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Digital assets in payments and transaction banking

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Digital assets in payments and transaction banking

Alistair Milne* and Vivienne Lawack†

Abstract

This paper defines digital assets as those directly controlled through public-private key cryptography. It distinguishes *code-based* (crypto) digital assets – without intermediaries – from *intermediary-based* digital assets – where one intermediary or more validates transfers. The paper argues that regulatory objectives are best served by crypto-asset separation: regulated financial intermediaries can either be crypto-asset service providers or provide other regulated financial services, but they should not do both. Efficient automated processing of financial transactions can be achieved through either *replacing* traditional financial assets with intermediary-based digital assets or *retaining* existing arrangements, standardising data and processes and using application programming interfaces (APIs) to support secure automated data exchange. Similar outcomes can thus be achieved with or without digital assets. In a middle-income country context, many of the asserted benefits of retail financial services – lower cost and risk, greater speed and heightened transparency – can be better achieved with traditional financial assets. Intermediated digital assets may however offer worthwhile reductions of cost and risk in financial markets.

JEL classification

E58, G23, M15, O33

Keywords

Central bank digital currency; clearing and settlement; code-based digital assets; cryptocurrencies; decentralised finance; delivery versus payment; digital payments; distributed ledger technologies; financial technology; intermediary-based digital assets; mobile money; programmable money; permissionless blockchains; public-private key cryptography; smart contracts; stablecoins.

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1. Introduction[1]

This paper reviews the economic benefits and prudential, market and conduct risks of adopting digital assets in payments and transaction banking.[2] It is written with particular attention to the situation of middle-income countries such as South Africa.

What are digital assets? The term is not precise. Traditional financial assets, including bank deposits and securities, have for many years been held in digital form. However, the term 'digital asset' has more recently come to mean something different: a reference (in what is now a standard usage) to assets held and transferred using similar technologies to those employed in the holding and exchange of cryptocurrencies such as Bitcoin.

The application of the word "similar" reflects the inherent imprecision of the term digital asset. It indicates that this is a matter of degree: the technologies employed can be more or less similar to those employed in Bitcoin.

The most similar are those digital assets acquired and exchanged like Bitcoin on shared databases, open without restriction to any participants – so-called permissionless blockchains. These can be financial (cryptocurrencies, stablecoins, other forms of coin offerings) and non-financial (non-fungible tokens (NFTs)). They also include all the assets that are traded in 'decentralised finance' using code-based protocols such as those traded on UniSwap, the decentralised exchange supported on the permissionless Ethereum blockchain. The holding and transfer of these digital assets does not require intermediaries.

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1 The authors are grateful for supporting work from Tlalane Mokuoane, Videshree Rooplall and Thabani Vythilingam used in writing section 3 (the review of the South African context) and for careful editing by Donald Powers and Thomas Cartwright of Clarity Global Strategic Communications. The analysis in this paper represents the views of the authors, not the South African Reserve Bank, and they alone are responsible for any remaining descriptive or analytical shortcomings.

2 Transaction banking is a standard industry term, shorthand for the execution of payments and financial market transactions.

Less similar are digital-asset versions of established traditional financial assets, such as securities, commercial bank deposits and central bank money. The expectation is that technologies similar to those used for holding and transferring cryptocurrencies can help improve the efficiency of holding and transferring established financial assets: lowering costs, increasing speed, facilitating automation, and making transactions and financial exposures more transparent.

Some claim that adopting digital assets in the form of decentralised finance (DeFi) will lead to a disruptive transformation of traditional finance (TradFi), making redundant the business models of existing financial firms – much as digital photography made redundant the business models of firms in analogue photography. In this sense, digital assets are a 'Kodak moment' in finance.

As discussed below, it is far from obvious that DeFi and new digital assets will replace TradFi, traditional assets and the intermediaries that provide them. The causes of the current inefficiencies in payments and transaction banking are primarily institutional, not technological. The adoption of new digital-asset technologies may promote greater efficiency, but it cannot replace all existing intermediary roles.[3] It is also open to question whether the perceived benefits of digital assets are better achieved through the *replacement* of traditional financial assets with digital asset equivalents or the *retention* and updating of existing operational arrangements to transfer traditional financial assets.

To properly assess these possibilities, it is necessary to distinguish three broad issues too often muddled together:[4]

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3 This is not even possible in DeFi (see Aramonte, Huang and Schrimpf (2021).

4 These issues are not entirely separate. A prominent example is the current interest in the issue of central bank digital currency (CBDC), now being seriously considered by central banks in more htan 100 jurisdictions worldwide. Issue (ii), new forms of private money, is a principal motivation for the creation of CBDC – a digital asset version of central bank money. A concern is that stablecoin versions of digital-asset money of uncertain value (stablecoins are stabilised but the stabilisation mechanism can break) might displace fiat money, undermining monetary and financial stability. However, issue (iii), the effective employment of digital-asset technologies, is critical: if CBDCs are to be successfully adopted, they must improve on the services provided by existing traditional bank deposits and notes and coin.

1. The opportunities and risks of crypto assets and DeFi, their potential growth as a new asset class and the challenges in their regulation.
2. The possibility of fiat money being replaced by new private forms of money – the most prominent examples being stable coins such as Tether or USDC coin, or the proposed but now terminated Libra and Diem projects.
3. The use of digital-asset technologies developed for crypto assets and DeFi to improve TradFi – both wholesale financial markets and retail financial services.

The analysis provided here is in two main parts. The first, in section 2, addresses the problem that the term 'digital asset' is too often unclear. Even in a financial context – that is, restricting attention to digital financial assets – the term is used inconsistently, loosely and without a clear idea of what is meant. Section 2 proposes a conceptual framework to clarify discussion of the opportunities associated with digital assets. This framework distinguishes two key features of the technology used in the blockchain and distributed ledgers underpinning digital financial assets:

1. The use of public-private key encryption as the sole mechanism for asserting ownership and control over asset holdings.
2. The possibility of having multiple versions of the databases that record asset holdings, each held by different participants (or 'nodes') in a computer network, using a consensus mechanism to ensure consistency between them.

In this conceptual framework, the first of these implementations of technology – sole control through public-private key encryption – defines digital assets and distinguishes them from traditional, established, institutionally controlled electronic means of holding assets (such as commercial bank deposits recorded electronically on computer databases) and accessing and transferring them by the bank on the instruction of (not directly by) the deposit holder.

This focus on the controlling role of public-private key encryption as the defining feature of digital assets departs from much of the established discussion of digital financial assets, which defines digital assets as assets recorded on blockchains and distributed ledgers. The goal is to demonstrate that this perspective provides a more detailed understanding of the applicable business applications and policy issues.

Identifying ‘digital assets’ with control through public-private key encryption yields three insights.

1. The choice of ‘consensus mechanism’, that is the arrangement for agreement on asset transfers and holdings, divides digital assets into two distinct groups:

   - Code-based digital assets, held on an open access (permissionless) network, in which consensus is based solely on code and institutions play no role.[5]
   - Intermediary-based digital assets, in which consensus is the responsibility of one or more institutions and access can therefore be limited.

   It is difficult to identify holders of code-based assets (and hence also difficult to apply regulations such as customer protection and anti-money laundering and combating the financing of terrorism (AML/CFT) regulation); furthermore, code-based assets can be extremely risky. These considerations suggest it may be best to strictly separate code-based crypto digital assets from all other regulated financial activities regardless of whether or not they employ digital or traditional financial assets.

2. One reason for interest in digital assets is that public-private key encryption makes it practical to hold financial assets directly, rather than indirectly – that is, as the liabilities of a financial intermediary.

   The importance of such direct holding is encapsulated in a phrase commonly used in DeFi: “Not my keys, not my crypto”. Direct holding substantially reduces dependency on the intermediary, removing exposure to fraud and the risk of intermediary default and associated systemic risk. While crypto (code-based) assets cannot be usefully applied to regulated payments and transaction banking, the direct holding of intermediary-based digital assets using private keys, for example central bank digital currency (CBDC), has potential to reduce costs and risks.

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[5] Examples of code-based digital assets are Bitcoin (with its proof-of-work consensus) and Ethereum (with its proof-of-stake consensus). Their reliance on code-based consensus places these and other crypto or virtual financial assets (DeFi, cryptocurrencies, stablecoins) in an entirely different category from digital financial assets that employ institutional consensus.

3. Because they use public-private key cryptography to control access to records of asset holdings and to instruct transfers, digital assets can be used to automate payments and other transactions, increasing the speed, transparency and certainty of transfers.[6] However, holding digital assets on distributed ledgers may not be *necessary* to realise these benefits. The discussion in section 2 highlights the standardisation of data and process and the use of application programming interfaces (APIs) as alternatives to adopting distributed ledgers to support automated transfers based on public-private key cryptography.

   To illustrate, it is sometimes suggested that digital assets are needed to make payments execute automatically when preconditions are met (the phrase often used here is 'programmable money').[7] This suggestion is misleading: holding and control of digital assets using public-private key cryptography can facilitate but is not necessary to make payments execute automatically.

   The question in many cases should therefore be whether the payment and transaction benefits of digital assets are best achieved by replacing existing, traditional, indirectly held intermediated assets with directly held digital assets or by retaining traditional assets and improving them by other means. The answer to this question depends on context: the specific transaction and the existing operational, jurisdictional, institutional and legal arrangements that support it. This question must thus be addressed on a case-by-case basis.

The second part of the analysis (presented in sections 3 and 4) considers policy issues. The position taken here is that the most appropriate policy stance in relation to digital assets depends on individual country circumstances. Section 3 therefore explores the circumstances in South Africa, as a prominent emerging market, looking at the development of crypto-asset regulation and at the potential to adopt digital assets in

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[6] A related issue not addressed in this paper is the role of 'pull' initiation in the automation of payments and other financial transactions (see Chan and Milne 2024). Pull initiation is supported by some digital assets (e.g. those held on the Ethereum blockchain) but is also commonly supported by many traditional financial assets (e.g. debit and credit cards).

[7] For example, see Bank of England (2024), which assumes a key role for digital ledger technologies in supporting 'programmable money'.

wholesale financial market transactions; in retail payments and to promote financial inclusion; and in cross-border payments and foreign exchange.

With this background in mind, section 4 then reviews the opportunities from and risks inherent in adopting digital financial assets, especially in a middle-income country context. This raises further questions about the pros and cons of using digital assets (including CBDC) in payments and transaction banking applications and what the use cases might be. Other relevant concerns relate to where specifically the potential benefits of employing digital assets are (in particular CBDC), and to what extent realising these benefits would require changes in the framework of financial law and regulation. There are also implications for bank liquidity management and central bank monetary operations and control over money market rates of interest.

This review in section 4 draws on a substantial policy literature as well as the conceptual analysis of section 2. It finds that a digital-asset solution that replaces traditional financial assets is only one way to access the major opportunities presented by digital technologies to achieve more efficient retail financial services. However, replacing traditional financial assets with directly held intermediary-based digital assets can substantially reduce counterparty risk and facilitate real-time exchange of assets and improve liquidity management in financial markets – benefits not easily achievable in other ways.

There are substantial risks for code-based crypto assets, suggesting the need for continued strict regulation. The risks are much more limited for intermediary-based digital assets, which can be regulated in much the same way as traditional assets.
While there are potential consequences for monetary operations and transmission and for financial stability, especially from adoption of CBDC, these should be manageable.

Section 5 restates some of the key insights of this research.

2. What are digital assets? Code- versus intermediary-based digital assets

What are digital assets? What can they achieve? Much commentary equates digital assets with assets held on distributed ledgers. This is unsatisfactory, however, as there

is no universally accepted definition of ‘distributed ledgers’, and it is often more of a marketing term than a precise statement of how data are held and processed, with implementation varying hugely, combining component technologies in different ways.[8]

This section provides the conceptual foundation for the subsequent analysis of the potential application of digital assets in payments and transaction banking. It explains the meaning of digital assets as employed in this paper.[9] It explains how two foundational technologies (public-private key encryption and consensus mechanisms) support three properties that distinguish digital assets both from each other and from conventional financial assets. These three properties are that digital assets (i) are directly held; (ii) can support flexible rights of data access and data control; and (iii) offer potential for ‘peer-to-peer’ exchange (without requiring intermediaries to validate transactions and maintain records of ownership).

This section also reviews a third major technological development – APIs in tandem with data standardisation – that has supported the automation of financial transactions without relying on digital assets. It discusses how these three technologies are combined in different digital asset and conventional financial asset architectures.

This analysis supports classification (Figure 1) that distinguishes two forms of digital asset:

1. *code-based*, for ‘peer-to-peer’ exchange, employing open data networks and using permissionless blockchains where consensus relies on computer code; transfers can thus be hidden from regulatory oversight; and
2. *intermediary-based*, where intermediaries confirm transactions and thus control

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8 It can be no more than a shared database for exchange of information, with no change in the way holdings of financial assets are recorded and controlled – see, for example, the discussion of distributed ledger technologies in settlement in Choudhury et al. (2023) (on page 67, exhibit 2.1.11, variation SS1).

