.

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associated with trading. As they processed larger volumes of payments, state institutions recognized their importance in maintaining financial stability and developed regulatory frameworks to govern their operations. These frameworks included setting standards for capital requirements, risk management practices and operational procedures to ensure the effective functioning of clearing houses and their contribution to overall market stability.

Clearing houses have often received legislative support and formal recognition within the financial infrastructure. Legal mandates may require the use of clearing houses for particular types of transactions or establish oversight and regulatory frameworks. The New York Clearing House Association (NYCHA), established in 1853, provides a notable example of successful public-private collaboration. Although it originated as a private enterprise by commercial banks aimed at streamlining the settlement process, it interacted with public authorities, particularly in times of financial crises. During the Panic of 1907, the NYCHA issued clearinghouse certificates to ease liquidity shortages.

Following the 2008 financial crisis, another notable illustration of collaboration between public and private sectors is evident in the implementation of the *Dodd-Frank Wall Street Reform and Consumer Protection Act* in the United States. The Act mandates, among others, the central clearing of over-the-counter (OTC) derivatives that conform to standardization via clearing houses, with the objective of mitigating systemic risk. Private sector actors, including clearing houses, collaborated with public regulators in order to develop and execute the necessary frameworks that satisfy the new regulatory standards. This cooperative effort aimed to ensure market functionality while simultaneously enhancing transparency and resilience to financial shocks.

The examples presented serve to illustrate the crucial interdependence of the public and private sectors in utilizing clearing houses to reinforce financial stability. The advent of globalization in the 21st century also brought about the standardization of international financial norms and regulations. This brief digression underscores the significance of a well-balanced regulatory structure. It can be contended that the alignment of commercial practices with public stability objectives, as demonstrated, among others, by the NYCHA, established the institutional backdrop that facilitated the explosive economic growth of the United States during the 20th century.

Throughout history, commercial banks have faced numerous liquidity and credit crises. As a means of preventing these crises and mitigating their effects, banks centralized the function of payments to reduce the associated costs of transporting and storing coin and bullion for end-of-day clearing. Transportation costs and the associated security risks were replaced by forgone interest on capital pledged for clearing in the 20th century. Nevertheless, considering all associated costs and risks, this remained the preferred solution. A fully decentralized solution, in which each commercial bank issued its own notes, was initially considered but eventually given up in favour of a multi-tiered centralized setup. This decision was not imposed from the top down but rather emerged as a stabilizing feature of the payment ecosystem. This centuries-old arrangement continues to shape the DNA of the financial and regulatory architecture we see today.

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The lessons learned from history have significant relevance to the fintech innovation culture of today, which places the weight of regulation exclusively on fragmented community-based institutions and rules.

I Today's Setup

The extant two-tier monetary system comprises central bank money, encompassing cash and reserves, and commercial bank money, which pertains to bank deposits in a broader sense. This dichotomy manifests a distinct division of responsibilities between commercial banks and central banks, particularly with respect to clearing and settlement. Additionally, it engenders significant implications concerning the functions fulfilled by payments made through either central bank money (cash) or commercial bank money (deposits).

The nexus between payment systems and credit risk management becomes particularly apparent when payment must be made from an account at a bank that engages in reckless credit creation or maturity mismatching as part of its business model. As evidenced by the recent Silicon Valley Bank (SVB) default, which echoes the 2008 Lehman Brothers debacle, unsound banking decisions can lead to balance-sheet stress and the potential for payment seizures in the event of insufficient liquidity. In instances where a bank has insufficient capital, depositors are prioritized behind bondholders, resulting in the diminution of their bank accounts to the deposit insurance threshold. This provides an initial indication of the crucial connection between payment systems, credit issuance and risk management.

Commercial banks are authorized to provide credit to households and firms, with the decision to issue credit being aligned with their primary objective of maximizing profits. This is subject to market rules and macro- and micro-prudential regulations, such as loan size and acceptable loan-to-value ratios. In addition to credit creation, commercial banks are responsible for managing payment flows and are subject to strict regulatory objectives to ensure prompt clearing of payments in and out of their clients' accounts, including technical requirements and working hours. To settle end-of-day outstanding payments with other financial institutions, commercial banks make use of central bank reserves, which they hold with the central bank. Therefore, the *functional linkage* between credit creation and payment settlement is established through reserves management.

Inadequate decisions concerning credit creation can result in lower asset values. Alongside these assets are equity and reserves held by the central bank. The occurrence of a liquidity crisis can easily precipitate a solvency crisis, causing the equity to be depleted. If the commercial bank in question has a large number of depositors, the expectation of a bank run and the ensuing instability of the entire banking system may necessitate interventions by either the government or the central bank.

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The works of McLeay[14] and the Monthly Report for April 2017 published by the German Bundesbank[15] are highly commendable academic resources that expound on the significance of this functional connection. These publications bring to light the extensive implications of the current money creation process on the stability or instability of the monetary system.

The existing payment system, which has been developed over two centuries of experimentation in the management of financial stability and monetary policy, represents an evolutionary outcome. It provides the public with an apparently seamless interchangeability of central bank money (cash) and commercial bank money (deposits). Nevertheless, despite the fact that we, as end-users, do not need to concern ourselves with this distinction while making our everyday purchases, there are significant differences between the two forms of currency that warrant attention.

When conducting a transaction with physical currency issued by the central bank, settlement occurs immediately upon exchange of the banknote or coin for the purchased item, such as a cup of coffee. However, potential concerns may arise regarding the authenticity of the banknote, which is a significant consideration for the central bank as the issuer of the currency.

Conversely, when utilizing a card or mobile device linked to a bank account, the underlying clearing mechanisms are vastly more complex, relying on a network of intricate electronic messages that are exchanged between the coffee shop's card terminal and the respective financial institution. In a standard scenario, the payment processor initiates contact with the bank of the purchaser and provides instructions for transferring funds from the purchaser's account to the account of the coffee vendor. The shop proprietor will incur varying costs for the ultimate settlement of the transaction, depending on factors such as the card issuer, point-of-sale installer and respective banks of both the buyer and seller, among others.

The infrastructure and technical specifications in place employ a multitude of checks and balances to mitigate or eliminate a variety of risks, including operational, legal and economic. Market mechanisms also play a role in the system. While the issuance of cash is solely the responsibility of the central bank, along with its distribution, the handling of payment via commercial bank deposits is an entirely different matter. In order to facilitate transactions with the utmost speed and at the lowest possible cost, competition is actively encouraged in payment through bank deposits. To optimize the settlement process, an ecosystem of enterprises constantly innovates the underlying technology and services. This has led to recent developments, such as payments made through smartwatches, phones and QR codes.

It is necessary to comprehend the implications of utilizing private (bank deposits) versus public funds (cash) for payment. This is due to the fact that the

14 M.M. McLeay, A. Radia & R. Thomas, 'Money Creation in the Modern Economy', Quarterly Bulletin 2014 Q1, Bank of England.

15 Deutsche Bundesbank, 'The Role of Banks, Non-banks and the Central Bank in the Money Creation Process', Monthly Report, 2017, April.

