



SWIFT INSTITUTE WORKING PAPER

PAYMENT 'TOKENS': A ROUTE TO OPTIMIZING LIQUIDITY MANAGEMENT?

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Abstract

This paper examines the opportunities for better management of intra-day and overnight liquidity in financial markets, using ‘tokenised’ rather than tiered money deposited with bank counterparts. It begins with a review of how financial firms manage their intra-day liquidity, dealing with the inevitable surprises in payments flows and payment obligations and the challenge of ‘timed’ payments that must be made by specified time, not just on value date. It then discusses the opportunities for reducing cost and risk from application of the new technologies of money associated with decentralised finance and Web 3.0. With this background it examines the application of these technologies in three situations: domestic securities settlement; cross-border transactions; and derivative transactions. The principal opportunity identified from this exercise is the creation of single pools of liquidity (SPoolLs) for each institution in each currency in which they transact. This should be both: directly held money, that supports legally final settlement, not tiered deposits; and directly addressable money, allowing settlement systems to achieve ‘atomic settlement’ in which trade settlement can only ever occur as DvP (delivery against payment) or PvP (payment against payment) and avoiding restrictions such as opening hours. ‘Distributed ledgers’ or ‘blockchains’ are one possible way of implementing SPoolLs, but it is the functionality not the technology that matters, implementation using conventional centralised databases is also possible. These arrangements could support new markets for near-real time liquidity exchange, such as foreign exchange swaps or repo with the first near leg executed & settled immediately. This will allow market participants to exchange assets or money (‘what they have’) into the form required for settlement (‘what they need, when they need it’). Further efficiency can be supported by ‘warehousing’ of future settlement commitments, to ensure agreement on and transparency of those obligations. These innovations can substantially reduce collateral requirements and counterparty risks across global markets. There are though significant challenges: persuading central banks to widen access to central bank balances, either as wholesale central bank digital currency (wCBDC) or a privately provided synthetic equivalent (sCDBC), and achieving sufficiently widespread industry adoption for a critical mass of SPoolL.

CONTENTS

1.	INTRODUCTION	4
2.	LIQUIDITY MANAGEMENT AND THE OPPORTUNITIES FROM TOKENISATION.....	8
2.1	INTRA-DAY LIQUIDITY MANAGEMENT FOR FINANCIAL FIRMS	8
2.2	‘TOKENISED’ VERSUS TIERED MONEY.	11
2.3	LESSONS FROM DECENTRALISED FINANCE AND WEB3.0	15
2.4	SINGLE POOLS OF LIQUIDITY: SPOOLS.....	16
3.	LIQUIDITY USE CASES	20
3.1	SCENARIO 1 – DOMESTIC SECURITY MARKET TRANSACTIONS.....	20
3.2	SCENARIO 2 – CROSS BORDER SECURITIES TRANSACTIONS	25
3.3	SCENARIO 3 – DERIVATIVE TRANSACTIONS	29
4.	REALISING THE BENEFITS: THE BUSINESS AND POLICY CHALLENGES	34
4.1	OPERATIONAL REQUIREMENTS	34
4.2	THE INDUSTRY CHALLENGE: CRITICAL MASS.....	36
4.3	THE POLICY CHALLENGE: ACCESS	37
4.4	HOW MIGHT WE GET THERE?	40
5.	CONCLUSIONS	42
	APPENDIX A – A PRIMER ON LIQUIDITY MANAGEMENT IN FINANCIAL MARKETS.....	44
	APPENDIX B – WHAT DOES ‘TOKENISATION’ MEAN?.....	52
	APPENDIX C – LESSONS FROM DECENTRALISED FINANCE.....	57
	GLOSSARY	61
	REFERENCES	74
	ACKNOWLEDGEMENTS.....	78

1. INTRODUCTION

Managing liquidity is an existential activity for financial institutions (FIs). It is essential for settlements and payments across the whole range of wholesale instruments: foreign exchange (FX), securities, money-market instruments, derivatives and in collateral management.