9 In particular, this sub-section draws on Milne (2022, 2023, 2024). ChatGPT4 confirmed the wide range of interpretations for ‘digital assets’, offering no less than seven different meanings of the term, of which only two (‘cryptocurrency and blockchain assets’ and ‘digital financial instruments’) related to financial transactions. Much of the related policy discussion is focused on the risk and regulation of cryptocurrencies or the implementation of distributed ledger technologies in mainstream financial markets.

access, implying that (unlike code-based digital assets) networks can be closed and regulatory oversight of holdings and transfers is always possible.

2.1 Technological foundations

The two key technologies underpinning digital assets are:

1. The use of public-private key encryption as the sole mechanism for asserting ownership and control over asset holdings;
2. The possibility of multiple versions of the database that records asset holdings, each held by different participants (or 'nodes') in a computer network, with a consensus mechanism ensuring consistency between them.

A proper understanding of digital assets requires a fuller explanation of these two technologies.

2.1.1 Public-private key encryption[10]

Public-private key encryption, a mathematical computing breakthrough of the 1970s, is a secure system of encryption based on pairs of matching large numbers (or keys) with special properties: any digitally represented computer record or file can be encrypted (transformed into an apparently meaningless binary number sequence) using one key of the pair and can only be decrypted (transformed back into the original

10 Many good internet sources summarise the history of encryption and its modern implementation using public-private key pairs (e.g. Thales 2023). Encryption can be traced back to ancient Egypt. Older encryption methods are much more easily broken than modern public-private key encryption, as they relied on a single key for decryption that had to first be transmitted from the sender to the recipient of the message. If this key was intercepted, the encryption was no longer secure. Even if the key was not intercepted, sufficient time and effort could crack a code that relied on manual operations (e.g. substitution of letters) for encryption and decryption. Automated operations using electro-mechanical machinery achieved encryption that was still single key but was much more complex and more difficult to break. Decoding could also be automated, however, and machine-based encryption could sometimes be decrypted – especially aided by user shortcomings in operation that gave clues to the underlying arrangements. A well-known example is the cracking of the German military's Enigma machine messaging by code breakers in Poland and later at Bletchley Park in the UK (see Turing 2018 and Welchman 2021).

readable file) using the other key.[11] It is also effectively impossible to use one of the keys in the pair to work out what the other key is.[12]

Once a public-private key pair has been created, it is only necessary to share the encryption (public) key and the encryption protocol to securely receive encrypted messages. It does not matter who has access to the public key, which can only be used for encryption and not for decryption. As long as the private key is secure, only the message recipient who generated the original key pair will be able to read the messages encrypted using the public key.[13]

Public-private key encryption is the technical foundation for modern database systems, supporting flexible and tailored data access and data sharing for a wide variety of purposes.[14] In conventional databases used in both banking and capital markets, a single database operator responds to requests to hold or transfer digital assets, or provides users with access through their systems. Public-private key encryption allows multiple users to interact directly with a database, with permissions defining what they can see and what changes to data they can instruct.[15] For digital assets, this allows

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11 Many sources provide details on public-private key cryptography, a core topic in current computer science teaching. A concise summary for the mathematically minded can be found in Chapter 4 of Lipton and Treccani (2022).

12 The matching key could hypothetically be found by trial and error (much as a three-digit combination lock on a briefcase can eventually be opened by trying all 1 000 possible combinations), but the 256-bit numbers used in encryption mean there are more possible combinations than there are atoms in the universe. Quantum computing could be used to crack public-private key combinations in a realistic time frame through brute-force trial and error, but this is simply an arms race that can be addressed by using larger keys (e.g. 512 bits).

13 Public-private key pairs can also be used in a slightly different way to 'digitally sign' a computer file, showing it was created by an individual associated with a public key. The author of the document creates a key pair and shares the decryption key publicly (e.g. on their website). The signed document comprises both the original unencrypted document and a second version of the document encrypted using the private encryption key. Anyone receiving the document can check the identity of the sender of the document by decrypting the second version (using the public key). If it matches the original version, it must have been encrypted by the creator of the key pair.

14 Such data access and sharing have wide applications in both the public and private sectors, well beyond their employment in digital assets (for further discussion, see Organisation for Economic Co-operation and Development (2019)).

15 The applications of public-private key cryptography in financial markets and financial intermediaries are far wider than this assertion of sole control in the case of digital assets. They can support a wide range of flexible, tailored data access arrangements and automated data processes, in line with other developments in the digital economy of internet commerce and

holders to directly view and instruct transfers for assets held on a single database or ledger.

For this paper, the distinguishing feature of digital assets is that access to the private key is the mechanism used by the holder to control digital assets (e.g. instruct transfers, allocate income generated from the asset or assert rights on the asset). This control is not necessarily absolute: if a control is misused (e.g. the asset is used for illegal purposes), the network may be established with intermediaries empowered to reverse network transactions (the digital assets are then what are defined below as intermediary-based – in contrast with code-based digital assets, where such reversal is not possible).

2.1.2 Consensus protocols in large open networks with no 'trusted third parties'

A consensus protocol ensures agreement on outcomes in distributed computing systems, where participants in a computing network share the processing of a common task (e.g. solving a computational problem or updating data).

The key technical breakthrough of the Bitcoin whitepaper (Nakamoto 2008) was its consensus mechanism, Bitcoin mining, which ensured agreement on ledger entries, even with a large and variable number of participants (a large open network) and without employing central operators (or 'trusted third parties').[16] Bitcoin mining is a so-called 'proof of work' consensus based on brute force solution of a mathematical puzzle requiring substantial energy expenditure, the difficulty and cost of which effectively eliminates competing false versions of the ledger. The Ethereum network, which supports most DeFi applications, uses a more energy-efficient 'proof of stake'

mobile apps. Grobler, French and Carr (2021) and Grobler, French and Renier (2022) argue that a shift to access-based controls and regulations offers huge efficiency gains to the financial services industry, replacing inefficient traditional arrangements. McNulty, Miglionico and Milne (2023) explore how these changes might better align the objectives of regulators and financial firms.

16 Consensus is comparatively easy in small networks with a fixed number of participants. Several effective consensus protocols are then based on message exchange (see (λx.x)eranga (2022) for a simple explanation).

consensus protocol.[17] These consensus protocols allow for the exchange of value without requiring the involvement of intermediaries.

2.2 Traditional versus digital financial assets

Figure 1 classifies financial assets into three categories – traditional assets, intermediary-based digital assets and code-based digital assets – according to their use of public-private key encryption and their choice of consensus mechanism. The cells shaded green indicate the possible choices. In this classification, the defining feature of digital assets is "Controlled, often on a shared database, through public-private key encryption" (the lower cell in column 1). One reason for employing this novel definition is to ensure that the term 'digital asset' includes those held on a single-operator database, a possibility under consideration for many implementations of CBDCs.

The term 'digital asset' is widely associated with cryptocurrencies and DeFi, where arrangements for holding and transferring assets do not require intermediaries. This is only possible if consensus across the copies of the shared database does not rely on a trusted third party (the lower cell in column 2). This category of digital asset for which this is true are labelled here as 'code-based', to distinguish them from all other digital assets in which consensus is based on intermediaries acting as trusted third parties, labelled here as 'intermediary-based'. While intermediaries may make mistakes, resulting in unintended asset transfers, these transfers can be reversed. Transfers using code-based assets cannot be reversed. Note that in this respect traditional assets are also intermediary-based and in the event of a mistake a transaction can be reversed.

As discussed in the next subsection, substantial risks are associated with code-based digital assets that do not arise for intermediary-based or mainstream assets. This high

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[17] Ethereum previously used a proof-of-work consensus protocol. With its 'merge' on 15 September 2022, it adopted a proof-of-stake consensus based on the random allocation of control to network participants ('validating node operators') who lock up a minimum stake of 32 Eth and are paid a small annual return for providing validation. The merge reduced Ethereum energy consumption to around 0.05% of its previous level (see Ethereum (2023)).

level of risk raises a central digital-asset policy issue: to what extent should regulated financial intermediaries be allowed to hold or offer services in code-based digital assets? In contrast, from a regulatory perspective, intermediary-based digital assets are not very different from traditional financial assets. Being controlled by regulated intermediaries, they can be subject to essentially the same regulation.

2.2.1 Directly versus indirectly held

A further feature differentiating traditional and digital assets is their liability status: whether they are indirectly or directly held (third column of Figure 1). An asset is indirectly held if it is the liability of an intermediary with a legal obligation to allow the holder to exchange it for an equivalent asset not held with the intermediary. A familiar example is money held in a transaction deposit with a commercial bank, which can be withdrawn as cash or paid to an account held at another bank. Another example is e-money issued by a non-bank (although the possibility of paying into accounts at other institutions may be limited, typically transfer is only possible to and from a nominated bank account of the holder). Securities may also be indirectly held as accounts with a custodian bank and can be transferred to other custodian banks.

An asset is directly held if no intermediary has a legal obligation to allow the holder to exchange it for an equivalent asset not held with the intermediary. Transfers then use a supporting database.[18] A 'borderline' case are stablecoins such as Tether and Circle's USD coin, used for trading on centralised crypto exchanges such as Binance and Coinbase and also in decentralised DeFi protocols. Their issuers seek to keep their market values stable, pegged 1:1 against the price of underlying assets, typically the US dollar. They do not though have a legal obligation to allow the holder to exchange at par. Instead, they intervene in the markets for stablecoins at the centralised crypto exchanges, selling reserve assets and transferring the proceeds into these exchanges to finance sales. Transfers to the centralised exchanges take time (a large value FedFunds transfer may only go through overnight). Such delays often result in stablecoin market prices falling at least temporarily below par.

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[18] Nowadays, typically, a computer database. Historically, before the computer age, ownership was recorded in writing, either as entries on a central register or through the issue of bearer assets like bank notes or security certificates passed from hand to hand.

Figure 1: A technology-based classification of financial assets

<table>
<tr><th colspan="2">Supporting technologies</th><th rowspan="2">Liability status</th><th rowspan="2">Traditional financial assets (intermediary-based)</th><th rowspan="2">Intermediary-based digital assets</th><th rowspan="2">Code-based digital assets</th></tr>
<tr><td>Database</td><td>Consensus</td></tr>
<tr><td>Conventional operator-controlled databases</td><td rowspan="3">Consensus using one or more ‘trusted third parties’</td><td>Indirectly held</td><td rowspan="2">Examples: bank accounts and security accounts, most of which are directly held.</td><td colspan="2" rowspan="2">No examples, because digital assets are not controlled by central operators (when they are, for example on centralised crypto exchanges, they are no longer digital assets).</td></tr>
<tr><td>Directly held</td></tr>
<tr><td rowspan="3">Controlled, often on a shared database, through public-private key encryption</td><td>Indirectly held</td><td rowspan="3">No examples, because traditional financial assets are not controlled through public-private key encryption.</td><td>Permissioned shared ledgers.

Examples: ‘tokenised assets’, CBDC and other digital currencies.</td><td>No examples, because ‘trusted third parties’ are <u>not</u> used for consensus in code-based digital assets.</td></tr>
<tr><td>Directly held</td></tr>
<tr><td>Consensus without ‘trusted third parties’</td><td>Directly held</td><td>No examples, because ‘trusted third parties’ are used for consensus in intermediary-based digital assets.</td><td>Permissionless shared ledgers.

Examples: cryptocurrencies, stablecoins and DeFi.</td></tr>
<tr><td colspan="3">Support for automated transfer and programmability</td><td colspan="3">Achieved by design within a single database, whether conventional or shared. Achieved between different databases, using APIs and standardisation to support automated transfer and programmability, whether assets are traditional or digital and are directly or indirectly held.</td></tr>
</table>

Note: Three technological implementations are possible (the examples highlighted in green): (i) existing traditional assets such as bank deposits held on conventional operator-controlled databases, the operator responsible for both maintaining records of asset holdings and executing transfers; (ii) code-based digital assets such as crypto-currencies held and transferred on shared ledgers without requiring the involvement of any intermediaries or other ‘trusted third party’; (iii) intermediary-based digital assets, which like code-based digital assets are held on shared ledgers and support automated transfer using public-private cryptography, but rely on intermediaries (‘trusted third-parties’) for controlling access to the ledgers (so they are “permissioned ledgers”) and maintaining the agreed record of asset holdings (establishing “consensus”),

Traditional financial assets such as commercial bank deposits are mostly indirectly held and fractionally reserved. Securities accounts held with custodian banks are also indirect holdings but are not fractionally reserved. They are fully reserved by a matching direct holding of securities by the custodian in an 'omnibus account' at the central securities depository (omnibus because they represent the holdings of many individual investors). Directly held traditional financial assets include central bank reserves and paper bearer instruments such as bank notes and physical security certificates. They also include individually segregated investor accounts held at central securities depositories.[19]

Code-based assets such as cryptocurrencies must be held directly when they are held and exchanged without the involvement of intermediaries, but they can also be held indirectly through centralised crypto exchanges. Most forms of intermediary-based digital assets (e.g. CBDCs or 'tokenised' securities) are directly held. Some emerging forms of private sector digital asset money are indirectly held, but with an obligation to support exchange into central bank money or traditional fiat money held at commercial banks.