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bank responsible for processing the electronic transaction must maintain reserves in the central bank for the ultimate settlement. When payment is made in cash, the debt is immediately settled. However, when payment is made through bank deposit, the debt is only conditionally settled, contingent upon the bank having sufficient central bank reserves or enough credibility to obtain such liquidity if required (either from the central bank or from the interbank market). In the event of a liquidity crisis turning into a solvency crisis, payments may become trapped as counterparties within the payment ecosystem fear that, at the end of the day, the distressed bank may not possess the necessary reserves to settle outstanding payments. Recent events, such as the early days of the 2022 Russian invasion of Ukraine, have seen numerous gas stations and supermarkets initially refusing electronic payments out of concern that large sums of money will be stuck in the processing stage if banks were to become insolvent.

When purchasing coffee while traveling abroad, it is necessary to utilize an additional layer of corresponding banking services. The opening times of each country's real-time gross settlement systems, as well as the banks' outstanding foreign exchange exposure, compound the list of legal and technical requirements. A myriad of fragmented technologies now work in tandem to support our increasingly globalized lives. Unfortunately, the lack of standardization in technology, national legal peculiarities, and the need for repeated checks by all payment system participants contribute to delays and increased costs. These inefficiencies are particularly apparent in cross-border money transfers.

Bitcoin's design is motivated by the aim of settling payments without the involvement of central counterparties, thus eliminating the risk of insufficient funds at any given time. The mechanism employed to achieve this goal involves a clear-cut exclusion of the use of credit-based money generated within the monetary system. Through technical specifications, this approach ensures that no payment can be made using the liabilities of an agent or institution. However, as evidenced in the subsequent sections, this does not necessarily negate the possibility of a crisis arising when trade or investment risks are taken into account.

D The Quest for Decentralization

The issue of payment innovation in relation to private currencies begs the question: is there space for both to coexist?[16] With Bill Gates suggesting that banking is necessary but banks are not, the question arises as to whether central banking is required without the need for central banks themselves. The exclusive focus on function, without considering the institutional form and context which enable it, would be warranted in a world without externalities, conflicts of interest and with perfect information. None of these are generally accepted about money. It is important to keep in mind that money is merely a means to an end, and taking into account both legs of the transaction, payment and trade, reveal the potential

16 https://www.imf.org/en/Blogs/Articles/2021/02/18/blog-public-and-private-money-can-coexist-in-the-digital-age.

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advantages of a new blockchain framework of roles and responsibilities in payments and credit creation. It is highly probable that digital central banks will operate in a significantly distinct 21st-century economic environment and will need to adapt accordingly – one in which the pillar of the economy is no longer populated by firms competing in well-established markets but in decentralized networks competing via platform business models.

The pursuit of decentralization must be situated in a broader framework, one that concerns the facilitation of exchange via novel payment and credit instruments. Oftentimes, the means and the ends are interchanged in terms of importance, as evidenced by the past few decades of hyper-financialization of our economies. Institutions created to utilize and oversee credit as a means of facilitating trade have exploited every possible opportunity to generate, structure and disseminate credit for a fee, with too little regard to its anticipated productivity or impact on the markets,[17] society and environment. Bitcoin decentralized the payment aspect and expressly prohibited the linkage of credit creation to money creation. Other endeavours have attempted to decentralize credit creation and have linked payment to credit on the condition that certain societal objectives are achieved.

The BristolPound[18] and The People's Bank of Govanhill[19] provide interesting case studies that demonstrate the importance of money as a facilitator of exchange in the pursuit of societal goals. These experiments support the decentralization of economic functions, with a focus on promoting social inclusivity and ecologically balanced production, which is achieved *and sustained* through the decentralization of money issuance. By relying on locally issued currency, small businesses that are unable or unwilling to access credit through traditional banking systems are able to conduct their activities. These communities are returning to their roots and reimagining money, much like their 16th-century Venetian counterparts, after decades of prioritizing efficiency through over-centralization. However, their contemporary monetary instruments are now powered by mobile apps that update accounts on a blockchain.

The rapid pace of globalization has resulted in the concentration of numerous economic activities within large urban areas, with a particular emphasis on global capitals such as London, Tokyo and New York. The migration of ideas and people to these areas has inevitably led to an influx of financial resources. Research by Balland et al.[20] has demonstrated that in the United States, high value-added industries, which are associated with well-paid employment and significant contributions to gross domestic product (GDP), are disproportionately concentrated in large cities as opposed to smaller urban centres. Recent publications further refine this finding, pointing to the structural ramifications of the geographical location of firms in France. Large service firms and manufacturing firms prefer urban areas, whereas manufacturing enterprises choose rural areas. Urban

17 M. Constantinescu, 'A Real-Estate Bubble Model', 2006, *Swiss Finance Institute Working Paper*, http://www.phd-finance.uzh.ch/static/Courses/Downloads/SRP06_Constantinescu.pdf.

18 https://bristolpound.org/.

19 https://thepeoplesbankofgovanhill.wordpress.com/about/.

20 P.-A. Balland, C. Jara-Figueroa, S.G. Petralia, M.P.A. Steijn, D.L. Ribgy & C.A. Hidalgo, 'Complex Economic Activities Concentrate in Large Cities', *Nature Human Behavior*, Vol. 4, 2020, pp. 248-254.

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agglomeration benefits thus accrue disproportionally more to services firms.[21] Low-density areas with sparse social and production networks provide relatively fewer productivity and innovation opportunities.

Financial institutions that target corporate and private clients in accordance with the Pareto 80/20 rule are primarily based in large urban areas. This trend has resulted in a growing disparity between urban and rural areas, with limited access to credit and a consequent reliance on less complex economic activities and lower value-added industries. Similar patterns of inequality have emerged in other countries, highlighting the interconnectivity between the real and financial sides of the economy.

In the presence of perfect memory and unwavering commitment, the use of currency might become obsolete. This is evident in geographically confined economies, where bartering proves to be sufficient for a limited duration. However, the moment long-distance trade becomes a requisite and deferred payment replaces immediate settlement, the necessity for interdependent institutions arises again to manage the risks involved in payments and exchange.

The interchangeability of the Govanhill Note and Bristol Pound as well as their exchange rate and stability over time are decisive aspects determining their adoption as payment instruments. How easily would one exchange a Govanhill Note for a Bristol Pound? What would the rate be, and how stable over time would it be? In the development of decentralized communities and their localized monetary systems, it is imperative to also consider the institutions that sustain complex transactions as they evolve with human needs. These narratives serve as essential reminders of the wide ramifications of reengineering central bank money. However, are these mere speculations? The Bristol Pound, an experimental currency designed by and for the local populace, has been running for over a decade. Localized production and distribution, limited to the boundaries of a small city, can in principle be sustained by local money, with contracts enforced by reputation and social norms, as early examples indicated. How did it perform? The Bristol Pound was retired in 2020 and was withdrawn from circulation in 2021. It was replaced by Bristol Pay,[22] and existing balances were exchanged for Bank of England pounds.

The Peoples Bank of Govanhill (PBG) has transitioned into a 'women*-led collective Feminist Exchange Network'. Its primary objective is to cultivate a feminist economic system that serves as an alternative to the current capitalist model. However, there is insufficient information available in the public domain regarding the existence of a payment system and its integration with a trust-based barter system for goods and services.

The lack of widespread adoption of alternative monetary systems begs the question: why have these solutions not gained traction as a replacement for the existing system? The modern world relies on an extensive array of goods and services, many of which require a high degree of specialization that can only be

21 N. Chen, D. Novy, C. Perroni & H.C. Wong, 'Urban-Biased Structural Change', 2023, CEPR DP18522.

22 As of October 2023, the Future Vision at https://bristolpound.org/future-vision/ is no longer available. The landing page of the project has now become https://www.bristolpoundlegacy.info/.