Liquidity management is complicated by legacy payment arrangements and financial market infrastructures (FMI). Multiple settlement and payment systems, lack of interoperability and limits on direct access to central bank money are but a few of the known obstacles. Nostro accounts are used for making cross-border payments and settling trades; this creates a need for intra-day credit lines. Liquidity is as a result fragmented and used inefficiently. There is a disconnect between the speed of front-office and the limited processing ability of the back-office.

Liquidity has been an even greater concern since the Global Financial Crisis (GFC) of 2007-08, since when regulators have introduced a range of new liquidity requirements. The Basel III reforms of bank prudential regulation introduced the NSFR (the net stable funding requirement for funding of illiquid assets) and the LCR (liquidity coverage ratio, the holding of sufficient high quality liquid assets to be able to absorb a projected thirty-day curtailment of access to funding). In addition, regulators have imposed additional discretionary buffers to ensure firms have access to intra-day credit for fulfilling their daily capital market and large value payment and settlement obligations.

The liquidity buffers required by the various regulators are large for individual banks and huge for the industry as a whole. One study reports that large international banks holding total liquidity buffers, holding of high quality liquid assets in excess of the requirements of the LCR, of \$2.7trn in 2018.¹ More recent data from the Basel Committee's data dashboards indicate that this total buffer, for the 79 of the largest international banks covered, has risen to \$4.0trn in June 2023.² Between 10 and 30% of that is to support intra-day liquidity.³ Intraday liquidity is not just a challenge for banks. It is also a challenge for non-banks and now recognised as a risk to systemic financial stability.⁴

These challenges of managing liquidity in globalised financial markets are far from new. More than two decades ago a task force of the New York Payments Risk Committee found that "Recent developments in the global payments environment have significantly increased demand for intraday liquidity by commercial banks, including intraday liquidity in foreign markets." and "Recent developments in the global payments environment have also increased the need to make "timed" large-value payments in both domestic and foreign markets." and called for private industry "... consideration to developing the following new intraday liquidity services: (a) intraday real-time repos, (b) cross-border collateral pool facilities based on the intraday credit provisioning of 15 one or more private institutions, (c) bilateral intraday currency swaps between banks, and (d) real-time intraday collateral swap services." with central banks

¹ (Hartung et al., 2019)

² (Basel Committee on Banking Supervision, n.d.)

³ (Sawjiy et al., 2018)

⁴ Measures to address this source of systemic financial instability amongst non-banks are currently under consultation by the Financial Stability Board (FSB, 2024).

establishing arrangements to provide intra-day credit against foreign cash and securities held in these global collateral securities pools.⁵ These ideas were never though implemented.

This paper examines the potential of new digital monetary technologies to address this longstanding problem. It focuses on the arrangements for exchange and transfer of cash, proposing a redesign of our legacy arrangements, with financial institutions and clients using technology to more effectively access, hold and transfer monetary assets, which might or might not be a central bank digital currency (CBDC). The focus is on intra-day and overnight liquidity and collateral management in transaction settlement and for complying with margin requirements. The research method employed is ‘scenario analysis’, drawing on the extensive knowledge of the two authors about the operational arrangements for execution of payments and other transactions in wholesale banking and financial market transactions. We examine three such scenarios: domestic securities transactions; international transactions; and derivative transactions.

The analysis is motivated by the strong current interest in ‘tokenisation’ of financial assets.⁶ This term ‘tokenisation’, while used inconsistently, most often refers to the holding and transfer of financial assets on decentralised blockchains or distributed ledgers. One finding from our analysis is that technological implementation is less important than the functionality offered by the technology. While decentralised blockchains / distributed ledgers are possible technologies which might be employed to implement our proposal for improved intra-day liquidity management, the outcomes we explore could also be achieved using more conventional centrally operated databases.

Our interpretation of ‘tokenisation’ is therefore not that of decentralised holding of money on blockchains or distributed ledgers. Rather, for the purposes of this paper, tokenised money means money in a form that overcomes the current challenges of intra-day liquidity management. In our scenario-based analysis this means providing financial intermediaries with access to a Single Pool of Liquidity (SPoolL) for each currency in which they conduct business, one in which: balances are both directly held and directly addressable; and from which settlement transfers can be instructed and executed, without restrictions based on either time or location, in near real-time with legal finality.