2.2.2 Application programming interfaces (APIs) and data standardisation

The bottom row of Figure 1 highlights a crucial but often neglected point. A widely made argument for the adoption of digital assets is that they support efficient automated operations through direct transfers on their shared databases and through the use of 'smart contracts' – automatic exchange or transfer when certain conditions, for example market prices, are fulfilled. A widely made argument is that these operational benefits come from holding digital assets on a single set of records (using consensus to ensure consistency across the different copies of the shared database).

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[19] In most developed countries, including the UK and the US, the central security depository does not offer individually segregated investor accounts, so investors must hold securities through a custodian. But in many emerging markets, including South Africa, individually segregated accounts at the central securities depository are commonly used.

In practice, there can be no ‘big bang’ transition from traditional to digital financial assets, so even if digital assets prove popular both will continue to be held. Operational automation for the exchange or transfer of assets between databases with their own operational systems is always challenging, be it for traditional or digital assets. It is thus necessary to be aware of other technologies, APIs and data standardisations that support operational automation across different systems and databases.

APIs allow software developers to work easily with other software[20] and are widely used (e.g. in smartphones and internet commerce) to transfer data from one application to another.[21] APIs limit the communication between programs to essential standardised data. The user can then embed an API in their code, using it to ‘call’ another software to provide required data, without needing any further understanding of the other software or how it is coded.

APIs rely on the standardisation of data and business processes, so if the datum exchanged between programs (e.g. an address) is recorded or used differently by the two programs, the API may not work as intended.

Blockchains or distributed ledgers supporting code-based digital assets are the ultimate in data and process standardisation – instead of participants in a digital network each using their own software and databases, all participants use the same software and multiple instances of the same database (with consensus ensuring the different instances contain the same, agreed-on information). However, the costs of replacing existing databases with a new shared database solution are substantial.

Discussion of the potential benefits of adopting digital assets, for example automated low-cost and low-risk transactions, must therefore recognise the possibility that similar benefits can be achieved by retaining traditional assets on conventional intermediary-operated databases with APIs and data and process standardisation to support

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20 See ‘What APIs are’ (2016).

21 For example, your smartphone very likely displays local weather information on its home screen; this functionality is enabled by an API that connects the phone to an internet weather service and retrieves the weather for a location identified by the phone’s GPS tracker.

automation. An open question that can only be answered on a case-by-case basis is whether retaining traditional assets or replacing them with digital assets is the most cost-effective approach to automation and reducing cost and risk.

2.3 Digital assets in payments: stablecoins and digital currencies

Figure 1 distinguishes the two forms of digital financial assets from traditional financial assets, but it does not distinguish digital payment assets from other digital assets. What are the possibilities for using digital financial assets in payments and what characteristics that distinguish digital payment assets from other digital assets are required for this to happen?

Digital assets have not yet achieved critical mass anywhere in the field of payments, but there has been speculation about private digital payment assets disrupting or even replacing existing arrangements that use traditional assets (summarised in Box 1). Working with a consortium of private firms, Facebook has paid particular attention to proposals for person-to-person transfer of value for a digital asset: first through Libra's multi-currency backing in safe fiat assets such as short-term government bonds, and then through Diem, with single-currency backing. Both proposals ultimately stalled, but they gave credibility to the idea that a privately created digital asset might disrupt existing systems of payment.

Box 1: A summary of the use of traditional assets in payments

Understanding the possibilities for employing digital assets in payments requires understanding how traditional financial assets are used in payment operations. Many assets have been used for payments or (in the more formal terminology of monetary theory) as a medium of exchange. If two parties agree, then any asset, be it digital or traditional, can be used for payment.[22]

The question then becomes what the possibilities are for digital assets to replace assets already in regular use for day-to-day payments, either retail or wholesale. Answering this question requires an understanding of existing payment arrangements.

There is substantial relevant literature.[23] Network effects and critical mass are central to payments: an asset is widely adopted and accepted for payment only if the recipient is confident that they will be able to use it themselves for onward payment. The state plays a central role by establishing the legal framework for payments, determining a standard unit of account and choosing the forms in which payments in this unit of account will be accepted for settling obligations to the state – most importantly, tax payments. Private convention also matters: in the absence of state action to establish monetary arrangements, media of exchange emerge as market outcomes.[24]

Technology is also key: for many centuries, the dominant media of exchange were directly held physical objects such as coin, but these have been increasingly replaced by indirectly held claims (e.g. bank deposits) exchanged by written authority (bills of exchange, cheques, giros) through supporting systems that include emergent arrangements for direct exchange between holders (negotiable bills of exchange and certificates of deposits, interbank settlement arrangements for cheques and giros) and, in the computer age, a range of electronic payment instruments (cards and automated payment instructions such as standing orders) to supplement and eventually supplant written authority.

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22 Even code-based cryptocurrencies used for payment in illegal or unregulated transactions, such as to purchase firearms or drugs on the dark web, remove ransomware or evade currency controls.

23 Vaz, Milne and Brown (2020) offer a review of this literature to assess the possibility of using digital assets in payments.

24 Radford (1945) documented the classic example of cigarettes as a medium of exchange in World War II prisoner of war camps. For an associated academic debate between proponents of market and state charter theories of money, see Goodhart (1998).

Holders of money at financial intermediaries may still prefer to make payments using notes and coin, first withdrawing from their deposit with the intermediary (using an ATM or a teller). This is only suitable for face-to-face payments, however, and holders of money increasingly want to make payments using intermediary deposits without a cash withdrawal.

Where payments are made by directly transferring money held at financial intermediaries to the recipient, collective arrangements known as ‘payment schemes’ have come to play a major role. These support the transfer from a sender (the payer) to the recipient (the payee) when their payment deposits are held with different intermediaries (indirect holding of money). These schemes fall into two broad groups: card schemes such Visa and Mastercard and bank payments for domestic fund transfers. These require that the intermediary cooperate in debiting and crediting customer accounts and executing an ‘interbank’ settlement, usually in central bank money, to transfer the value from one institution to another.

If deposits at these institutions are not in the same unit of account, exchange from one of these units of account to the other becomes complicated. This occurs in two common situations:

Money market mutual funds (MMFs), which are not denominated in the unit of account but rather as shares of the net asset value of the MMF. Holdings in MMFs cannot be used as a payment asset simply by the MMF joining a payment scheme. Instead, their use in payment requires first a withdrawal by the payer, who exchanges a share of the MMF for a transaction deposit at the current price of the MMF. This transaction deposit is then used for payment via a payment scheme. This exchange may be automated (e.g. a credit card balance may be automatically paid from the MMF), but the money is always denominated in the standard unit of account used for payment, not the MMF share itself.

A payment from one currency to another (e.g. ZAR to USD), in other words ‘cross border’. Opportunities to use digital assets in cross-border payments are discussed in the following subsection. The key point is that an accompanying, possibly deferred, foreign exchange transaction is necessary – a requirement that holds true even when the two currencies are held as digital assets.

The framework presented in Figure 1 helps in analysing the forms of such digital payment assets and whether they can achieve the necessary critical mass to disrupt existing arrangements. Stablecoins and private digital currencies are privately issued possibilities, while CBDC is a third, state-issued possibility. Figure 1 can help yield a precise interpretation of these terms and an understanding of how they might be employed in retail or wholesale payments.

The term **stablecoin** has emerged to describe code-based crypto assets such as Tether, Coinbase's USDC and DAI, which have a mechanism that keeps their value stable in US dollars (or another fiat currency).[25] As Figure 1 shows, code-based digital assets are not held indirectly (there are no intermediaries to hold them with). Crucially, this means that while stablecoins are managed with the goal of maintaining a stable value in terms of a fiat currency, *they cannot share the fiat unit of account and must instead be represented by their own unit of account*. One Tether is not identically equal to one US dollar; instead, Tether has a market value that fluctuates, normally in a narrow range close to UST=$1.00. Comparing it with traditional assets, a stablecoin is more like an MMF with a fluctuating market value than like a bank deposit or e-money, which has a fixed value denominated in a fiat unit of account. Thus, stablecoin cannot be used as a direct substitute for existing payment arrangements.

Working with this definition of stablecoins, our understanding of **private digital currencies** can be limited to private intermediary-based digital assets. Examples include: (i) Facebook's Libra and Diem; (ii) 'tokenised deposits' that are commercial-bank liabilities but are exchanged using public-private key cryptography on their own database;[26] (iii) privately developed financial market infrastructures that provide digital-asset money accepted as legally final settlement for wholesale financial market transactions;[27] and (iv) potentially, an e-money that is held and exchanged as a digital

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25 The term stablecoin is sometimes also extended to code-based assets that are managed to maintain a stable value in precious metal, usually gold (see Montague Law (2023)). These are not considered stablecoins for the purposes of this paper.

26 Garratt and Shin (2023) distinguish stablecoins from tokenised deposits, arguing that the latter are more suitable for payments because they do not depart from 'par' values and so better support the 'singleness of money'.

27 Examples are Fnality (2023) and RTGS.global (2023).

asset using public-private key cryptography (unlike existing e-moneys that require an instruction to the intermediary to execute a transfer).

Usage of the term ‘private digital currency’ is itself not standard, however, and is often used more broadly to include code-based stablecoins – and ‘stablecoin’ is often used to include intermediary-based digital payment assets. The Bank of England has defined a stablecoin, somewhat loosely, as “a form of digital asset that can be used to make payments … backed by a specified asset or basket of assets.”[28] This definition is imprecise both because it does not clarify what is meant by a digital asset and because the definition does not distinguish code- and intermediary-based digital assets.

However, the key point is the importance of ‘backing’ to maintain the stability of a stablecoin or private digital currency. ‘Backing’ itself can mean different things but can be elucidated with the help of Figure 1.

In the code-based case, what we call a stablecoin, this backing describes any pool of underlying assets available to stabilise the market value – that is, to make the stablecoin stable. This pool of underlying assets can be either intermediary-based (traditional assets with stable values in terms of the underlying unit of account, held by a trusted third party, as for Tether and USDC coin) or other ‘crypto’ assets (the arrangement for the decentralised stable-coin DAI).[29]

In the intermediary-based case (distinguished from stablecoins, which in our usage are always code-based), a private digital currency must be indirectly held but can take two possible forms: an e-money deposit, which might be transferred via mobile phone, or an MMF. If it is an e-money, the private issuer commits to exchange, one for one, for commercial bank or central bank money in the same unit of account. If it is an MMF,

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28 Bank of England 2023.

29 See Nambiampurath (2022) for a description of DAI’s collateral, which includes USDC coin. Some discussions refer to a third, ‘algorithmic’ type of support mechanism for stablecoins, but this is always based on code-based collateral and is not a distinct approach; a more accurate classification is the one made here of ‘intermediary-based’ and ‘code-based’.

the private digital currency is a share in the underlying asset pool, with its own separate unit of account, and the commitment is to exchange for commercial bank or central bank money at the current market value of the share.

Two further points follow:

1. All intermediary-based private digital currencies fall within existing regulatory frameworks for e-money, mobile money or MMFs and thus may not require new regulation or legislation.
2. Only e-money versions of private digital currencies can be used in regular day-to-day payments. Neither stablecoins nor intermediary-based private digital currencies modelled on MMFs can be used directly in payments, as settlement would have to be indirect, the payee first accepting the stablecoin- or MMF-based private currency and only then exchanging it for fiat deposit money held in their own account. Only a 'dollarisation' event in which the stablecoin or digital MMF became accepted as the unit of account for a large proportion of transactions could precipitate any threat of a stablecoin replacing fiat money in day-to-day payments.

2.3.1 Further insights

Using this novel conceptual framework, further insights are possible into the distinction between permissioned and permissionless ledgers and the separation of ownership claims for digital assets from account management services (not easily achieved with traditional financial assets).

A common distinction in discussions of blockchain and distributed ledgers is between 'permissionless ledgers' (used for crypto assets and DeFi), where anyone can participate in the network and the consensus protocol, and 'permissioned ledgers', where the consensus is limited to a smaller number of trusted participants.[30] Code-based digital assets are here held on permissionless ledgers. The definition of

[30] Miller (2019) provides a detailed technical discussion, noting that this is really a continuum (participation in the consensus can vary from just one participant to all) and that the choice involves inherent trade-offs between trust and network performance.

intermediary-based digital assets proposed here – control exercised through public-private key cryptography – is broader than assets held on permissioned blockchains or distributed ledgers. Digital assets as defined here can also be held on a centralised ledger, a possible architecture for the implementation of CBDCs that need not necessarily use distributed ledgers for record keeping.