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sustained in geographically dispersed markets spanning continents. It is not uncommon for the very devices that enable the use of a localized currency, such as Bristol Pay, to be manufactured in Taiwan or other distant locations. In such cases, what value could a Taiwanese smartphone producer derive from a hypothetical Bristol Pound or a note issued by the PBG? Additionally, certain services may necessitate specialized knowledge that is developed over a prolonged period, as is the case with the advice of a cardiologist. The constraints of time and space do not favour hyper-localized currencies.

I Alternative Solutions

The initial unclear legal status and lack of contractual dispute resolution along with the high levels of volatility have impeded the widespread adoption of early cryptocurrencies, contrary to the expectations of their creators. In response, stablecoins were developed as an alternative. Although stablecoins resemble a patchwork solution, they have nevertheless served as a valuable intermediary between the volatile world of cryptocurrency trading and the rigid regulatory climate of the banking industry.

Stablecoins represent a type of digital asset designed to maintain a stable value when compared to a specified currency, typically the US dollar or Euro, or a combination of financial assets and currencies. Nevertheless, it is important to note that their relative price stability may not be durable due to fluctuations in their peg, the nature of their reserve assets (if any) and their governance structure. The stable in stablecoins is extracted from the implicit stability of their reserves: central bank-issued coins or government bills and bonds that act as value anchors. Stablecoins are payment instruments that combine features from both cryptocurrencies and traditional currencies, resulting in a Frankenstein-like amalgamation.

Stablecoins are frequently utilized as a mediator between conventional fiat currencies and various digital assets, which are often more volatile. They are also commonly employed as collateral in crypto-asset derivative transactions and to facilitate trading, lending and borrowing in Decentralized Finance (DeFi). However, despite the potential for their functions to expand over time, the present iteration of stablecoins has not yet gained widespread usage as a means of payment.

Stablecoins are directly connected to the traditional financial system through their reserve assets, which may involve exposure to short-term money markets. However, there is a lack of consistency in disclosure practices among stablecoin issuers, and they are not subject to a consistent set of standards regarding the composition of reserve assets that back the stablecoin. In the event of large-scale redemptions or a run on a stablecoin's reserve assets, fire sales of those assets could arise, creating disruptions in the markets in which the reserve is invested, such as the short-term funding markets.

II Alternative Financial Assets and Products

DeFi utilizes a combination of various technologies to disintermediate and unbundle commercial banking services and products commercial banking services and products, thus creating separate markets for each individual banking

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component. The aim of this approach is to foster competition and augment transparency in an industry typically known for its high entry barriers. The fundamental building blocks of DeFi comprise distributed ledgers (blockchains) that function as the transaction settlement layer, digital assets (tokens that represent value and can be traded or transferred within a blockchain network), blockchain-based financial products (replicas of traditional products like insurance or derivatives), software interfaces (wallets) that enable users to manage assets stored on a blockchain, and the associated platforms that act as digital markets.

DeFi platforms heavily rely on the utilization of smart contracts for the facilitation of transactions in a peer-to-peer or peer-to-contract manner, with minimal human oversight. These platforms offer a plethora of services ranging from lending, borrowing, trading and custody of crypto-assets, among other unregulated financial services that closely resemble those offered by the conventional financial system. Typically, transactions are secured by digital assets, including both unbacked crypto-assets and stablecoins.

The achievement of trustless transactions is facilitated through the utilization of over-collateralization and programmatic enforcement of required margins via smart contracts. The distinguishing features of DeFi in comparison to traditional financial institutions are permissionless access, decentralized ownership claims, and transparent governance structures.

DeFI has experienced significant activity in the replication of conventional financial assets and products. Digital assets typically secure DeFi loans as collateral, with smart contracts holding the assets, thereby eliminating the need for borrower-specific evaluations or credit checks. To buffer against price fluctuations, loans are usually over-collateralized. Derivatives services establish direct connections between buyers and sellers, supported by incentivized collateral pools. Some services enable users to trade synthetic exposure to digital assets without holding them. Insurance services primarily concentrate on DeFi-specific risks such as smart contract failures, DeFi protocol hacks, or the incentive systems' game-theoretical risks.[23]

Platforms coordinating DeFi strive to establish a decentralized governance framework through the issuance of governance tokens. This poses a significant challenge for regulatory bodies and public authorities as it becomes difficult to pinpoint an entity or individual accountable for meeting regulatory obligations. In an extreme case where a DeFi platform is entirely decentralized, there may not be a single person or entity responsible for the effective functioning of the protocol.

Tokens issued in association with liquidity mining or corresponding mechanisms typically confer governance privileges for the DeFi platform. By holding tokens, individuals can exercise their right to vote on proposed amendments to the protocols, as well as on predefined parameters, including interest rates and collateralization ratios. This token-based governance approach offers a means for furthering the decentralization of DeFi services.

23 Blockchain and Digital Asset Project, in collaboration with the World Economic Forum 'DeFi Beyond the Hype: The Emerging World of Decentralized Finance', 2021.

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Digital asset trading platforms that aggregate various services and activities, such as lending and custody, constitute the majority of trading volumes. However, only a limited number of platforms offer these services, which exacerbates concentration risk and may lead to potential conflicts of interest. Furthermore, many of these platforms operate beyond the regulatory perimeter of certain jurisdictions or fail to comply with relevant regulatory requirements.

Despite the continuously changing landscape of the field, with occasional instances of duplicating efforts, certain structural features have become apparent. The subsequent SWOT analysis can serve as a model for evaluating current DeFi propositions.

Strengths:

1 *Open Access:* DeFi protocols are open to anyone with an internet connection, which fundamentally lowers entry barriers to both potential customers and innovators in financial services.
2 *Interoperability:* DeFi applications are built on public blockchain platforms like Ethereum, which allows them to interact and integrate with each other seamlessly.
3 *Transparency:* All transactions on DeFi platforms are recorded on a public blockchain, providing increased transparency.
4 *Efficiency:* DeFi protocols can operate 24/7 without intermediaries, which can lead to faster and more efficient financial transactions. Lower costs are possible, thanks to the use of 'smart contracts'.
5 *Anonymity:* DeFi provides users with much greater anonymity than transactions in centralized finance or traditional finance systems.

Weaknesses:

1 *Smart Contract Risks:* Smart contracts in DeFi can and do have bugs or vulnerabilities that can be exploited by malicious actors.
2 *Lack of Insurance:* Unlike traditional finance, many DeFi protocols typically do not have insurance. If a protocol is hacked, users can potentially lose all their funds.
3 *Complexity:* DeFi protocols can be complex and difficult to understand, which can lead to user errors or misuse.
4 *Lack of Regulation:* DeFi operates in a regulatory grey area, which can lead to legal uncertainties and risks.
5 *Decentralization Illusion:* There is a 'decentralization illusion'[24] in DeFi due to the inescapable need for centralized governance and the tendency of some blockchain consensus mechanisms to concentrate power.

Opportunities:

1 *Financial Inclusion:* DeFi has the potential to provide financial services to the un-banked and under-banked populations around the world.

24 W. Huang & A. Schrimp, 'DeFi Risks and the Decentralisation Illusion', 2021, https://www.bis.org/publ/qtrpdf/r_qt2112b.htm.