⁵ (The Payments Risk Committee, 2003) pg 11, pg 13. See also (Pattinson, 2003).

⁶ This strong current interest is reflected in a number of reports: a related analysis to our own is (World Economic Forum & Accenture, 2024) who focus on the use of wholesale central bank digital currency to reduce costs and risks in wholesale financial market transactions; and other reports (Choudhury et al., 2023; UK Finance, 2023b) focus on tokenization of securities.

By directly held and directly addressable we mean the following:

- (i) Directly held. Settlement money is held directly by financial intermediaries, not as a nostro account with a commercial bank. These settlement assets could be central bank liability such as a wholesale CBDC or a 100% reserved private money. Settlement money is one in which transfer supports legally final settlement, there is no requirement for an intermediary to itself source liquidity to complete payment.
- (ii) Directly addressable. The accounts holding settlement assets, both money or securities, can be directly addressed by settlement systems, in order to reserve or earmark funds required for settlement and then subsequently co-ordinate the transfer of money and assets, thus ensuring PVP or DVP. This in turn can facilitate near instant settlement and can serve as a building block for intraday liquidity markets.

Building on these functionalities, we argue that it can be possible to further support more efficient liquidity and risk management by developing warehouses (or repositories) for holding agreed future commitments, interoperable with directly held and directly addressable liquidity pools.

The paper is arranged as follows. Section 2 reviews: (i) the arrangements for intra-day and overnight liquidity management in global financial firms; and (ii) the various interpretations of tokenisation as a means for improving operational efficiency in transaction banking. It also sets out our key proposal: for Single Pools of Liquidity (SPoolS) to support real time legally final transfers and exchange of cash for liquidity and risk management. Section 3 is the core analysis, exploring the three scenarios for the application of payment tokenisation to facilitate liquidity management by capital market firms, in: (i) settlement of domestic securities market trades; (ii) cross-border transactions; and (iii) in derivatives trading. Section 4 discusses the costs and benefits of the development of such single pools of liquidity (SPoolS) and associated industry and regulatory challenges. The concluding Section 5 restates the key arguments and notes some questions for further research.

There are three Appendices. Appendix A summarizes the day-to-day liquidity management operations in global capital markets firms, supporting the scenario analysis conducted in Section 3. This material will be familiar to some readers, those who have worked in Treasury and money market roles in large global financial institutions; it is provided for the many others, even those with extensive experience in financial market firms or in financial regulation, who need more of the detail of capital market operations in order to follow the Scenario Analyses of Section 3 in full.

Appendix B discusses some of the various different interpretations of 'tokenisation', highlighting the two that are capable of providing a single pool of liquidity (SPoolL): either directly held central bank money (a wholesale or wCBDC) or an indirectly held 100% reserved monetary claim that can be used for legally final settlement of payments (which can be described as a synthetic or sCBDC). This Appendix also highlights the importance of control – the unhindered ability to dispose of a money or use it for payments – here labelled as T2 to distinguish it from the historical monetary usage of the word token as a low value representation labelled here as T1; and discussed the different legal concepts of property and their monetary applications.

Appendix C is a review of decentralised finance (defi), discussing how it is able to offer 'atomic trading and settlement' in which the acceptance of a trade is accompanied by the instant settlement of the resulting obligations, all part of the same operational process, and considering how these functionalities might be replicated in the operations of mainstream financial markets. An important difference from mainstream finance is that assets are held not with intermediaries, but directly using 'wallets'. This is one way but not the only way of implementing direct holding and direct accessibility.

2. LIQUIDITY MANAGEMENT AND THE OPPORTUNITIES FROM TOKENISATION.

This section reviews current challenges of liquidity management in major financial institutions from the perspective of the management of intra-day liquidity, the problem on which this paper focuses. It then examines the concept of ‘tokenised money’ and reviews some of the issues this raises for central banks, monetary policy, and financial regulation. Finally, it sets out, in sub-section 2.4, our proposed single pools of liquidity SPoolS for unlocking the liquidity benefits of tokenisation.