Several 'enterprise' solutions now exist to implement permissioned distributed ledger solutions in public services and industry, with substantial development communities undertaking coding and exploring applications.[31] Platforms range from those provided by commercial consortia and firms (e.g. R3's Corda) to others with a more open-source philosophy (such as Hyperledger Fabric, supported by the open source Linux Foundation). Many solutions are based on the fully programmable Ethereum platform but, because they are intermediary-based, do not use Ethereum's consensus mechanism.[32]

Using public-private key cryptography in intermediary-based digital assets allows ownership to be separated from the account services that manage holdings, a separation that is not possible with traditional financial asset architectures. It is this that makes a retail CBDC feasible. Without control through public-private key cryptography, direct retail access to central bank money is not a practical proposition. No central bank would want to provide direct retail banking services. The closest possibility to retail central bank money under traditional arrangements is transaction deposits (provided indirectly) with 100% reserving, imposing an obligation for close supervision of the providers of 100% reserved money.[33] With public-private key cryptography separating ownership from account services, the money holdings are no longer on the balance sheets of the intermediaries providing account services. Interface providers can

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31 Polge, Robert and Le Traon (2021) provide a comparison.

32 Ethereum also supports permissionless blockchains, notably for its own cryptocurrency, Ether, and many DeFi protocols. An example of an Ethereum-based enterprise blockchain solution is Quorum, originally developed on Ethereum by JP Morgan and sold to Consensys in 2020 (see Phemex (2021)). The Consensys website and its 2023 rebranding suggest that it is now more focused on 'Web 3.0' solutions for commercial engagement with crypto assets and other decentralised exchange.

33 Such arrangements do exist – for example, the mobile money of AliPay and Wechat Pay in China is reserved 100% in central bank money.

provide account services for central bank money held directly and not on their balance sheets, which significantly simplifies supervision. A separate issue is whether the holders directly manage their own keys or whether key management is a responsibility of the interface provider or a third party.

Properly implemented, this separation of ownership and account services will also allow assets to easily be transferred from one interface provider to another. Using retail CBDC as an example, most holders will want a convenient interface like that provided for a commercial bank transaction deposit account, allowing them to monitor and execute transactions using a mobile app or through a webpage. Separation of ownership can allow holders to transfer from one interface provider to another and ensures that their digital assets are entirely separate from those of other customers of the interface provider.

The phrase ‘properly implemented’ is critical here. An all-too-obvious weakness of centralised cryptocurrency exchanges in the wake of the failure of the FTX exchange is that these exchanges do not properly implement public-private key cryptography. Ownership is not separated from account services, so the crypto assets they support are claims on these centralised crypto exchanges. Many commentators have pointed out the resultant problem of “Not my keys, not my crypto”. These arrangements indicate that the crypto assets on centralised exchanges, no longer controlled solely through private keys, are traditional, not digital, assets – indirectly held representations of a shared claim on underlying code-based crypto assets.

This failure of separation allowed FTX to divert crypto assets to its own trading fund, Alameda. This remains a weakness of other centralised cryptocurrency exchanges such as Binance and Coinbase (although their internal controls seem much better than those of FTX). In principle, it should take no more than a simple instruction to move keys and transaction records for crypto assets from one centralised exchange to another. In practice, however, they have not been set up in this way: they have reinvented the indirect holding of TradFi instead of taking full advantage of the possibilities offered by digital assets.

3. The South African context

This section provides an illustrative review of the South African arrangements for payments and transaction banking. It draws on a more detailed unpublished paper (Lawack et al. 2024), providing a fuller discussion than can be given here of the institutional, legal and regulatory arrangements for payments and other financial transactions in South Africa.

This review provides contextual background for the conduct of payments and other financial transactions in one major emerging market economy to help assess the opportunities and risks of adopting digital assets. While review of such context in all countries, emerging and developed, is not feasible, a short discussion of the South African case supports the point that context is important.

Two related points already made in section 2 merit restatement (see Figure 1):

1. The adoption of digital assets (in the definition of this paper, “assets directly controlled using public-private key cryptography”) does not require employing the permissionless distributed ledgers without intermediaries used for code-based assets such as cryptocurrencies. They can implemented as ‘intermediary-based digital assets’ on permissioned shared ledgers with intermediaries responsible for controlling access, maintaining records and confirming transactions.
2. The anticipated benefits of digital assets – lower costs and risk, greater speed and transparency – do not necessarily require the adoption of digital assets at all. These same benefits can be achieved using standardisation and APIs while keeping the records of asset holdings on traditional centrally controlled databases (not directly controlled using public-private key cryptography). Moreover, even if digital assets controlled using public-private key cryptography are widely adopted, they will not all be placed on the same database and so there will still be a need for data standardisation and APIs to automatically exchange data between different databases.

This implies that adopting a digital-asset solution is a ‘replace’ or ‘reform’ decision: to either ignore existing operational arrangements and start from scratch (replace) or

investigate how existing operational arrangements can evolve to take advantage of new technological opportunities (reform). This decision is always a comparison of alternatives: adopt digital assets and replace existing traditional financial assets or adopt common standards and agreed APIs to automate the exchange of existing asset holdings. Which is more cost effective will depend on existing institutional, legal and regulatory arrangements. This short review of the South African context supports this key point.

This review is set out as follows: it first looks at cryptocurrency and DeFi in South Africa, including emerging crypto regulation, then turns to the financial markets in South Africa. It next considers retail payments and finally discusses cross-border transactions.

3.1 Code-based digital assets in South Africa

A recent review by the Financial Sector Conduct Authority (FSCA 2023) of the adoption of crypto assets in South Africa finds that their application to payments and the purchase and sale of non-crypto-assets remains very limited. The FSCA reports that 60% of crypto assets held in South Africa are unbacked crypto assets (cryptocurrencies such as Bitcoin or Ethereum's Ether), 26% are stablecoins (such as Tether) and the remaining 14% are tokens of various kinds (security tokens similar to equities issued, utility tokens that give rights to services, and NFTs that represent non-financial assets such as digital works of art).[34] To date, the main use for South African holders has been as a speculative investment asset.

The principal crypto-asset policy statement for South African financial authorities is the consolidated view published in the final position paper of the Crypto Assets Regulatory Working Group (2021), a sub-working group of the Intergovernmental Fintech Working Group (IFWG).[35] The paper makes 25 recommendations for a revised South African

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[34] See Figure 3 in their review; the figure is based on survey responses by 47 South African-based crypto-asset service providers.

[35] This position paper reflects the collective position of key stakeholders and member regulatory authorities, including the Competition Commission, the Financial Intelligence Centre, FSCA, National Credit Regulator, National Treasury, the South African Revenue Service and the South African Reserve Bank (including the Prudential Authority).

policy, legal and regulatory position on crypto assets and related activities and provides a roadmap for the implementation of a framework to regulate crypto-asset service providers (CASPs) in South Africa.

In October 2022, the FSCA, which is responsible for the supervision of market conduct, published General Notice 1350 of 2022 in Government Gazette 47334 declaring crypto assets financial products in terms of the Financial Advisory and Intermediary Services Act 37 of 2002. This declaration established the foundation of a regulatory and licencing regime, stipulating that, to address shortcomings in the crypto-asset ecosystem pertaining to consumer protection and market conduct, any individual or business in its jurisdiction providing financial advice or intermediary services with respect to crypto assets must register as a financial services provider.

Following the publication of the Crypto Assets Regulatory Working Group's position paper, the National Payment System Department of the South African Reserve Bank (SARB) drafted a policy position paper on the use of crypto assets for domestic payments. While the National Payment System Department has not yet offered a public position on the use of crypto assets for public payments, its final position is expected to align with the prevailing global approach to the definition and eligibility of crypto assets as a payment system and money.[36] Its regulation of CASPs is thus likely to parallel that of the European Union's Markets in Crypto-Assets Regulation, suggesting a separation between crypto (code-based) digital assets and all other intermediated financial assets, and focusing on regulation of the 'on ramps' and 'off ramps' for exchange from ZAR into crypto and vice versa. This is appropriate both for enforcing AML/CFT reporting and ensuring appropriate consumer advice on and protection from risky and potentially fraudulent crypto investments.

The need to incorporate crypto assets into the prudential regulation of the South African banking system has also been recognised. In December 2022, the Basel

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[36] This is consistent with the South African legal status of crypto assets, which fall clearly outside the scope of recognised forms of money, be they legal tender currency or book money provided by commercial banks or e-money providers (see IFWG Crypto Asset Working Group (2019) for a more detailed discussion).

Committee on Banking Supervision (BCBS 2022) released its regulatory standard for the prudential treatment of crypto-asset exposures for global implementation and regulatory alignment. The Prudential Authority (PA) of SARB subsequently drafted its prudential standard for the treatment of bank exposures to crypto assets, including tokenised traditional assets, stablecoins and unbacked crypto assets, in alignment with the BCBS publication. However, as yet there has been little discussion about the 'tokenisation' of traditional assets in South Africa. While some ZAR stablecoins have been issued, they are not widely traded in cryptocurrency exchanges and are not yet perceived as a substitute for central bank money in retail payments to the same degree that the major dollar stablecoins are for US dollar payments.[37]

Consistent with the emerging framework of crypto regulation in South Africa, this suggests it will not be difficult for the authorities to separate the trading or holding of all such code-based assets. Accordingly, regulated firms should either be CASPs, providing services in code-based assets, or provide services in intermediary-based assets (digital assets or traditionally held assets) – but they should not be both.

3.2 South African financial markets

South Africa has the most developed financial markets in Africa, with a deep and liquid market for equities and government bonds (including reserve bank debentures issued by SARB). The South African rand is freely traded, with the Bank for International Settlements survey for April 2022 ranking it 18th in the volume of global currency trading, just behind the Mexican peso and Taiwanese dollar, and ahead of the Brazilian real and Danish krone. South African money and financial derivative markets are also well-developed. Investor confidence is underpinned by a strong regulatory framework and SARB's established track record of ensuring both monetary discipline and – through its oversight of the payments system, prudential supervision and risk monitoring – financial stability.

In common with other emerging markets such as India and Brazil, the infrastructure of South African financial markets is more up to date in important respects than financial

[37] Examples of ZAR stablecoins can be found at xZAR (n.d.), Zarban (n.d.) and ZARP (n.d.).

markets in developed countries. The operational architecture of the United States (US), United Kingdom (UK) and other developed country jurisdictions was put in place in the 1970s and 1980s, guided by design decisions determined by the more limited computer technologies of that time. South African arrangements were instituted later, in the 1990s. South Africa thus supports individually segregated securities account ownership in the central securities depository STRATE for domestic investors. As discussed in section 2.2 above, this is direct ownership of traditional assets (of the kind more commonly associated with digital asset technologies – see Figure 1).

While this presents exciting opportunities, it is not obvious that South Africa will want to be a 'first mover'. The analysis in section 2 (drawing on the BIS work on the 'tokenisation continuum') suggests the need for caution about tokenisation. Tokenisation will only be of limited benefit to bonds, equities and other assets for which liquid markets already exist in South Africa. Costs would also be incurred moving the records of these holdings out of the central securities depository STRATE database to a new distributed ledger (it might be less costly to allow limited use of private keys to execute transfers through STRATE).

Digital technologies could also be used to improve the registries and other records of South African asset holdings – such as land, buildings and private unlisted companies – to increase ownership transparency, a goal best accompanied by an identity system that effectively links assets to owners. This is not primarily a payment and transaction banking issue. The principal benefit would be to limit the potential for misrepresentation of ownership of real assets. Lowering transaction costs is a secondary benefit, but – more importantly – none of these outcomes requires digital assets held through private keys.

Another digital-asset opportunity in South African financial markets may be to use public-private key cryptography to support the temporary real-time exchange of cash and securities to efficiently move collateral to support trading positions and meet the liquidity needs of market participants – through repo borrowing of cash, securities borrowing or (especially for cross-border transactions, discussed in section 4.3) foreign

exchange swaps.[38] However, it is unclear whether the most appropriate solution is based on digital or traditional assets. Key constraints are the opening hours of payment and settlement systems and the necessary increase in the direct holding of money and securities. The South African Multiple Option Settlement, the real-time gross settlements system for exchange of central bank money, already has relatively long opening hours, and securities are often held directly. The current programme of real-time gross settlement (RTGS) renewal in South Africa may also be increasing the direct holding of central bank money.

3.3 Retail payments in South Africa

Opportunities exist to use payment technologies to promote financial inclusion, a major policy issue in South Africa. Levels of bank account ownership are comparable to other middle-income countries but remain a substantial policy challenge, with continued concern about the lack of access of the most disadvantaged people to financial services and the desirability of easing credit constraints for small businesses.