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2 *Innovation:* The open and permissionless nature of DeFi can lead to innovative new financial products and services.
3 *Yield Farming:* DeFi protocols often offer attractive yields to attract liquidity, which can provide lucrative opportunities for investors.
4 *Decentralization:* DeFi can reduce reliance on centralized financial institutions, potentially leading to a more resilient financial system when decentralization is achieved.

Threats:
1 *Regulatory Risks:* Governments and regulatory bodies around the world could impose strict regulations on DeFi, hindering its adoption and further growth.
2 *Market Volatility:* The value of cryptocurrencies used in DeFi exhibits non-negligible volatility, leading to significant financial risks, particularly for users with low financial literacy.
3 *Scalability Issues:* Some of the blockchain platforms that underpin DeFi can struggle to scale, leading at times to high transaction fees, low throghput and slow transaction speed.
4 *Smart Contract Failures:* If a smart contract fails or is exploited, it can cause significant financial losses.
5 *High Leverage:* High leverage in DeFi exacerbates procyclicality, causing more significant price swings and potential financial instability when connected to traditional financial institutions.

III Stablecoin Design and Legal Implications

In the year 2022, the Committee on Payments and Market Infrastructures (CPMI) and the Board of the International Organization of Securities Commissions (IOSCO) issued a report[25] concerning the adherence of stablecoin solutions to the Principles for Financial Market Infrastructures (PFMIs). These guiding principles serve as regulatory frameworks for payment providers at the national level. The report enumerates the fundamental principles that any financial market infrastructure must comply with.

The systemic importance of stablecoins is evaluated considering several critical topics. These include governance models, their approach to settlement finality, as well as risk management procedures. These topics intersect with the ongoing debates regarding the legal implications of stablecoin design and use.

The concept of settlement finality is considered fundamental in both traditional and digital finance. It pertains to the stage of a transaction where payment is deemed final and irreversible. Once a transaction attains settlement finality, the transfer of assets or funds from one party to another is complete, and the receiver can be confident of their ownership.

This concept is crucial as it mitigates the risk of transactions being reversed after they have been executed. This is especially critical in financial markets, where

25 Committee on Payments and Market Infrastructures, Board of the International Organization of Securities Commissions, 'Application of the Principles for Financial Market Infrastructures to Stablecoin Arrangements', 2022, https://www.bis.org/cpmi/publ/d206.pdf.

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the value of assets being transferred can involve multiple counterparties. It instils certainty and confidence in the financial system, ensuring that transactions are executed promptly and that their status is transparent to all parties involved. However, it should be noted that certain decentralization models may rely on probabilistic settlement, causing settlement finality to be uncertain.

Due to the decentralized and often cross-jurisdictional nature of these systems, guaranteeing the finality and immutability of transactions can be a complex but crucial task for maintaining trust and stability in these alternative arrangements. It is worth noting that the trustless revolution still relies on a foundation of trust elements.

Additionally, the report underscores further challenges associated with the creditworthiness, capitalization, access to liquidity, and operational reliability of stablecoin issuers. High levels of technical proficiency and reputational standing are required at the settlement account provider, as well as the custodian(s) of the reserve assets. These are essential qualities for the faultless and sustained operation of a stablecoin. It is imperative that reserve assets held or placed in custody are safeguarded against claims from a custodian's creditors. Any selected custodians should have robust accounting practices, safekeeping procedures and internal controls to protect the assets, as well as a sound legal basis supporting its activities, including the segregation of assets.

The presence of mechanisms intended to mitigate credit and/or liquidity risks is an additional source of robustness. Feasible illustrations encompass collateral pools buttressing committed credit lines, third-party guarantees and protocols for apportioning losses stemming from a default by the issuer or a depreciation in the value of the stablecoin.

E Identifying Mutable from Immutable

The cyclical pattern of economic growth and decline is a fundamental characteristic of many contemporary market-based economies. Financial institutions are incentivized to provide credit to fledgling enterprises or established firms seeking expansion, as the potential for substantial returns from new products or markets is alluring. The subsequent increase in labour demand generated by these firms has a positive effect on employment. This, in turn, triggers a wave of consumption among the newly employed, which further amplifies demand for credit as individuals seek to purchase long-term assets such as real estate.

The establishment of a positive feedback loop between increased demand and supply provides economic agents with reason to be optimistic. One important condition enabling interest rate payments and eventual repayment of outstanding loans is the promise of higher levels of efficiency in production. This condition applies to firms investing today in anticipation of higher future sales, as well as to individuals consuming more today in expectation of increased productivity and, hopefully, a higher salary.

Inability to repay a loan can lead to liquidations for both firms and individuals, resulting in many homeowners being forced to sell their properties and many firms

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seeing their equity wiped out. Unfortunately, the synchronization of credit issuance to firms and households at the beginning of the expansion episode often places overly optimistic individuals at risk of losing both their houses and their jobs at the same time if an economic contraction coincides with a real estate or financial market crisis.

Numerous economic disasters have raised awareness of the shortcomings and dangers of mismanaged credit issuance. Although solutions have been implemented, our economic systems are not fully immunized against further crises, as evidenced by the events of 2008. The solutions consist of a complex mix of institutions and mechanisms that aim to prevent risky build-ups and minimize damage when crises occur.

Deposit insurance has emerged as an essential element to mitigate the strain on bank deposits when financial institutions face a wave of defaults. State-insured schemes alleviate depositors' concerns and prevent otherwise healthy banks from being dragged into a downward spiral of mistrust. The ability of the state to establish and maintain a reserve to cover such losses is a reassuring factor in times of financial turbulence. This is just one of the several mechanisms that have been developed to address these issues. Another mechanism involves the ability of financially strained institutions to borrow short-term funds from a central bank against eligible collateral. This possibility prevents an initial liquidity weakness from becoming a solvency illness, blocking payment settlement while triggering asset fire sales.

While these mechanisms are not panaceas to all problems, they have successfully prevented some negative consequences. Financial stability requirements regulate individual loan levels to firms and private consumers through maximum leverage levels and minimum earnings requirements. Macroprudential policies, which have taken centre stage in regulatory circles as the response to the 2008 financial turmoil, address the possibility that any one bank's micro shocks lead to macro instability effects through high leverage and opaque exposures across the entire banking liabilities network.

However, there are also negative consequences of these policies, which are occurring more frequently.[26] The expectation of state support, either through capital or liquidity injections, may encourage even more reckless behaviour, both in individual banks and in the aggregate. Limited liability implies that high-risk investment payoffs accrue to bank managers, while large losses wipe out equity, bondholders and ultimately land on the balance sheet of central banks and national governments and, hence, tax payers. This is a result of a combination of market practices, regulatory prescriptions and a lack of transparency. To maintain competition, essential decisions on credit issuance and its subsequent management are only partially visible and only to regulators. This opacity, designed to encourage a healthy level of competition in the commercial banking sector, is used at times to conceal poor investment choices or outright theft.[27]

26 E. Farhi & J. Tirole, 'Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops', 2016, *NBER Working Paper*, No. 21843.

27 SVB's Loans to Insiders Tripled to $219 Million Before It Failed (yahoo.com).

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I The Institutional Credit-Payments Nexus

The allure of the democratization of money and finance has been a persistent Cypherpunk theme since the 1970s.[28] One of the main mechanisms ensuring the preservation of a cryptocurrency value is their initial limited supply and the lack of any central party deciding on the timing and volume of issuance. Inflation may be prevented initially, even though hard forks may increase the total coin supply through new varieties of issued currencies. Cryptocurrencies may obscure the increase in volumes through a larger assortment of coins.