2.1 INTRA-DAY LIQUIDITY MANAGEMENT FOR FINANCIAL FIRMS

To envisage how payment tokens might change how liquidity is managed, we start with a summary of the cash management function for institutions participating in financial markets. The description that follows is of the operation of the cash management function of a global bank participating in global capital markets; but similar challenges of cash management arise for all financial institutions. Appendix A, a more detailed primer on cash management in financial markets, provides fuller detail.

The role of the cash manager is to ensure the bank meets all its payments and settlement obligations every day. This is a regular process: a routine that is repeated each day, ideally without major problems or surprises (that is “reassuringly boring”). At the centre of this process are two tasks:

1. Ensuring that there is enough cash in the right currency in the right place and at the right time to make planned payments & settle securities transactions
This is what is described in the Appendix A as ‘funding to plan’.
2. Dealing with the inevitable unplanned events: for example, receipts which do not arrive when anticipated, and/or unpredicted payment needs such as margin calls which arise during the day. This is what is described in the Appendix A as ‘funding to actual’.

If payments were entirely predictable then there would be no great problem of cash and liquidity management: the task would simply be to fund-to-plan, implementing the bank’s Treasury policies, funding outgoing payments at least cost and investing long balances for the best return. The liquidity challenges arise because of need to deal with the unplanned need for cash or securities. Cash managers have several tools at their disposal for dealing with these surprises which can be used depending on whether these obligations are for overnight settlement (on “value date”) in the relevant payment system or for a timed obligation that must be made a specific time e.g. by 9.00 CET as part of a CLS⁷ settlement. In both cases the objective is meeting payment obligations at least cost.

⁷ CLS: Continuous Linked Settlement. CLS Bank is an FMI, a financial market infrastructure, which support settlement of FX trades in 18 currencies. Only when both sides of an FX trade are CLS currencies can it be settled via CLS. CLS works on a net funding, gross settlement basis. One-way payments between two participants are not supported. See: <https://www.cls-group.com>

Often a bank makes and receives payments using a nostro account with another bank (as described in Appendix A, this is indirect settlement) rather than with an account held directly with a central bank or an international settlement system such as CLS bank or Euroclear (this is direct settlement). For indirect settlement the costs (interest due or forgone; credit risk) are associated with either running an overnight unsecured overdraft with the nostro or leaving an unutilised overnight balance. The cash manager will seek to minimise these costs by aiming to be as near flat – i.e. having a zero overnight balance in the nostro – as possible.

Payments which are simply made on value date, are normally charged on a ticket fee basis. There are other immediate, direct costs when the bank needs to make an immediate i.e. timed payment settlement. Payments to CLS and margin calls from CCPs fall under this category. Typically, the nostro will charge on an ad valorem basis for these specific payments.

There are also indirect costs⁸. Capital regulations require banks to have liquidity buffers, which include buffers for intraday liquidity. Supervisors now apply the monitoring tools introduced under Basel Committee’s BCBS248 standard, for overview of the exposure of internationally active banks, requiring banks to demonstrate they have adequate access to intraday liquidity in both normal operating and defined stressed situations⁹. A major driver of size of the intraday buffer requirement is the use of intraday credit from the nostro. This affects both the “credit taker” and the “credit giver”.

For managing overnight balances the principal tool is repo (using collateral to obtain cash) and reverse repo (lending excess cash balances vs. collateral). An alternative to the latter is a sweep to a money market fund to avoid having unsecured receivables.