This opportunity is central to the National Payment System Department's (2018) South African National Payment System Framework and Strategy: Vision 2025. The same department recently released a roadmap to realise Vision 2025's retail-payment goals (National Payment System Department 2024), highlighting the launch of faster payments and the need for support for digital payments at point of sale through contactless payments and the development of an agreed national standard for quick read (QR) codes.

A barrier to realising this opportunity is the continued high level of reliance in South Africa on notes and coin for payments. South Africa has not experienced the same uptake of mobile money for payments as Kenya, China and a number of other low- and middle-income countries. This raises the broad question of whether developments in payment technology could lead to digital payments substantially replacing cash in South Africa and what form this might take (a retail CBDC, a mobile money or some other solution). And, however pursued, a decision would also have to be made about

[38] See Milne and Ransome (2024) for a discussion of such opportunities in global financial markets.

whether to use intermediary-based digital assets (controlled through public-private key cryptography) or traditional intermediary-controlled accounts.

Digital assets – in the sense of this paper, user controlled through public-private key cryptography – are not obviously necessary to achieve the efficiency gains on offer from applying technology to retail payments. Brazil, which has a similar financial-inclusion situation to South Africa, recently modernised its retail payments using traditional rather than digital financial assets. In Brazil, a high proportion of adults hold bank accounts and there was, until fairly recently, a high dependence on cash for most retail payments.

Financial inclusion in Brazil was transformed by the 2020 launch of the Pix bank-based fast payment system. As the International Monetary Fund (IMF) reports, Pix had been used by 140 million individuals, around 80% of the adult population, in less than three years. Transactions reached 3 billion per month, around 20 per month for each user, "facilitating transactions by 71.5 million individuals (as of December 2022) who had not made any electronic credit transfers over a one-year period prior to the launch of Pix and are Pix users now" (IMF 2023a).

South Africa is pursuing a similar fast payment solution for digital retail payments with the March 2023 launch of the first phase of Payshap, a collaboration between BankservAfrica (the automated clearing house owned jointly by SARB and South African commercial banks) and the Payments Association of South Africa. Payshap allows instant bank-to-bank payments from within mobile payment applications to registered recipients using a recipient's Shap ID (their mobile number combined with a bank identifier, e.g. 0824825822@bankX) or their bank account number. Adoption has been healthy, with some 14 million transactions between 13 March 2023 and 29 February 2024 (BankservAfrica 2024), but is still some way short of the 20 transactions per month for 80% of the population achieved by Brazil's Pix.

One alternative in South Africa for digital retail payments is the biometrically secured SASSA card, linked to a Post Bank account. This was introduced in 2012 as a MasterCard debit card (the white SASSA card) and was superseded in 2018 by a Visa

debit card (the gold SASSA card) for the secure receipt of social grant.[39] Around 7 million social grant recipients hold SASSA cards to receive their social grants, but the card is primarily used for ATM withdrawals rather than to pay for goods and services. As such, it does little to promote digital payments or address financial inclusion.

It is not clear whether a ZAR CBDC intended to promote financial inclusion would be more effective as a digital asset or a traditional financial asset. In South Africa, lack of access to the internet and limited use of smartphones (many South Africans use cheaper phones with fewer features) could make it difficult for many South Africans to employ public-private key cryptography to control their holdings of a ZAR CBDC, so a non-digital-asset solution might be more appropriate. However, it may be more important to focus on the interoperability of different payment instruments – for example, working to ensure that the SASSA card or similar can be held in virtual form on both feature and smart phones and can be used seamlessly and reliably in a range of digital payments.

Overall, this discussion suggests some caution is required when considering the relevance of digital assets to improve retail payments in the South African context.

3.4 Cross-border transactions in South Africa

South African households and companies could benefit in many ways from lower-cost, quicker and more transparent cross-border payments, with the greatest benefits achievable where inefficiencies are greatest – for payments by smaller companies, for intra-African trade, for incoming and outgoing remittances, and for tourism and travellers. Cross-border payments through African banks are especially problematic, as they are generally costly, slow and have limited accessibility.[40]

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39 From this year, 2024, social grants can also be paid to an account with another Visa debit card (the black Post Bank Manzi card).

40 Bindseil and Pantelopoulos (2022, pp. 8–9); Adrian et al. (2023, p. 5); Carstens (2020, p. 18).

One possible solution is to further develop regional payment infrastructures. Examples of possible ways to integrate regional and cross-regional payment infrastructure include clear and simple agreements across payment infrastructures, interoperability arrangements and standardising operating procedures.[41] The Southern African Development Community RTGS, established in 2013, is an example of a sub-regional infrastructure model in Africa.[42] PAPSS, launched in 2022, was designed by Afreximbank in partnership with the African Union and African Continental Free Trade Area Secretariat to enable cross-border payment transactions throughout Africa.[43] Cross-border opportunities also exist at the wider global level, including remittance payments from the South African diaspora to family back home and small business payments.

As for retail payments, it remains far from clear that digital financial assets are the most effective way of promoting lower-cost, more efficient cross-border payments in South Africa, as existing regional initiatives are based on traditional architectures. While cross-border payments might be facilitated by direct exchange of CBDC in the form of digital assets, a more immediate practical opportunity for improving wholesale financial market and retail cross-border payments would seem to be the widening of intermediary access to ZAR accounts at SARB.[44] This possibility is under discussion for the renewal programme of the South African Multiple Option Settlement RTGS system.

4. The opportunities and risks of digital assets

This section discusses the opportunities and risks associated with adopting digital assets (as defined in section 2) and their supporting technologies. It draws on extensive worldwide analysis of digital assets and CBDC published in recent research papers, policy statements and practitioner commentary. Emphasis is on issues of most importance to emerging markets, particularly South Africa.

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41 Committee on Payments and Market Infrastructures (2021). See also Brandl and Dieterich (2023).

42 Bech, Faruqui and Shirakami (2020, p. 57); Domingo and Teevan (2022, p. 7).

43 TRALAC (2022, p. 11; 2023).

44 On this point, see He, Milne and Zachariadis (2022) and Milne and Ransome (2024).

The opportunities and perceived benefits of using code- or intermediary-based digital assets for payments and transaction banking are reviewed, and alternative digital technologies are also assessed. Finally, there is a consideration of the risks associated with code-based digital assets, where the risks are substantial, and intermediary-based digital assets, where the risks are relatively limited.

4.1 Economic opportunities

The literature discussing the benefits of adopting digital assets in financial services goes back a decade to the first industry interest in Bitcoin and blockchain, so a full review is beyond the scope of this paper. The discussion here is limited to payments and transaction banking, comparing the potential benefits of using digital assets in payments and transaction banking with those available through other digital data technologies.[45]

The comparison of digital assets and other data technologies is made because it remains an open question whether the benefits of digital technologies are more cost-effectively achieved by *replacing* traditional financial assets with digital asset equivalents (e.g. nostro accounts with commercial banks replaced by wholesale CBDC) or by facilitating automated processing and programmability and *retaining* conventional arrangements (as discussed in section 2).

The choice to replace or retain depends on both the specifics of the transaction (retail, wholesale; B2B, C2B or G2C; etc.) and the legal, regulatory and institutional framework of the jurisdiction in which the transaction takes place. Thus, any discussion of the opportunities to employ digital assets for payments and transaction banking is context-dependent, and broad universal conclusions are not possible.

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[45] This summary has relied mostly on analyses by the IMF, the World Economic Forum (WEF) and the BIS. Prominent papers consulted include Auer, Haene and Holden (2021); BIS (2023); Gorjón Rivas (2022); He, Milne and Zachariadis (2022); IMF (2023b); UK Finance (2023); Weisman and Zacharias (2021); World Bank (2023). Relevant reports by the WEF include WEF (n.d., 2021, 2023) and WEF and Boston Consulting Group (2021). The discussion of cross-border payments draws on He, Milne and Zachariadis (2022).

This summary is presented under six headings, as set out below.

4.1.1 Retail payments

Some of the most prominent technology-based benefits in transaction banking are greater convenience, speed, security, transparency and lower costs for retail payments, especially merchant payments virtually or at point of sale. Major advances worldwide over the past two decades have exploited mobile and internet technologies, along with near field communication (NFC) and QR codes. While notes and coin are still the dominant instrument for small-value retail payments in many countries, including South Africa, elsewhere three broad innovations have taken an important share of small-value in-person retail payments and support online retail merchant payments where notes and coin cannot be used:

1. Mobile-based non-bank money: in China, Kenya and increasingly in other countries in sub-Saharan Africa and south and south-east Asia.
2. ‘Tap and pay’ (NFC) card payments: in high-income countries, where use of credit and debit cards is well established. The mobile and card payment rails are combined in solutions such as the Apple Pay or Google Pay apps, which hold card information and transmit it securely via NFC. Similar functionality has been provided in many emerging markets using QR codes.
3. ‘Faster payments’: solutions for near-instant bank-to-bank payments embedded in mobile apps are making substantial inroads for retail merchant payments in some countries, notably through Pix in Brazil and UPI in India.

These emerging technology solutions are all digital, but none employs public-private key cryptography as the sole mechanism for controlling assets held on a database (the meaning of digital asset employed in this paper). A digital-asset solution for retail merchant payments is conceivable as a retail CBDC or a private digital currency, but it is difficult to see what advantages a private stablecoin could offer over existing mobile money, card or bank-to-bank payment solutions, even if held indirectly with a value guaranteed by an intermediary. A retail CBDC might achieve more traction as a trusted form of central bank money and could operate as a public utility without having to levy high merchant fees – but here it is the issuance by the central bank that makes the difference, not its holding using public-private key cryptography on a shared database.

4.1.2 Financial inclusion

Digital technologies are important tools for increasing access to financial services. Such financial inclusion is a multi-faceted challenge: to provide access to credit, insurance, savings and investment products and payment instruments. Issues beyond technological innovation that need to be addressed include the role of bank and non-bank service providers; culture, gender and faith (which influence demand for and viability of financial products such as credit and insurance); financial literacy; access to broadband and mobile telephony infrastructure; digital identity solutions; consumer protection; and AML/CFT regulation.

Given this paper's focus on digital assets and transaction banking, the relevant issue is the implication of digital payment innovations for financial inclusion.[46] Payments are acknowledged as the 'gateway' to financial inclusion. The same technologies that promote digital payments for retail merchant payments can encourage the opening of transaction accounts for the previously unbanked. Increasing the adoption of transaction accounts for a range of payments, whether provided by a bank or non-bank, can be achieved by, among other interventions: ensuring convenient access for both cashing-in and cashing-out, be this through agents, branches or ATMs; proportionate regulation that protects against risk while allowing competition and innovation; and robust information and communications technology (ICT) infrastructure with arrangements as necessary to support offline and online transactions. The public sector has a particular responsibility here, for example by promoting identity solutions that reduce the costs associated with AML/CFT compliance and by integrating digital payments into tax collection and government-to-household payments in both regular social security support and emergency response.

As with retail merchant payments, it is far from obvious that private digital-asset money (stablecoins, private digital currencies) based on public-private-key-based control will help promote financial inclusion in any way not already possible with traditional money

[46] Central banks worldwide acknowledge the importance of payments and payment oversight and regulation to financial inclusion, with a common approach developed by the Committee on Payments and Market Infrastructures and the World Bank (2016, 2020).

and payment solutions (whether these are bank-based or, like many mobile payments, non-bank). A stronger case can be made for a retail CBDC to promote financial inclusion – but again, implementation as a digital asset using public-private key cryptography does not make the difference.

4.1.3 Cross-border transactions

There are concerns about the high costs, length of time and lack of transparency of cross-border payments, including remittances, retail merchant payments (online or as part of travel and tourism) and business-to-business payments for small- and medium-sized enterprises – especially for 'corridors' (from one currency to another) with few alternative payment solutions. The G20 has coordinated ongoing efforts to address these concerns.[47]

Digital assets are frequently viewed as a natural technological solution for improving cross-border payments, in part because of the demonstrably low costs of transferring code-based digital assets (crypto assets such as cryptocurrencies or stablecoins) from one country to another. Provided CASPS are available to exchange the crypto assets at low cost using the domestic fiat currencies of the money sender and the recipient, a cross-border transfer using code-based crypto assets can be both quicker and cheaper than a traditional transfer using intermediated bank or non-bank international payment services.

Again, however, it is not clear that adopting either code-based or intermediary-based digital assets offers substantial advantages over other digital technology innovations for cross-border payments. It is difficult to enforce global AML/CFT regulation without intermediaries, presenting a substantial challenge to using code-based digital-asset exchange in cross-border payments. Intermediary-based digital assets can comply with AML/CFT regulations but their exchange in cross-border payments requires an institutional architecture that does not currently exist and may be difficult to establish.
As an illustration of the second point, consider the use of CBDC in cross-border payments. At some point in the transaction, an exchange of the two CBDCs must take

47 See CPMI (2020); FSB (2020, 2023).

place, for example digital EUR in exchange for digital ZAR. Technically, this is straightforward, as the coding can ensure simultaneous transfer on the two CBDC ledgers (payment vs. payment (PvP) to eliminate counterparty risk).[48] The real problems arise in terms of the law and economics, and the institutional architecture that is designed must address three questions: (i) Who holds the CBDC involved in the exchange?; (ii) What role does their exchange play in the cross-border payment?; and (iii) What mechanism determines the transaction timing and exchange rate between the two CBDCs?