Ironically, despite the proponents of cryptocurrencies actively criticizing the complexity of banking operations, they expect end-users to have the technical expertise to comprehend the rapidly evolving technological innovations proposed by various developers and communities in the cryptocurrency space and, hence, even greater complexity. Since trust does not scale, it is crucial for everyone to be aware of the best practices and anticipate all possible outcomes. The launch of a new coin is often preceded by fierce battles on social media, ostensibly under the banner of ideological dissent. Unfortunately, a significant number of those who stand to benefit from the DeFi revolution – especially the unbanked – are hampered by low scores of digital and financial literacy. Yet the lack of wider adoption of DeFi is frequently attributed by its proponents to regulatory stringency.

Impatience is a fundamental characteristic of human nature that has been observed throughout time and space, and credit serves as its economic manifestation. It is difficult to fathom an economic system that does not rely on credit, as its utilization has been a part of human transactions since ancient times. Despite the need for credit, its issuance and management can and should be reformed for optimal economic benefit.

To further explore this concept, let us examine a hypothetical economy consisting of cryptoborrowers and cryptolenders with a fixed supply cryptocurrency. Such an exercise illustrates how the monetary policies of current cryptocurrencies, whether intentionally or unintentionally designed, may result in aggregate financial and economic instability, despite their lower initial inflationary rates.

In the event that an individual is incapable of servicing or repaying a cryptoloan, they will forfeit ownership of the collateral, as was the case previously. However, the identification of the said individual and the subsequent repossession of the asset pose non-trivial challenges in a market designed to thrive on the anonymity of agents. With the cryptobank having issued numerous loans and possibly facing multiple defaults, a liquidity deficit ensues, compounded by the necessity to liquidate assets such as McMansions and expensive cars in a fire sale. Although the market value of these assets may surpass that of the unpaid balance, the time required to sell them results in a shortfall of liquidity. Invariably, depositors become aware of the cryptobank's predicament (thanks to the increased transparency) and withdraw their deposits, be it in fiat or crypto or both. Lacking the backing of any central bank-like institution, the cryptobank must resort to identifying a willing party to lend its crypto against the collateral. However, since most cryptocurrencies

28 A. Narayanan & J. Clark, 'Bitcoin's Academic Pedigree', *Communications of the ACM*, Vol. 60, No. 12, December 2017, pp. 36-45.

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cannot be generated instantaneously, illiquidity concerns can quickly escalate into insolvency issues.

Looking at past Twitter disputes, it seems safe to say that competitors in the sector may be inclined to abstain from providing assistance, preferring instead to witness the sale of assets at reduced prices, and relishing in the schadenfreude of a 'we told you so' moment. The greater the diversity of the cryptoloan portfolio, including loans issued in a wide range of coins, the higher the risk of illiquidity in the event of many defaults occurring simultaneously. This is unless, of course, one anticipates the business cycle to become obsolete in the interim, with risk management becoming far more effective for a cryptobank of this sort. Alternatively, could perhaps a hard fork produce a 'rescue' coin to alleviate the situation?

The aforementioned scenario seems familiar, its resemblance to the recent FTX impasse is though no coincidence. The hypothetical example presented above was already discussed in a concise March 2018 publication, distilling commonalities of many past banking failures.[29] *When the institutional framework and inherent behavioural biases coalesce in accordance with the historical formula, the resulting outcome will inevitably be similar*.

The absence of a functional, system-wide crypto mechanism analogous to deposit insurance poses an until now insurmountable challenge. In order to establish such a mechanism, the community would need to collectively agree to donate some of their own assets to a decentralized fund accessible to any active market participant experiencing financial strain. The case of a hybrid bank engaging in both fiat and crypto transactions further complicates matters. Such a bank derives trust benefits from centralized insurance mechanisms and subsequently extends them to all accounts. Addressing fundamental economic queries regarding loss allocation and capital requirements in the event of cryptoloan defaults remains elusive. Very little attention is paid to macroprudential considerations, probably under the assumption that such issues might not arise in the first place.

Human impatience is an innate trait, which manifests itself economically through credit. Credit necessitates an entire gamut of risk management techniques, practices, models and institutions. Cryptos have the potential to revolutionize the architecture of trust among agents, perhaps diminishing some types of inflationary risks. However, they must also consider the broader role of money in the economy and the associated consequences. Although unforeseen events may be tackled by sophisticated institutional and market mechanisms, history shows that these mechanisms typically emerge only in the aftermath of financial crises. Neglecting to plan for possible contingencies renders them inevitable.

F CBDCs – The State of (Dis)Agreement

Central Bank Digital Currencies (CBDCs) are 'a digital form of central bank money that is *different* [emphasis added] from balances in traditional reserve or settlement

29 https://www.linkedin.com/pulse/cryptos-maybe-taming-inflation-definitely-poking-constantinescu/.

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accounts'.[30] Although there is no universally accepted definition, this description, which contrasts CBDCs with traditional CB money, is the closest official explanation of the concept.

It is important to differentiate between retail and wholesale CBDCs. While wholesale solutions are relatively straightforward to evaluate, the introduction of retail CBDCs poses numerous challenges. Furthermore, a key differentiating factor in terms of implementation, benefits and costs is the market development status, that is, whether the economy is developing or developed.

For instance, policymakers and academics have advocated for the banking of the unbanked through a carefully designed retail CBDC in developing markets. This has also been a core marketing strategy for stablecoins. The costs associated with introducing a retail CBDC vary depending on the financial market's development stage and the current use of electronic payment methods.

While Sweden would likely not encounter significant obstacles due to its already low cash preference, the recent instance of demonetization in India[31] highlights the existence of non-trivial real costs during any transition to new payment instruments for cash-intensive economies. The policy rendered 86% of cash in circulation illegal overnight, with new banknotes being introduced in the ensuing months. The outcome was a temporary reduction in transaction volume, employment and credit creation in regions with the highest cash usage, as well as a faster adoption of alternative payment technologies. It is worth noting that the Indian experiment pertains to the replacement of old banknotes with new denominations, and the observed economic costs may therefore represent a conservative estimate of the costs associated with a more significant change in payment instruments and resulting transaction habits.

The emergence of distributed ledger technology (DLT) architectures presents a plethora of possibilities with regards to the varying degrees of anonymity, decentralization and access rights in relation to open blockchains. The implementation of algorithmic settlement, and the widespread availability of escrow services for low-value payments, are significant features that could be designed to be technically compatible with the national CBDC, further differentiating them from other forms of currency.

The advantages and disadvantages of various CBDC designs remain uncertain as the discussion continues in both academic and policy circles concerning fundamental design features. For instance, some scholars[32] argue that the ability of CBDC to pay interest would be advantageous in eliminating the 'zero lower bound', enabling greater flexibility in monetary policy through negative rates. However, this may necessitate the imposition of limits on or outright elimination of cash,

30 Committee on Payments and Market Infrastructures, BIS. 'Central Bank Digital Currencies', 2018, https://www.bis.org/cpmi/publ/d174.pdf.

31 G. Chodorow-Reich, G. Gopinath, P. Mishra & A. Narayanan, 'Cash and the Economy: Evidence from India's Demonetization', 2018, *NBER Working Paper*, No. w25370.

32 A.G. Haldane, 'How Low Can You Go?' 2015 Speech given by Andrew G. Haldane, then Chief Economist at Bank of England, Portadown Chamber of Commerce, Northern Ireland; J. Barrdear & M. Kumhof, 'The Macroeconomics of Central Bank Digital Currencies', *Journal of Economic Dynamics & Control*, 142, September 2021, pp. 1-24.