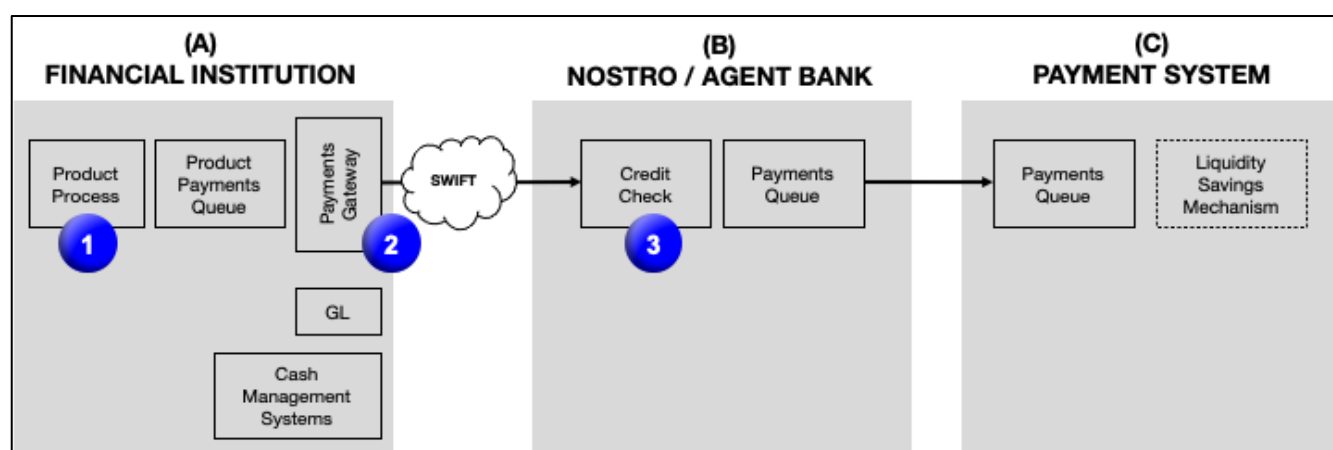
The cash manager has limited scope for managing intraday exposures. Whilst expected incoming payments are known, the timing is not. Where a bank is direct member of payment scheme, there is typically either an overdraft facility, for example the “debit cap” at the Fed, or an associated intra-day repo facility with central bank, for example in Switzerland with the Swiss National Bank.

The remaining tool, open to those using a nostro and those with direct access to a payment system, is throttling, but this only shifts the liquidity management challenge to other institutions. Throttling in order to reduce use of intra-day credit from the nostro is illustrated by Figure 1.

⁸ (Sawjiyany et al., 2018)

⁹ (BCBS, 2013)

Figure 1: Intraday Payment Flows and “throttling”



Payment obligations are generated by the product processes (Point 1) of the bank or other financial institution (A), e.g. from securities or foreign exchange transactions. Nostros (B) control the flow of payments downstream to the payment systems (C).

To limit intraday overdrafts at the nostro (Point 3) the bank might ‘throttle’ the payments upstream in their own systems (Point 2), delaying payments out of the nostro account until incoming payments are received. While reducing the use of intraday overdraft, it adds operational and systemic risk to the overall system. In the worst case there is a “Mexican stand-off: I don’t pay you and you don’t pay me.”

As the more detailed discussion of Appendix A documents, cash management involves a great deal of additional complexity, omitted from this brief overview. There are many product processes each generating both planned payments and receipts. There are many entities within the bank and these entities can hold accounts in many currencies. Each entity must have an already established relationship with many counterparties, used for example for borrowing funds through overnight repo. Transactions must take place within the operating hours and cut-off times of the payment systems used.

Dealing with this complexity requires further tools for effective monitoring of liquidity in real time. These must give the cash manager a transparent and up to date picture of all incoming and outgoing flows, what is anticipated and what actually happens, in all the many accounts where the institution holds cash and securities. The cash manager must then respond to surprises and the risks of these accounts either having insufficient balances, while avoiding the costs and risks of unnecessarily large balances.

The pressures on intra-day liquidity management seem set to increase only further in the future. The US and other markets are shifting to T+1¹⁰ settlement in security markets, but as we describe below in this makes daily management of foreign cash particularly difficult for foreign banks and investors; the next working day may leave them with a window of only 2 hours (instead of 26 hours) or even less to replenish or utilise balances; imposing considerable additional costs and risks¹¹. Frequent

¹⁰ On the general move to T+1 settlement and its implications for FX markets see Bullmann 2023.

¹¹ On the challenges posed by T+1 for foreign investors see (Gandy et al., 2023).

episodes of market volatility, together with the trend towards increased use of central counterparty clearing to limit counterparty risk, are triggering more frequent variation margin calls which in turn drives intra-day demands, with which come added costs and increased systemic risk.