One conceivable design is a direct exchange of retail CBDC, effectively a digital replication of the transfer and exchange of bank notes (but with the CBDC accounts linked to real-world identities for enforcement of AML/CFT regulations). This would require: (i) no restrictions on who holds digital EUR and digital ZAR accounts, meaning they can be held by domestic and foreign residents, individuals and institutions; (ii) foreign exchange intermediaries who keep the balances of digital EUR and digital ZAR (similar to the foreign exchange booths at airports, but operating online); and (iii) regulation ensuring effective competition between these intermediaries in the retail market for foreign exchange. This design would require substantial cooperation between central banks – difficult to imagine before retail CBDCs have been successfully launched in their respective jurisdictions.

A second conceivable design is to use wholesale CBDC to support intermediary-based transfers, but on a more open basis, with both bank and non-bank participation. This might involve: (i) wholesale digital EUR and digital ZAR accounts being held by any approved, regulated domestic or foreign intermediary (with mutual recognition by European and South African authorities of each other's regulatory approvals); (ii) the digital EUR and digital ZAR being set up to allow automated sending to and receipt from any domestic retail digital money account (bank, non-bank or retail CBDC (should that exist)). This will allow these intermediaries to hold balances of digital EUR and digital ZAR and use them to transfer directly from a retail holder of money in one

[48] As demonstrated by the several 'mCBDC' experiments by central banks, including the Project Dunbar proof of concept involving the SARB (BIS Innovation Hub 2022).

currency to a retail holder in another currency at an agreed exchange rate and charge. This model does not require retail CBDC to be successfully launched in both jurisdictions, but it does require substantial cooperation between authorities.

In this second design, it is wider access to central bank money that is critical, not the employment of digital assets or the ability to engage in simultaneous CBDC-based PvP foreign exchange. The intermediaries do not need to settle each payment on an RTGS basis but can instead adapt the traditional arrangement of holding inventories of both currencies. Established spot and foreign exchange swap markets can be used to ensure they have sufficient balances to meet their payment obligations, and bank-based faster payments in the two jurisdictions can ensure the rapid receipt of money from the original payer and rapid onward transmission to the final payee.

As with technological solutions to improve retail payments or promote financial inclusion, none of the intermediary-based alternatives for improving cross-border payments requires that central bank or private money be held as a digital asset. One possibility is directly linking domestic payment infrastructures in the two jurisdictions.[49] A promising development in this regard is the linking of domestic faster-payment schemes to support near-real-time cross-border retail payments, realised in the collaboration between Singapore's PayNow and Malaysia's DuitNow, which launched in November 2023 (Monetary Authority of Singapore 2023).

A key design choice in linking domestic payment infrastructures is the conduct of foreign exchange. Participating institutions can keep and freely manage inventories in both currencies (with correspondents or directly with central banks) or, in line with domestic faster-payment rules, close all resultant foreign exchange exposure on a regular (e.g. daily) basis, perhaps at near-market exchange rates of the participating central banks.[50] The most ambitious of this range of possibilities is a common or

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[49] CPMI et al. (2023) classify different arrangements and distinguish interlinking as well as traditional correspondent banking, peer-to-peer (the direct holding and exchange of central bank money as bank notes or retail CBDC) and 'closed loop', where a bank has a presence in both jurisdictions and is effectively its own correspondent.

[50] Governance and oversight are also crucial (see CPMI (2023)).

multilateral platform. It is not strictly interlinking, however, because intermediaries in different jurisdictions sign up to a set of common rules and procedures in addition to those required by their participation in domestic-payment infrastructures.[51] Digital assets could apply here, as a common platform might use CBDC to exchange and settle cross-border payments.

4.1.4 Liquidity, collateral and counterparty risk management

Turning from retail to wholesale, opportunities exist to employ digital assets for greater efficiency in financial market transactions, especially to better manage liquidity, collateral and counterparty risks. Box 2 provides a summary of this specialised and complex subject area, offering a background for the present discussion.

Two papers from 2023 usefully review the perceived benefits of digital assets in financial markets (Choudhury et al. 2023; UK Finance 2023). These benefits include (i) lower operational costs; (ii) accelerated settlement with an improved trade-off between counterparty and liquidity risks; (iii) using repo and other tools to improve arrangements for the exchange of cash and collateral in liquidity and collateral management, both intraday and overnight; (iv) 'tokenisation' to support the development of liquid secondary markets for what are currently illiquid assets; and (v) improvements in asset servicing through 'digital custody'.

[51] Such multilateral platform arrangements are explored in CPMI et al. (2023).

Box 2: Liquidity and counterparty risk management in financial markets

Analysis of the potential benefits of employing digital assets in financial markets requires a basic understanding of existing arrangements for managing liquidity and counterparty risks. There are three elements to these arrangements: (i) deferred settlement; (ii) the securing of money and securities for settlement and their legally final transfer; and (iii) prudential oversight and regulation of the liquidity risks of market participants and the supporting market infrastructures, including large-value payment systems. Risks are magnified in cross-border transactions.

Deferred settlement

Deferred settlement is a collective arrangement that balances counterparty risk (increasing with the settlement window, i.e. the period between trade execution and final settlement) against liquidity risk (more easily managed with a longer settlement window). The current convention across equities, bonds and foreign exchange markets is most often for a T+2 settlement window.[52] An equity trade conducted on Monday T is settled overnight for the morning of the Wednesday, two working days later (T+2) – with legally final (irreversible) delivery of the shares and payments synchronised to take place together (delivery versus payment (DvP)).

There is an inherent trade-off between liquidity and counterparty risk. Settlement at T+2 provides liquidity to market participants, who do not need to 'pre-fund', holding the necessary cash and securities for each and every trade beforehand; instead, they have a full working day to locate what they need for settlement. This benefit comes at the cost of counterparty risk, since the securities may not be delivered or payment received as agreed in the trade.[53]

These risks have changed over time. The volume and value of trades requiring settlement has risen substantially with the shift to electronic trading and the

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52 South African arrangements are: T+3 settlement of equity trades and a range of settlement from T+0 to T+3 for bonds; settlement is on the books of the central security depository STRATE with DVP payment in the SARB large value payment system SAMOS; settlement is overseen by the Johannesburg Stock Exchange Clearing and Settlement system. Further details can be found on the JSE's webpages (JSE 2024).

53 The settlement period in most major markets has been shortened since the practice of 'book entry'. Paper-based settlement using physical certificates was first established in the 1970s and 1980s and has been replaced by the holding and settling of securities through accounts in custodian banks and central securities depositories. For example, settlement in the US was reduced from T+5 to T+3 in 1993 and to T+2 in 2017. A shift to T+1 settlement has already been adopted in India, was implemented in the US and Canada in May 2024 and is under consideration in other jurisdictions. This is primarily an operational change for domestic market participants (less time to secure funding), but it makes international investors' liquidity management more challenging (see Milne and Ransome (2024)).

automation of trade execution. This has helped support market liquidity, reducing the impact of trading on market prices, but it has also increased counterparty risks in securities transactions. Technological innovations such as electronic trading have also helped automate processes for accessing liquidity.

Supplementary tools (e.g. central counterparty clearing, netting and margin payments) are increasingly used to reduce counterparty risk. Originally developed to cope with the relatively large counterparty risks in derivative trading, these methods are now also regularly applied to securities and foreign exchange transactions. This risk reduction comes at the cost of a new liquidity risk exposure: short notice requests for margin payments.

Securing and transferring cash and securities

Deferred settlement allows market participants to trade without pre-funding, acquiring securities or cash to fulfil their settlement obligations during the settlement window. This is a core part of the business models of dealers and traders, whose trading in turn supports the price discovery and market liquidity that allow longer-term 'cash' investors (e.g. mutual funds, insurance companies, pension funds) to value their portfolios and transact, buying or selling without significantly affecting market prices.

Dealers and traders such as hedge funds borrow cash and securities for settlement. The amount due, for both payment of cash and delivery of securities, is then often substantially reduced, but not eliminated, by netting (with the greatest 'netting efficiency', i.e. the maximum possible reduction if a central counterparty becomes the 'buyer to every seller and the seller to every buyer'). Dealers and traders acquire any remaining cash and securities, not already in their possession, through collateralised borrowing: selling and repurchasing cash 'repo' from commercial or investment banks,[54] and borrowing securities from cash investors. Taking the example of T+2 settlement of a securities trade, this borrowing will often be at T+1 for settlement at T+2, with legal ownership transferred in the initial borrowing (e.g. a government bond for ZAR, USD for ZAR, at T+1 to settle T+2; this borrowing is then either unwound with a reverse transfer at T+2 or is renewed for an additional day).

Further liquidity risks arise in the cash leg of trade settlements, regardless of whether the cash is already held or must be borrowed. Dealers and traders hold their cash as deposits with commercial banks. This is a revenue stream for commercial banks but also exposes these banks to their own overnight and intraday

[54] This is private repo. Banks providing the cash may in turn use central bank repo to obtain reserves for settlement. Another possibility for T+1 borrowing is the 'tomorrow next' foreign exchange swaps.

liquidity risks: overnight, because by the end of each working day they must ensure they have sufficient central bank reserves to settle their client's commitments to overnight trade settlement; intraday, because some client payments (e.g. CLS Bank foreign exchange settlement, intraday margin payments) are timed and must be paid out before anticipated incoming payments are received.

This is not such an issue for borrowed securities deposited with custodian banks, which are always 100% reserved (i.e. backed one-for-one with an omnibus (reserve) account with the central securities depository). Trading obligations are not finally legally settled until the DvP or PvP exchange, with the cash payment (P) leg consisting of a transfer of central bank money. The fractional reserving of the commercial banks, where the traders and dealers conducting market transactions hold their cash balances for settlement, means there is always a possibility – a counterparty risk – that the commercial bank could have insufficient reserves for settlement.

Prudential oversight

Market participants are well versed in managing liquidity and counterparty risks on a day-to-day basis. Counterparties are professionals who (unlike retail bank depositors) are expected to understand these risks and not need, for example, protection through deposit insurance. Where counterparty risks are greatest, many participants can only access markets indirectly via the larger established institutions (where there is a central counterparty, these are the general clearing members). An example is of hedge funds that rely on investment banks as prime brokers to execute their trades and provide collateralised lending of cash and securities. The concern for regulators is systemic risk: the heightening of both counterparty and liquidity risks in a financial crisis (as materialised in the global financial crisis (GFC) of 2007–08 and more recently with the onset of the global pandemic in March 2020) leading to the breakdown of the infrastructure for the settlement of financial market transactions and for large value payments.

This systemic risk is addressed by close oversight of the infrastructure and liquidity and counterparty risks of the major market participants, together with a range of rules, regulations and principles to protect the integrity of financial infrastructures – arrangements that have been tightened across the globe since 2008. Before the GFC, intraday credit and liquidity savings mechanisms were established arrangements with which to avoid liquidity problems and gridlock in RTGS payments.[55] Post-GFC developments include the Basel III tightening of capital requirements on commercial banks, the imposition of the liquidity coverage ratio

[55] For more on liquidity savings mechanisms and their evolution since the GFC, see Kabadjova et al. (2023) and Martin and McAndrews (2008).

(LCR) and net stable funding requirement on commercial banks (with the LCR in particular requiring banks to hold sufficient 'high-quality liquid assets' (HQLA), i.e. assets of undoubted value as collateral to support access to cash through repo in a 30-day liquidity-stress scenario) and the promotion of central counterparty clearing in securities and over-the-counter derivative markets.

Cross-border exposures

The challenges of counterparty and liquidity risk management and associated systemic risk are magnified by cross-border financial market transactions and global time differences.[56] Banks operating in multiple jurisdictions create problems of oversight, regulatory cooperation and (to reduce counterparty risk) the assurance of PvP settlement in foreign exchange transactions in most major financial centres. Cross-border market participation can substantially reduce the available working hours to source cash and securities for trade settlement. CLS Bank provides a partial solution, providing a mechanism for simultaneous T+2 legally final foreign exchange settlement using the reserves at the central banks of its 18 participating countries, but global institutions still face substantial challenges in intraday liquidity risk management (Milne and Ransome 2024).