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which could likely have more negative than positive consequences.[33] Other authors view interest-bearing CBDCs as a potential threat to financial system stability due to their disintermediation effects. In a nearly frictionless environment, the shift from bank deposits to CBDC could be particularly destabilizing during financial crises.[34]

I Macroeconomic and Financial Stability Effects

Empirical analyses of the expected, likely effects of CBDCs on macroeconomic and financial stability typically focus on a preselected set of CBDC characteristics. Quantitative studies often focus less on the optimal design process of selecting different features (such as centralization vs. decentralization, interest-bearing or not, multi-tier architecture vs. central bank accounts for all) and more on evaluating how different designs influence macroeconomic outcomes (GDP, employment, inflation). Even for selected features, existing models are complex and rely on non-trivial assumptions about the long-run expected behaviour of users and institutions.

In their 2019 paper, 'Central Bank Digital Currency: Design Principles and Balance Sheet Implications', Barrdear and Kumhof construct a monetary-financial model and introduce CBDC as 'a universally-accessible and interest-bearing central bank liability, implemented via distributed ledgers, that competes with bank deposits as medium of exchange'. They explore the potential effects of issuing CBDC instruments equivalent to 30% of GDP (in contrast to government bonds) and estimate a long-run increase of 3% in GDP for the United States. The authors also examine the countercyclical variation of CBDC volume, suggesting its potential complementarity in macroprudential policy. Within the model, the ability of CBDCs to counterbalance over- or under-shooting of commercial money creation has a stabilizing effect on business-cycle fluctuations. The findings suggest an increasing interdependence between monetary and fiscal policies.

The increase in GDP observed in Barrdear and Kumhof's (2019) study is the result of the presence of the following characteristics:

– *Greater Transactional Efficiency and Use of CBDC:* users will prefer CBDC to conduct transactions due to their higher transactional efficiency, and the central bank will be able to earn a positive interest margin on CBDC issuance (on average). These are remitted to the government, reducing the interest burden on existing debt stock. After reducing the debt service, the central bank is expected to reduce the real interest rate on the outstanding debt. Note an important assumption here: for the interest margin to remain positive, the value of (implicit and explicit) services offered by a CBDC payment must be

33 A. Haldane, 'Haldane Calls Out CBDC "Stealth Tax Scandal"', 2023, https://www.finextra.com/newsarticle/42725/haldane-calls-out-cbdc-stealth-tax-scandal.

34 B. Broadbent, 'Central Banks and Digital Currencies', 2016, https://www.bis.org/review/r160303e.pdf; M. Raskin & D. Yermack, 'Digital Currencies, Decentralized Ledgers, and the Future of Central Banking', 2016, *NBER Working Paper*, No. 22238; O. Bjerg, 'Designing New Money: The Policy Trilemma of Central Bank Digital Currency', 2017, *CBS Working Paper*; M. Kumhof & C. Noone, 'Central Bank Digital Currencies – Design Principles for Financial Stability', *Economic Analysis and Policy*, 71, September 2021, pp. 553-572.

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recognized by the user and remain competitive with comparative services (e.g. a private stablecoin). An additional benefit is the improved perception of risk in the economy due to the lower stock of defaultable government debt. The lower interest rate on government debt thus reverberates through the entire economy and reduces borrowing costs for all other economic agents, increasing investment and making positive contributions to long-run growth.

– *Reductions in Distortionary Tax Rates:* the introduction of a CBDC volume of 30% of GDP leads to an increase in the consolidated fiscal income flow. This increase offers the fiscal authority more room to reduce distortionary taxes, increase expenses, or both, without an increase in debt.
– *Reductions in Monetary Transaction Costs:* increased competition in payment services is expected to reduce costs when bringing the system to operate on a 24-hour basis. Furthermore, as the CBDC payment would be settled on the central bank's account, there would be no need to post collateral to mitigate credit and liquidity risk (as is currently the case in a multi-tier system). Capital is thus released for higher economic uses.

The potential macroeconomic and financial stability implications of 'a universally accessible, non-interest-bearing e-krona supplied according to demand' are examined by Armelius et al. (2018) in the context of Sweden.[35] Although these authors do not provide numerical estimates of the overall effects of the new monetary instrument, they anticipate that its macroeconomic impact in the long run will depend on the level of adoption and market participants' response. They suggest that the introduction of the e-krona could have positive effects if it brings about efficiency gains and enhances the resilience of the payment system, but negative outcomes may arise from the possibility that it could disrupt bank funding and limit credit supply to the economy. One disadvantage of the expected increased cross-border flows, in particular for developing economies, is the higher associated volatility in exchange rates. This may become a non-trivial risk source for a sovereign dependent on foreign capital.

In the study conducted by Bindseil,[36] the potential impact of a universally accessible central bank account in the Euro Area is analysed. Bindseil presents a series of stylized financial account operations to illustrate how a tiered remuneration of CBDC balances could prevent a structural disintermediation of commercial banking deposits. Furthermore, Bindseil considers the political and economic implications of sovereign money proposals.

It should be noted that the aforementioned analysis does not take into account the potential benefits of reduced frictions in improving cross-border transactions. According to the 2020 Financial Stability Board report, remittances of US$200 from G20 countries incur an average cost of 7%. While this percentage may vary

35 H. Armelius, P. Boel, C.A. Claussen & M. Nessén, 'The e-Krona and the Macroeconomy', *Sveriges Riksbank Economic Review*, Special Issue, 2018, pp. 43-65, https://www.riksbank.se/globalassets/media/rapporter/pov/artiklar/engelska/2018/181105/20183-the-e-krona-and-the-macroeconomy.pdf.

36 U. Bindseil, 'Tiered CBDC and the Financial System', 2020, *ECB Working Paper*, No. 2351, European Central Bank, Frankfurt.

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depending on the country of origin and the amount transferred, the absolute cost can be significant when considering the total yearly remittances to developing economies with large migratory flows. For instance, a conservative estimate of 5% applied to the US$14 billion remittances to Ukraine in 2018 (World Bank) yields an absolute cost of US$ 700,000,000 for this country alone. Given the large number of post-war Ukrainian emigrants, this cost is expected to be even higher in the future. The global remittance flow for 2023 has been estimated at US$647 billion.[37] This means that the migrant workers who can least afford it are losing about US$32 billion this year alone. These estimates only concern individual remittances. Firm-related import and export activities are another area with larger contractual and payment cross-border frictions that may benefit from lower transaction fees and improved transactional efficiency (across both payment and contracting).

II An Incomplete Summary of Knowns and Unknowns

There exists a degree of consensus regarding the potential benefits of wholesale CBDCs, as noted in the 2018 BIS CPMI report.[38] It is expected that wholesale CBDCs will enhance the efficiency of settlement for securities and derivatives transactions, while also potentially reducing costs and frictions in cross-border transactions. However, the impact on foreign exchange rates is an area that has not been fully explored.

The following summary draws upon the works of Agur (2018, 2019)[39] and Bindseil (2020).[40] It is important to note that a strong political economy undercurrent permeates the current debate.[41] Some scholars contend that a lesser role for commercial banks in the money creation process, which may come about through the introduction of retail CBDCs, could have positive implications. This would occur by naturally constraining the credit creation ability of commercial banks and could potentially result in a new era of financial stability. However, others argue that the disintermediation argument presents a threat to the ability of businesses and households to obtain credit, potentially resulting in higher costs of borrowing if banks are forced to rely on wholesale markets for funding. Such a curtailment in borrowing ability could negatively impact the long-term investment and growth potential of an economy.