The key issue explored in the remainder of the paper is the extent to which access of financial institutions to ‘tokenised money’ can address these large and increasing problems of intra-day liquidity management. As we shall argue, there are opportunities to overcome the problems of fragmentation and access that currently hinder inter-day liquidity flows; offering greater transparency about the timing of future cash and securities flows; and allowing each institution able to manage and to much more easily exchange ‘what they have’ (cash or other HQLA) for ‘what they need’ (the required account balances at the time of settlement). We shall argue that ‘nirvana’ for the global cash manager is just one single pool of liquidity in each currency (i.e. SPool) and to be able to connect that to any payment or settlement need; P for payments. DvP for securities and Pvp for FX. The latter is extremely important; same-day FX without settlement risk is practically impossible today. This would simplify cash management and greatly reduce the associated liquidity costs.

2.2 ‘TOKENISED’ VERSUS TIERED MONEY.

A principal finding of this paper, with the applications explored below in Section 3, is that there are substantial liquidity management benefits for financial institutions from holding settlement money directly, either as central bank liabilities (a wholesale wCBDC) or as a privately provided equivalent (a synthetic or sCBDC), and which they can in turn use as a ‘single pool or liquidity’ or SPool for settlement in each of the currencies in which they transact, without requiring the services of a nostro. This direct holding of settlement money, alongside direct addressability to facilitate automated settlement, are in our analysis the two key features for using tokenised money in intra-day and overnight liquidity management.

Such direct holding of settlement money though runs counter to the ‘access rules’ which govern who may have a settlement account with the Central Bank (CB). Money held in a CB account is a settlement asset and thus of unquestioned value in payments. In a crisis a rational actor, given the choice of holding money directly in a central bank or indirectly with a commercial bank, and a payment system that supports instant transfer, will shift to direct holding. Access thus brings with it ‘run risk’: in a crisis, money will withdraw from the commercial banks. This adds systemic risk and complicates monetary policy. This consideration is a central issue for any development of Central Bank Digital Currency (CBDC) of both the retail and wholesale flavours.

An implicit part of these ‘access rules’ is regulatory oversight. As a rule, direct participants in any payment system need to be licensed legal entities local to that jurisdiction, with local offices and local employees. The local requirement is driven by a need for oversight and accountability; if regulators need action to be taken, they do not want to chase individuals in foreign countries. There are exceptions; CLS Bank, which is a US regulated bank, has been granted remote access to a central bank

settlement account in 17 currencies outside of the US dollar¹². Switzerland too has shown flexibility, allowing some foreign participants access in order to participate in the repo market. There are then so-called “joint oversight” arrangements in place to ensure accountability.

The literature uses the term ‘tiering’: to describe how indirect participants must have accounts with direct participants, i.e. with a nostro. This structure has both benefits and risks. (Adams et al., 2010) explained that for direct participants in a payment system, there are potentially two types of benefit to offering to be a nostro to indirect participants: the Liquidity Effect and the Pooling Effect. The liquidity effect arises if both the paying FI and the receiving FI use the same bank. The transfer is internalised as a simple debit and credit. No liquidity is needed. Pooling occurs when the nostro can take advantage of its customers’ incoming flows to cover its own or other customers’ outgoing flows. (Adams et al., 2010) also points out that this tiering, i.e. indirect participants using the services of a nostro to access a payment system, leads to certain risks when payments are internalised and that these transactions are not visible to regulators. This is easy to visualize; imagine that in 2023 the entire cross-border business of the combined UBS and Credit Suisse were just in UBS. Extensive internalisation, but potentially requiring lots of new intra-day overdrafts. Importantly, (Adams et al., 2010) were writing before the advent of BCBS 248 in April 2013.

The Bank of England (BoE) has taken steps to open access to reserve accounts & the UK RTGS payment system CHAPS for new participants. New FMIs such as Finality may now have so-called omnibus accounts. Nonetheless, the real access issue remains unsolved as the BoE restricts who may hold a direct account and a balance with Finality.

The use of tiering introduces further liquidity challenges. Financial firms holding direct tokenised money have little incentive to delay a payment on value date; there is no saving of either interest or the other costs of large nostro overdrafts. In contrast tiered holding introduces liquidity problems in real time gross settlement RTGS payments; making payments on behalf of clients often requires the nostro to grant them an intra-day overdraft and so they are incentivised to delay making the payment.