The present discussion is focused on liquidity and collateral management in secondary market transactions, where the most immediate opportunities to employ digital assets in financial market transactions exist. For the main asset classes (equities, bonds, foreign exchange), traditional operating processes are already highly efficient and have low operational costs. While promoted by some vendors of distributed ledger solutions, accelerated settlement poses substantial challenges for liquidity management (see Box 2). From a technical perspective, it could be achieved using traditional intermediated indirect asset holdings through custodian banks and commercial bank accounts; it does not itself need to shift to holding digital assets (although it might become necessary to cope with the accompanying challenges of liquidity risk management).

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56 These challenges were recognised as far back as the 1974 failure of the relatively small Hamburg-based Bankhaus Herstatt, which highlighted the interconnectedness of financial institutions and the challenges of supervisory cooperation in global financial markets. This was a key factor in the establishment of the Basel Committee on Banking Supervision and has influenced subsequent international bank regulation (Goodhart 2011; Mourlon-Druol 2015; Schenk 2014). Many of the concerns raised by Herstatt have still not been fully addressed, notably the incompleteness of PvP foreign exchange settlement (CPMI 2022).

The principal opportunity for improved liquidity management is the direct holding of money in a form accepted as legally final settlement (a payment leg (P): DvP for securities transactions or PvP for foreign exchange). Together with arrangements for rapid intraday exchange and the final transfer of settlement money and securities (through repo, securities lending and foreign exchange swaps), firms will be able to quickly and easily preposition – that is, have both cash and securities ready before they need to settle obligations from financial market transactions.[57]

Note that the digital asset solution – using public-private key cryptography for direct holding and transfer – is needed for the payment (P) but not for the securities delivery (D). As discussed above, indirect holding of securities is 100% reserved through omnibus accounts, so the holder can guarantee immediate transfer. This is not the case for 'nostro' accounts with commercial banks, currently used to hold cash for the P-settlement legs. In this case, transfer requires additional confirmation by the intermediary, which is typically only for overnight settlement and not for immediate transfer to preposition obligations.

4.1.5 Smart contracts and programmability

A widely discussed benefit of digital assets is the potential for automation and cost savings through smart contracts and programmability, often with reference to so-called 'programmable money'. These arguments sometimes lack coherence and confuse code-based and intermediary-based digital assets – which this paper posits should be kept completely separate.

The term 'smart contract' has a specific usage in the context of the code-based digital asset arrangements that have emerged in DeFi.[58] Here, complex financial arrangements for exchanging crypto assets, often with reference to internet-sourced data accessed through so-called 'oracles', are supported by computer code, without any intermediaries. These coded arrangements are referred to as smart contracts,

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57 See Milne and Ransome (2024) for a more detailed discussion.

58 See Auer et al. (2023) and Schär (2021).

although they are neither smart nor contracts. They are not smart in that they do not learn over time in the way that artificial intelligence solutions (such as machine learning) learn from experience (their outcomes are determined algorithmically by their supporting code), and they are not contracts, because they do not represent the agreed legal obligations of a legal or natural person.

The automation and programmability of digital or traditional intermediary-based assets are different from the automated transaction of code-based digital assets, because the intermediaries must agree on common data and processes for market participants. As illustrated in Figure 1, this agreement can be implemented by *replacing* traditional assets with digital assets (for this paper, employing public-private key cryptography to hold and control assets on shared databases to record ownership and execute transfers) or by *retaining* existing traditional financial assets and standardising data processes, with separate databases interoperating through APIs.

The common reference to 'programmable money' is confusing, because any form of monetary record held in electronic form can be exchanged automatically using computer code, without delay and with little cost. It is the transaction, not the money, that is programmable, so it is more appropriate to refer to a 'programmable transaction'. The practical question is how to do this reliably, safely and cost-effectively.

The review of the South African context in section 3 identifies opportunities for automation in retail payments, but does not establish that these opportunities in emerging markets depend on the adoption of digital assets.

4.1.6 Supporting financial innovation

A broader argument regarding the potential of digital assets is that they are central to supporting an innovative financial 'ecosystem' and fully exploiting the opportunities of digital financial technologies.[59] Commentators sometimes argue that regulators should support the integration of methods in DeFi using code-based digital assets into TradFi

[59] The wealth of relevant references often dominate industry conferences on financial technology. A well-argued recent example is the Future of Finance (2023) interview with Ricardo Correia.

using intermediary-based digital assets on shared ledgers. One possibility is to use the 'liquidity pooling' that supports trading in DeFi in a more traditional setting.[60] Other innovation-related arguments more specific to crypto assets are economic empowerment, by offering individuals and small businesses alternative sources of fundraising through initial coin offerings (ICOs), and an opportunity to invest in an alternative asset class uncorrelated with mainstream markets.

However, these arguments are somewhat tangential to the central issue of this paper, which is the adoption of digital assets for payments and transaction banking. While the DeFi innovation could also be employed for payments and transactions with intermediary-based assets, it does not mitigate the substantial risks associated with crypto code-based assets and the need to keep them separate for intermediated activities. An innovative financial technology ecosystem does not necessarily require digital assets, even intermediary-based ones.[61]

4.1.7 Other proposed benefits of digital assets

Other claimed benefits of intermediary-based digital assets, outside of or not specific to transaction banking, include: traceability and transparency of non-financial assets (e.g. vehicles, land or property) and of non-financial transactions and supply chains (e.g. to monitor and allocate contributions to carbon emissions); operational resilience; support for competition through open architectures; and rapid and effective resolution of the default, especially the complex resolution challenges of banks and other financial institutions.

While these are all significant benefits of employing digital technologies, it is unclear that any of these benefits could not be equally or better achieved using digital solutions other than digital assets (in the sense employed in this paper) .

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60 This is a principal finding of the Project One collaboration of prominent industry players, supported by the Monetary Authority of Singapore, reported in Oliver Wyman Forum et al. (2022).

61 Examples from the UK are the mandatory APIs for open banking, which support increased competition in a variety of banking-related services (Dinckol, Ozcan and Zachariadis 2023), and the widening of access to central bank balance sheets, which can be based on holding conventional rather than digital assets, to promote competition in payments (Bank of England 2019).

4.2 Costs and risks of crypto and DeFi

In conjunction with the IMF, the Financial Stability Board and other multilateral institutions, central banks and regulatory authorities are concerned with the costs and risks associated with the adoption of digital assets and digital asset technologies. Much of their attention has been on crypto assets and DeFi (what we classify as 'code-based' digital assets): both fully DeFi without intermediaries, and transactions in cryptocurrencies and stablecoins executed using crypto exchanges such as Binance and Coinbase.

The total market value of crypto assets and DeFi remains small relative to the value of mainstream intermediated financial assets.[62] Nonetheless, the 'crypto winter' of 2022 that precipitated prominent failures, including that of the linked Terra stablecoin/cryptocurrency Luna and of the leading cryptocurrency exchange FTX, has highlighted substantial risks in these novel financial instruments and raised widespread regulatory concerns.[63] Monetary and regulatory authorities around the world have since conducted extensive assessments of the risks of crypto and DeFi.[64]

Policymakers, regulators and central banks around the world have been clear that crypto assets are not 'money' in accordance with the legal tender definition, but note that crypto assets do perform some of the functions of money. The use cases of crypto assets as an alternative investment class and as a medium for cross-border remittance also appear to be gaining traction among retail customers.

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62 Data taken from the Bank for International Settlements (https://www.bis.org/statistics/secstats.htm), the World Federation of Exchanges (https://www.world-exchanges.org/our-work/statistics) and proprietary data summarised by Statistica (https://www.statista.com/statistics/421215/banks-assets-globally/) suggest that the total value of global bank assets, traded equities and bonds was around $450 trillion. The total market capitalisation of cryptocurrencies and stablecoins is around $1.5 trillion, with Bitcoin accounting for around half of this total – still less than 0.5% of the value of mainstream assets. That said, it should not be forgotten that the total of US sub-prime mortgage lending that triggered the GFC was only around $1.2 trillion (Milne 2009).

63 The events of the 'crypto winter' are well known but usefully summarised by Ardizzi et al. (2023).

64 This discussion draws on IMF (2023b), which provides a comprehensive review of the risks of crypto and a set of recommendations for regulatory and policy responses; on Azar et al. (2022); and on IMF and FSB (2023).

While public authorities remain cautious about adopting crypto assets, practitioner opinions are much more varied, often seeking to strike a balance between the risks of crypto and its perceived benefits. These benefits include both the substantial business opportunities of facilitating transactions in crypto as a novel asset class and the envisaged major, even transformative, economic benefits of using distributed ledgers to support direct financial exchange, with limited roles for intermediaries. This transformational potential is often described as DeFi replacing TradFi – or at least as a merging of the two.[65]

The World Economic Forum (WEF) has provided an informative platform for the exchange of these different views, and its publications seek to balance concerns about risk against the goal of supporting innovation and realising the opportunities of adopting crypto and digital assets. A recent example is a WEF analysis of crypto-asset regulation that highlights the growing interconnectedness of crypto and mainstream finance and the need to develop global standards and classifications, understand fragmented regulations and address gaps in monitoring and enforcement.[66]

The discussion here draws on all these sources to distinguish the macro and micro risks of crypto (code-based) assets, including cryptocurrencies, stablecoins, DeFi protocols, exchanges and other arrangements in their supporting 'ecosystems'.

4.2.1 Macro risks of crypto (code-based) assets

- **Loss of monetary sovereignty.** Countries with relatively weak monetary frameworks may find their ability to employ monetary policy instruments undermined if crypto assets and stablecoins denominated in a foreign currency come to be widely held and used instead of money denominated in the domestic currency unit. The concerns here are the same as those associated with

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65 An articulate expositor of this viewpoint is author and commentator Michael Casey (see e.g. Casey (2022)).

66 WEF 2023. Other relevant WEF contributions bringing together a range of practitioner and policy views are the white papers of the Digital Currency Governance Consortium, such as WEF (2021) and WEF and Boston Consulting Group (2021).

'dollarisation' (a shift to US dollars as the store of value and medium of exchange), but are magnified by the anonymity and ease of transfer that crypto assets offer.

- **Weakening of capital controls and tools of capital flow management.** These measures can be circumvented by executing a foreign exchange transaction indirectly, first buying and then selling crypto assets (in the foreign/domestic market). This is much like any other 'black' or unregulated foreign exchange transaction but is facilitated by the anonymity and ease of transferring crypto assets.
- **Fiscal risks.** These are both direct (undermining the tax base through anonymous crypto holdings to evade taxes) and indirect (covering losses arising from financial sector or household exposure to crypto).
- **Systemic financial risk within the crypto and DeFi 'ecosystem'.** Cryptocurrencies are highly volatile. The arrangements that peg the value of stablecoins to fiat or physical assets to avoid the volatility of cryptocurrencies while retaining their blockchain-based anonymity and ease of transfer are unregulated, often opaque and lack credible reserve backing. As a result, stablecoin pegs are not entirely stable. Stablecoins can and do fluctuate in relation to their pegs and have sometimes collapsed (e.g. Terra). While DeFi supports a range of liquid trading and crypto-asset exchange exposures, it also creates a complex network of interconnectivity across crypto assets. The possibility persists of another 'crypto winter' disrupting crypto investment and causing major portfolio losses.
- **Systemic spillovers to the mainstream financial system.** While there are currently only limited direct links between crypto and mainstream finance, investor participation in crypto markets could lead to 'spillovers', with crypto losses affecting regulated firms and markets. These risks could be amplified if investment in crypto grows substantially and is facilitated to a substantial degree through regulated mainstream firms.
- **A particular systemic spillover of stablecoins that hold reserves of traditional assets, such as Tether and USDC.** Regulators are pressing for these stablecoins to be backed with HQLA, the same assets that banks are

required to hold to meet a 30-day stress outflow under the Basel III LCR. Some argue that a large-scale withdrawal of funds from stablecoins could lead to sales that undermine the liquidity of HQLA.[67]

Central bank commentators and researchers have paid particular attention to potential systemic risks in DeFi in the event of a 'run' on stablecoins. In the absence of effective regulation, such a loss of confidence leading to the breakdown of stablecoin pegs is a possibility that must materialise.[68] The principal issue for policymakers is the extent to which such crypto-asset instability leads to a spillover to regulated institutions.[69] The first regulatory responsibility must therefore be to monitor and limit the exposure of regulated institutions to code-based digital assets.

4.2.2 Micro risks of crypto (code-based) assets

- **Customer protection.** A variety of scams based on consumer ignorance of crypto assets posed a major risk even before the crypto winter,[70] but the failure of the FTX crypto platform at that time made the issue of customer protection more pressing.[71] Like other centralised crypto exchanges, FTX offered a combined service as a venue for trading and a custodian of crypto assets. This allowed them to fraudulently divert customer assets to the trading activities of the FTX-owned trading fund Alameda Research. This underlines the importance of the saying "Not my keys, not my crypto" to protect customer assets in crypto exchange.

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67 Focusing on the sale of HQLA by stablecoin issuers, this argument is not entirely persuasive (see Long (2021)). If those selling stablecoins seek to hold HQLA instead of stablecoins, there is no change in HQLA demand or collapse in liquidity. The bigger concern would seem to be the holding of illiquid assets by stablecoins, whose values could fall in a 'fire sale'.