Several CBDCs features are presented currently in the literature either as arguments in favour or against, depending on the above political economy stance. These concern primarily the need to preserve anonymity in transactions and the

37 https://www.migrationdataportal.org/themes/remittances#:~:text=In%202022%2C%20remittance%20flows%20to,et%20al.%2C%202022.

38 Bank for International Settlements, 'Central Bank Digital Currencies', Basel Committee on Payments and Market Infrastructures publication, March 2018.

39 I. Agur, 'Central Bank Digital Currencies: An Overview of Pros and Cons', *in* D. Masciandaro & E. Gnan (Eds.), *Do We Need Central Bank Digital Currencies? Economics, Technology and Institutions*, SUERF/BAFFI CAREFIN Conference Volume, 2018; as well as I. Agur, A. Anil & G. Dell'Ariccia, 'Designing Central Bank Digital Currencies', 2019, *IMF Working Paper*, No. WP/19/252.

40 U. Bindseil, 'Tiered CBDC and the Financial System', 2020, *ECB Working Paper*, No. 2351.

41 O. Bjerg, 'Designing New Money: The Policy Trilemma of Central Bank Digital Currency', 2017, *CBS Working Paper*.

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balance between sovereign and private money creation. The list of unknown unknowns may reveal many future surprises depending primarily on user behaviour and changes in their preferences.

Arguments in Favour of CBDC (Varying by Design Specifications)

Improved Efficiency of Payment System	
Faster and more resilient payments Increased transparency and financial market oversight (wholesale) Lower costs (management, fraud) as compared to cash Faster and cheaper cross-border transfers increased contestability of retail payments Lower aggregate use of collateral in the banking system	An important argument for economies with low incidence of electronic payments and/or high shares of shadow economy. A positive externality is the potential reduction in tax evasion. Faster restructuring in case of individual bank failure.
New Monetary Policy Tools (in Case of Remunerated CBDC)	
Direct transfer to economic agents and households Negative rates possible Stronger and more targeted monetary policy transmission	To be effective, would need substantial changes in the use of cash and its conversion from and to CBDC (either through a tax or a cap on individual CBDC accounts).
Diminished Role of Commercial Banks in Money Creation	
Improved financial stability Lower moral hazard by eliminating the 'too-large-to-fail' Negative rates possible	Whereas Bindseil (2020) considers this as an advantage, Agur (2018, 2019) presents commercial banking disintermediation as a counterargument. Barrdear and Kumhof (2019) argue CBDC may help stabilize the business cycle and reduce the negative macro impact of procyclical private money creation (implicitly reducing the frequency and potential severity of financial crises).

Arguments against CBDC (Varying by Design Specifications)

New Monetary Policy Tools (in Case of Remunerated CBDC)	
Possible loss of anonymity in transactions Negative rates possible	To be effective, this requires substantial changes in the use of cash and its conversion from and to CBDC (either through a tax or a cap).
Diminished Role of Commercial Banks in Money Creation	
Financial stability risks in crisis periods Disintermediation may lead to lower credit creation for the real economy (unless compensated by increasing market shares of FinTech platforms)	For retail CBDC, some authors indicate the risk of deposit flight in times of financial turmoil. For interest-bearing CBDC, commercial banks stand to face the risk of lower retail deposits, an important funding source. Bindseil proposes a two-tier system of CBDC remuneration, similar to what has been applied already by the Swiss National Bank (more negative rates applied to higher excess deposits). Implementation may vary either caps on the volume of CBDC (with constant rates) or variable rates as a function of volume.
Increased Operational and Reputational Risk	
Cybersecurity issues may lead to a broader loss of trust in the central bank's ability to fulfil its mandate	

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G Thinking Forward – Reforming Money and Contracts

The present system exhibits limitations when it comes to cross-border payments and transfers, particularly in cases of contractual non-performance. In situations where services are ordered online from local sellers, a lack of delivery may be addressed through measures beyond a mere negative review. However, when dealing with sellers from different jurisdictions and the payment has already been settled, a negative review may be the only recourse available, especially when subjective evaluation of contractual performance comes into play. Consider, for instance, the scenario of the 'amazing villa with an ocean view' booked during a recent trip or the 'almost new' smartphone ordered online. Such anticipated hurdles are likely to deter a considerable number of trades, and addressing such obstacles is a costly and time-consuming endeavour, even for established counterparts who are not hesitant to venture into cross-border business. Much more intricate scenarios unfold for business-to-business contracting and payment.

What if an autonomous agent were to mediate the trade? One that offers its service at minimal cost, performs its duty with the precision of a computer and releases funds only when all parties have agreed that the trade's initial parameters have been satisfied. The possibility of algorithmic clearing and settlement, managed by AI agents handling multi-party 'smart contracts', has considerable potential to enhance cross-border financial investment along with goods and services trade.

Systems for securities settlement have been developed to ensure that delivery is made only upon receipt of payment. This practice is necessary in facilitating the exchange of money for ownership rights in a company, which in turn supports the development of effective financial markets. It would be desirable to have a similar system in place for all trades, regardless of their size and nature. Additionally, it may be feasible to incorporate a mechanism into these systems that allows for the direct payment of VAT to the relevant fiscal authorities upon completion of a trade. The use of a 'smart contract' process in this context raises important questions about the appropriate currency to be used for such transactions. But it would most likely need to be a CBDC.

In addition to its financial benefits, there is a nonfinancial argument in favour of the adoption of CBDCs. This argument is based on the growing need for vast amounts of data to conduct the main functions of government, particularly to support sound fiscal policy in conjunction with a central bank's independently set monetary policy. Modern governments produce and consume large volumes of highly heterogeneous data. These data are fed into a range of statistical models to inform policymaking, to assess the effectiveness of existing interventions and to design future laws and regulations. From deciding fiscal transfers for the less well-off to estimating life expectancy or quality of employment, governments often devise policies relying on rather blunt statistical averages. The full details regarding the flow and timing of payment related to an outstanding loan may well remain known only to the bank and borrower. Yet timely, anonymized statistical distributions of these flows with geographical or industry-level disaggregation may become highly valuable tools in policymaking. Ensuring that policymakers have access to timely and accurate data is essential for making informed decisions

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and avoiding crises in financial markets caused by blind spots. By adopting a CBDC, governments may be better equipped to achieve their fiscal and monetary policy objectives, resulting in sharper policy decisions and improved outcomes.[42]

The potential impact of regulatory oversight on the magnitude of the 2008 crisis remains a topic of significant academic debate. Could a more thorough assessment of the leverage in the various CMBS tranches have prevented the crisis from reaching its ultimate scale? Furthermore, would the utilization of a public blockchain to track the underlying assets, with instant valuation by competing Machine Learning algorithms and full transparency of mortgage payment delays, have altered the course of events? The vulnerability of repo markets, where securities may be pledged multiple times, contributing to systemic instability, also raises questions about the effectiveness of contemporary financial regulation. All the above are garnished by the selective use of accounting practices for income and loss reporting.

With imperfect commitment, second-best institutional settings to enforce contracts, and occasionally context-dependent memory, we are stuck with money and contracts. The gains from the wide adoption of a CBDC can be uncovered when considering the full exchange cycle, not exclusively the payment leg. Benefits will emerge from the integrated, AI-enabled management of credit issuance and servicing and timely forecasting of spill-over effects of contractual non-performance. Payment systems are only half of the story. It is in the *complementarity* between payment and exchange that we will find the sources of societal benefit. It accrues from the improved functioning of government, central banking and financial markets through reduced asymmetric information and its associated disruptions.

I Co-design of Public and Private Money and Assets

Successful transactions require not only well-executed payments but also the support of contractual agreements and the associated legal infrastructure. The complexity of today's transactions, which involve multiple time zones, geographies, industries and payment clearing systems, is a response shaped by various national regulations, regional commercial priorities and global production and distribution chains.

Commercial parties must carefully consider the jurisdiction and applicable law governing possible disputes and arbitration when entering into contractual agreements, given the intricate and expensive nature of such arrangements. The efficiency and independence of the legal system play a decisive role in the selection of the presiding authority over contractual disputes. Payment simplicity and ease are often counterbalanced by the complexity and cost of contracting, whether it is for renting an apartment, buying a car or conducting international transactions.

In the current context, payment processes are characterized by low complexity, low cost and fast execution, while contracting procedures are excessively complex, high cost and slow. History indicates that private sector innovation has had greater success in improving payment processes than the state has in enhancing contractual

42 M. Constantinescu, 'Central Bank Digital Currencies in the Age of Autonomous Algorithms', National Bank of Ukraine Expla, 2020, https://expla.bank.gov.ua/expla/news_0143.html.

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settlement. However, past performance does not necessarily predict future outcomes.

Numerous crypto payment solutions have been proposed to establish a new balance between low complexity, low cost, and somewhat slower execution of payment processes, and medium complexity, faster execution, and lower costs in contracting. The payment-exchange functional division is being reshaped by new technologies. The potential advantages of this new payment system over traditional good/asset/service flow architecture are derived through two primary channels: *adjustable opacity* and *algorithmic analysis and execution*.

Adjustable opacity, specifically, allows for a shift from the limited visibility of transaction information in the old system (which was restricted to those involved in the specific transaction) to a decentralized architecture that enables most individuals to access some level of information regarding the transaction. This is realized through the decentralization of part or all of the payment layer, as well as through novel, yet insufficiently tested, complementary governance solutions involving semi-anonymous agents. Blockchains expand the parameter space of informational asymmetry and permit user- and application-specific settings. It is important to recall the definition that 'money is memory' in this context.

Decentralized and distributed payment systems present a novel and adaptable approach to addressing information asymmetry among disparate parties. This technological breakthrough carries significant economic and legal ramifications. Within a blockchain framework, money can be conceptualized as a hierarchical sequence of prior smart contracts that have been effectively implemented.

The ability to access various levels of transactional data paves the way for *algorithmic analysis and execution*, which in turn opens up new opportunities for private and public entities, households and small and medium-sized enterprises (SMEs). Thanks to innovative algorithms that rely on borrower data to assess creditworthiness, microcredit transactions are already now a viable option. This trend has the potential to not only enhance business dynamism and individual entrepreneurship but also help address the persistent issue of income and wealth inequality. The careful risk management and sound business practices of a young firm, documented through auditable time-series of fast turnaround in receivables and inventory, are a new form of reputation-based capital.

Data markets play a critical role in facilitating this new economic model, and regulators and central banks are paying close attention to their development – particularly in the context of AI-driven financial products and platforms. The design and regulation of such data flows remain subject to ongoing debate, with questions surrounding the potential organization of markets and the resulting impacts on privacy and aggregate efficiency gains. The risk of private monopolies over aggregated data flows has led to increased government intervention.

Given the increasing significance of granular, timely data in fuelling large AI systems, a not-too-far-fetched future scenario may entail citizens and firms paying their taxes with digital data flows. Improved targeting of investment or fiscal transfers and better estimation of their causal impact across households and firms can lead to lower debt burdens for governments, improved transparency for their constituents, and higher accountability for both. If this assumption becomes a

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reality, governmental agencies will consider the cost and benefits of a highly targeted policy against those of an average-targeting policy. In this scenario, data pools needed to train AI agents will become extremely valuable. This data may well be a heterogeneous mixture of payment history and smart contracts performance in relation to both private and public entities. The data tax will provide higher value the more specific, timely and auditable these data streams are.

H Instead of an Epilogue

The current state of CBDC development and its interaction with private money and decentralized asset solutions is a topic of great interest in academic and policy circles. Focusing solely on the economic incentives driving transactions can obscure the potential shape and function of CBDCs, which in turn may have implications for the innovative redesign of financial markets. Discussions surrounding CBDCs have largely revolved around payment parameters such as speed, efficiency, throughput and market microstructure. However, such a narrow focus, divorced from the transaction's purpose and broader economic and social implications, may constrain the discussion to consider costs and benefits for an economic model that is increasingly becoming obsolete.

In the past, the consumption and production of mainly physical goods were supported via credit and payment arrangements that centralized information for rent extraction. This model created aggregate risks that were often obscured to regulators until it was too late to take preventive action.

To be effective, CBDCs must facilitate transactions that settle and are settled by data streams emerging from potentially disparate platforms, ideally from different jurisdictions. Moreover, CBDCs must enable these transactions with any digital asset that satisfies technical, economic and regulatory requirements.

The contemporary economy is no longer solely reliant on consumerism and urban sprawl. While these concepts will continue to have a place in the economic system, an increasing share of value added will be generated and delivered through imaginative virtual realms that utilize blockchain technology to establish ownership rights of digital art and fashion, deliver immersive classes or provide medical advice in the metaverse. Additionally, socially innovative communities will require financial resources and credit to empower their members. Unlike the previous infrastructure that prioritized steel bridges for the transportation of merchandise (which still remain relevant), the new infrastructure will prioritize optical fibre for the transmission of data related to both physical and digital land transactions.

The actual gains of CBDCs will not be derived from the acceleration of payment processing by mere milliseconds; rather, the advantages will stem from the ability to utilize open-source AI algorithms that can perform millions of small cost/benefit evaluations that are easily and publicly auditable by both governmental entities and private individuals. Additionally, CBDCs will aggregate data streams to comprehend real-time macroprudential and fiscal risks, thereby avoiding multibillion bank bailouts. While these benefits are presently counterfactual, one

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may argue that the unrealized advantages are not illusory arguments when weighed against the actual costs of recent economic historical episodes ('What would we pay to avoid a 2008-style Great Recession?').

Currently, private financial solutions are attracting clientele with their cost-effective services, convenience and user-friendly interfaces available on mobile devices and smartwatches. During a recent conversation with a fellow central banker regarding their plans for a CBDC, my colleague responded with a mix of humour and seriousness, stating, 'We are planning to issue a new banknote soon!' The balance between fungible and non-fungible currencies crossing both physical and digital realms provides valuable insight into how to approach the development of public money while also promoting social inclusivity and environmental sustainability through credit creation. Addressing the question of the optimal design of a CBDC with payment objectives in mind alone would be a missed opportunity.

It is critical to consider that neither CBDCs nor decentralized assets can achieve their maximum potential and deliver societal benefits as standalone solutions. Instead, a rebalancing of rights and responsibilities between private and public money is necessary, as opposed to simply relying on new technological innovations to dress up an arrangement that has been in place for centuries. While form follows function, function must first be redefined for an economy that transforms bytes rather than atoms.

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