68 See, for example, Guaglioni et al. (2022) and MacDonald and Zhao (2022).

69 There are many potential channels of transmission, such as the sale of collateral by code-based stablecoin (for discussion, see Hacibedel and Perez Saiz (2023)).

70 Stanford (2021) provides a popular account of these scams, while Bartoletti et al. (2021) review the literature to categorise different forms of crypto scam and examine the effectiveness of their own algorithmic tool for scam detection.

71 See Trautman, Foster and Larry (2023) for a detailed account.

- **Market integrity.** Even when customer property rights are respected, major concerns persist about market abuse in unregulated crypto trading, with widespread manipulations such as wash trading, spoofing and 'information'-based abuse such as front running (Bains 2022; Twomey and Mann 2020; Werner et al. 2022).

- **Governance concerns.** 'Smart contracts' and other protocols employed in DeFi are often controlled by tokens with voting rights. This presents the opportunity for a malign participant to obtain a majority of tokens and alter protocols to the disadvantage of other participants, for example by draining funds.[72]

- **Market power.** A further concern is that high transaction costs, network fragmentation and resulting congestion may give some participants market power – for example, if large players participate in consensus mechanisms, they may be able to extract substantial rents for selecting and validating transactions (Aramonte, Huang and Schrimpf 2021).

- **Financial crime and the financing of terrorism.** Blockchain networks are mostly transparent, as they have a permanent public record of all asset transfers and the public keys to which they are sent. However, it can be difficult to link these public keys to real-world identities. While still not as widely used in volume or value as more established bank and cash transactions, crypto assets are frequently employed for anonymous fund transfers for money laundering and terrorist financing.[73]

- **Cyber risks.** Despite claims of inherent security provided that private keys are not disclosed, blockchains and distributed ledgers have been subject to many hacks – of centralised crypto exchanges (Johnson 2020) and of the 'bridges' established to link decentralised blockchains (Krishna and Singh 2023; Zhou et al. 2023).

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72 See Gogel (2021).

73 The Financial Action Task Force (FATF) promotes a globally consistent approach to the application of AML/CFT to virtual assets (their name for crypto assets) and virtual asset service providers (see FATF (2023)). Their principal tool is the extension of the 'travel rule', long established for wire transfers, to require the reporting of information about both the sender and recipient in all virtual asset exchanges and transfers. However, crypto exchanges and wallets face substantial practical problems when applying the travel rule (Ragha and Ossio 2021).

- **Legal risks.** The legal claims of crypto-asset holders may be uncertain in the event of a dispute or the insolvency of a service provider, as there is no intermediary from which they may seek redress. Furthermore, crypto-asset property rights are not covered by the established framework of property law,[74] and transactions that cross jurisdictional boundaries face the familiar problem of conflicting laws.

A broader problem affecting the oversight and management of these crypto-related risks is regulatory uncertainty and inconsistency, where regulatory frameworks are ambiguous or evolve with little international consistency. The decision of some small countries to give Bitcoin official or legal tender status is a source of further inconsistency.[75] While international regulatory bodies – the FSB (Financial Stability Board), BCBS (Basel Committee on Banking Supervision), CPSS (Basel Committee on Payment and Settlement Systems) and FATF (Financial Action Task Force) – are making efforts to standardise the international prudential and AML/CFT regulation of crypto assets, no parallel international committee is responsible for setting standards for customer protection and market integrity. Debate in the US about the classification of crypto assets is ongoing and unresolved: they could be counted as securities (according to the so-called Howey test) and fall under the oversight of the Securities and Exchange Commission, as commodities or derivatives under the oversight of the Commodity Futures Trading Commission or remain outside the regulatory perimeter altogether. The UK recently announced a framework for crypto regulation, but it leaves much of the detail to the rule-making powers of the Prudential Regulation Authority at the Bank of England and the Financial Conduct Authority (FCA). The most coherent regulatory framework at this point in time is the European Union's Market in Crypto Assets regulation, which came into force in June 2023 to provide a framework for the regulation of CASPs in the European Union.[76]

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74 This problem is being addressed through the International Institute for the Unification of Private Law's principles on digital assets and private law.

75 Alsancak (2023) reviews the decisions of El Salvador and the Central African Republic in this regard.

76 The supporting level 2 and level 3 rules are not expected to be fully implemented until December 2024 (see ESMA (n.d.)).

4.3 Costs and risks of intermediary-based digital assets

Relative to code-based digital assets, the risks of intermediary-based digital assets have received little attention. This is unsurprising, as there are few (if any) fundamental barriers to applying existing traditional financial asset regulations to intermediary-based digital assets. There are challenges, of course: legislation may have to be amended; the ease of automated online exchange may make it harder to implement AML/CFT regulations; the novelty of digital assets and the inexperience of many of their providers may lead to intermediaries making mistakes that trigger prudential risks or expose customers or clients to harm.

The possibility that Big Tech platforms might replace banks as the principal providers of transaction deposits has received considerable attention from central banks worldwide (possibly triggered by alarm about Facebook's proposed Diem, subsequently Libra). Central banks and researchers have expressed concern that such developments could undermine monetary sovereignty and the effectiveness of monetary policy.[77]

This is different from the technological enhancement of 'dollarisation' discussed above, where the risk is that citizens in a country with weak monetary and fiscal discipline, in which the domestic currency is losing credibility, may prefer to conduct transactions in US dollars or other non-domestic currency, or that code-based stablecoins or even cryptocurrencies such as Bitcoin may become attractive and convenient substitutes for domestic currency.

Setting aside 'technologically enhanced dollarisation', it is difficult to see the threat of Big Tech's non-bank money replacing bank money and undermining the monetary operations of central banks or creating substantial problems over the short term. There are a few reasons for this:[78]

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77 See, for example, Arner, Auer and Frost (2020) and Diez de los Rios and Zhu (2020).

78 Similar issues and debate arose in the late 1990s when digital non-bank money first emerged. While there was concern about the possible weakening of central bank control over money and interest rates, the consensus (e.g. Schmitz (2007)) was that because settlement between institutions still relied on central bank money, this need not be a major policy concern.

- There is little indication that such Big Tech money (in the form of an intermediary-based digital asset such as Diem or a conventional non-bank mobile or e-money such as PayPal) has any prospects of becoming a dominant form of money in day-to-day exchange in most countries.
- Even where non-bank money has become a significant payment instrument (e.g. China), monetary policy can still be used to exercise control through the central bank's monopoly over central bank liabilities for the legal settlement of interbank and inter-institutional payments. This allows them to exert control over short-term money market interest rates, which are the principal channel of monetary transmission.
- Central banks and regulators can also require non-bank money providers (based on conventional deposits or intermediary-based digital assets) offering payment instruments to fully back these instruments with central bank reserves (as China has required of AliPay and WeChat Pay).

Even if monetary operations are only slightly affected by the adoption of intermediary-based digital assets, their adoption especially of CBDCs may still affect monetary transmission.[79] Widespread adoption of CBDCs could, for example, change both the level of commercial bank lending and its responsiveness to changes in market rates of interest. Wide adoption could result in substitution out of commercial bank deposits and constrain the supply of bank loans.[80] On the other hand, greater reliance on interest paying funding could make both the price and quantity of commercial bank lending more sensitive to market rates of interest.[81] A consequent lowering of monetary policy interest rates to offset the impact of higher bank funding costs could reinforce the constraint of the 'effective lower bound' and, in a negative interest rate environment, result in a weaker transmission of monetary policy (though this is more of a concern in developed than in emerging markets). The ease of transfer of digital financial assets could also affect the volatility of international capital flows, posing

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79 See, for example, Das et al. (2023) for a discussion of the impact of the adoption of CBDCs on monetary transmission, they ague that retail CBDC adoption will generally strengthen monetary transmission.

80 This is a concern for the European Central Bank (see European Central Bank (2021)).

81 This is the position of Das et al. (2023).

challenges for those countries that seek to manage their exchange rates rather than let them float freely.[82]

More generally, the adoption of intermediary-based digital assets, which can be easily and rapidly exchanged into a medium of exchange, could make it easier for households and firms to access bond and money markets as a store of value instead of bank deposits; this in turn could raise the funding costs for banks and reduce the supply of bank credit. This is similar to past concerns about what impact the growth of money market mutual funds as stores of value or of the issue of CBDC might have on bank credit supply. While this could be a challenging business issue for banks, it is not unprecedented, and it is not obvious why banks should have a privileged position in competition for funds in bond and money markets. Subject to the constraint of the effective lower bound, any macroeconomic impact can be largely offset through central bank control over money market rates of interest.

A separate concern is that widespread access to CBDC in a crisis could facilitate bank runs, with money being withdrawn from commercial banks in a matter of hours or even minutes. This risk is not limited to CBDC, as highlighted by the 2022 failures of Silicon Valley Bank and Signature Bank in the US. There, the problem was rapid withdrawal and transfer into other traditional financial assets, be they money market instruments or deposits at other safer-seeming commercial banks. Discussion about how to deal with these risks is ongoing: both through more effective market-, credit- and liquidity-risk regulation and oversight and through arrangements for faster replacement of central bank reserves against eligible bank collateral to finance withdrawals.

5. Conclusion

This paper provides a detailed review of the application of so-called digital assets in payments and transaction banking. The key insights can be summarised as follows:

1. The term ‘digital assets’ is not always used precisely. It is now often used to refer to assets held and transferred using distributed ledger technologies, similar to those employed in cryptocurrency transfers and DeFi. This is

[82] See, for example, Reserve Bank of New Zealand (2021).

problematic: similar is a matter of degree and this usage does not make clear how these new digital assets differ from traditional financial assets – for example bank deposits or financial market securities such as equities or bonds – that have been held in digital form for many years.

2. To deal with this terminological confusion, in this paper digital assets are defined more precisely as being solely controlled using public-private key cryptography. Figure 1 illustrates the key differences that then emerge between traditional and digital assets. One difference is that the use of public-private key cryptography supports direct holding, which offers efficiency advantages over intermediated indirect holding for both central bank money and securities, but many of these advantages can also be achieved with existing traditional assets through standardisation and use of APIs.

3. Figure 1 also highlights another distinction, that between code-based digital assets (where consensus on ledger entries is achieved without relying on a trusted third party) and intermediary-based digital assets (where consensus relies on one or more intermediaries). Code-based digital assets are used in peer-to-peer cryptocurrency transfers and DeFi without intermediaries. However, the absence of intermediaries means that these digital assets cannot be subject to the same prudential, conduct and AML/CFT (financial crime) regulation as in mainstream financial services (only CASPs that facilitate transfers between mainstream and crypto finance can be regulated). This indicates that as strict a separation as possible should be maintained between, on the one hand, transactions in code-based digital assets, which cannot be directly regulated; and, on on the other, intermediary-based digital and traditional financial assets, where existing regulation can be applied without great difficulty. This is consistent with the approach to regulation of crypto assets already taken in South Africa.

4. Neither code-based nor intermediary-based digital assets are necessary for the automated transfer and exchange of financial assets transparently, at high speed, and at low cost and risk. These benefits can also be achieved using traditional financial assets held on centralised databases by developing and adopting data standards and using APIs. There is thus a choice when

considering modern digital technology to improve payments and transaction banking: either to *replace* existing traditional financial assets with digital assets controlled using public-private key cryptography or to *retain* and improve the operational arrangements of existing traditional assets.

5. In particular, it may not be cost-effective to replace traditional financial assets with digital assets where this requires substantial changes to existing asset-holding arrangements. In the case of retail financial services, retaining and improving existing traditional financial assets may be a better choice – whether the goal is lower-risk, lower-cost retail transactions, promoting fiancial inclusion, or reducing the costs of cross-border payment. This is especially true of many middle-income countries, for example South Africa, where far from all individuals and small businesses have adequate access to smartphones and the internet in order to conduct digital asset transactions. For the same reasons, while the risks seem manageable, it is unclear that the introduction of a retail CBDC is a cost-effective means to promote improved, digital retail payments and financial inclusion in a middle-income country context – this may be better achieved through the digital enhancement of existing e-money, mobile-money and bank account services, especially when, as in South Africa, a large proportion of the population is already banked but still relies substantially on ATM cash withdrawal for conducting retail transactions.

6. On the other hand, a stronger case can be made for the employment of digital assets to support direct holding of central bank money and of securities by financial market participants. This can substantially reduce counterparty and liquidity risks. The case may be even stronger for many middle-income countries where the legacy arrangements can be less of a constraint on the adoption of digital assets in financial markets. For example, in the South African case, the existing practice of offering individually segregated security accounts at the central security depository STRATE (such segregated security accounts are not provided in the financial markets of most developed countries) could be relatively easily adapted to allow South African investors to hold bonds and equities directly as digital assets.

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