The challenge here is that banks seeking to economise on their own liquidity (holding of central bank reserves) will always look to make payments as late as possible. If there is a chance to free ride, in other words, wait to receive funds before paying, they will seek to take it. This problem has been addressed in the literature on RTGS payments¹³. In order to prevent gridlock, an RTGS system needs to be complemented by further tools, such as intra-day netting of offsetting payment obligations and intraday credit in the form of interest-free intraday repos provided by central banks in all the major currencies. At times, participants in an RTGS system may have enough liquidity without any other tools. In 2000, (Heller et al., 2000) made this observation about the period 1993 to 1999 in Switzerland. The same would largely be true of the post GFC period up to late 2022.

¹² Japan is an anomaly in the CLS landscape. There is a local entity, however it has no role in day-to-day operations. It is like an “Honorary Consul”.

¹³ Contributions include (Leinonen & Soramäki, 1999; Bech & Garratt, 2003; Buckle & Campbell, 2003; Martin, 2005; Jackson & Manning, 2007; Bech, 2008; Martin & McAndrews, 2010).

Some RTGS systems have local throughput rules or targets for volume and value exactly to combat the risk of gridlock and ensure that “the payments day” is completed in an orderly fashion. Price incentives are also used. In Switzerland, for example, payment costs range from a single cent or two at the start of the day and 300 cents or so at the end. This intra-day credit is not though ‘free liquidity’ because the collateral used has an opportunity cost. (Bech, 2008) suggested this cost was some 12 to 15 bps.¹⁴ This is consistent with the experience of one of the authors (Ransome) from his time at a G-SIB. This cost has been referred to as the “cost of immediacy” (Kahn & Roberds, 2001).

All this points to broader issues, going beyond the scope of this paper: the appropriate use of both tiered (fractionally reserved) and tokenised (directly held or 100% reserved money). The use of tiered money creates challenges of managing intra-day and overnight liquidity and ensuring unrestricted flow of payments in large value RTGS systems. The routine use of tokenised money eases these problems; but can potentially worsen a systemic crisis if holders of money can freely shift out of tiered deposits to directly held tokenised money. Accepting direct participation in a large value payment system creates a range of further practical challenges for central banks and regulators.

All this links to a well-established economics literature which examines why financial institutions, households and firms hold low-yielding, but easily exchangeable assets, such as money or treasury bills, forgoing income on other higher-return but less liquid assets.¹⁵ The principal reason is because of the risks and costs of exchanging other relatively illiquid assets for monetary assets that can be used for settling transactions and making payments.

One standard example: even a well-established profitable firm cannot easily exchange claims on future earnings (e.g. by issuing shares) to meet unanticipated financial and business needs. Holding low yielding liquid assets provides insurance against the costs of and constraints on obtaining external finance, whether this is obtained through borrowing, share issue or asset sales. This liquidity management can also be liability rather than asset based, maintaining a line of credit to deal with unanticipated payments.

The resulting arrangements for the holding and exchange of liquid assets to cope with financial and business extend well beyond the intra-day and overnight markets on which this paper focuses, into the full range of longer maturity securities and their use in portfolio and corporate financial management. In this broader context liquidity risk is intertwined with both market and credit risk: as evidenced by numerous banking crises including the relatively recent failures of SVB and Signature bank in March of 2023.

This same theory highlights further liquidity management issues:

1. A distinction between liquid assets provided by private firms and financial institutions (“inside liquidity”, the most important example being tiered monetary

¹⁴ Bps: Basis points. 1/100th of 1 percent or 0.01%.

¹⁵ Holström and Tirole (2008) provide a detailed exposition of this theory.

deposits) and liquid assets provided by government or international financial markets (“outside liquidity” including directly held tokenised money)¹⁶;

2. The possibility of market-wide aggregate liquidity shortage, for example in the GFC, the onset of the global Covid pandemic in 2020, and yet again following the SVB / Signature failures when (i) FIs faced difficulties in renewing short-term money market funding ; (ii) credit spreads to all but the best quality borrowers widened dramatically, resulting in a (iii) ‘flight to quality’ with an increased premium (a price rise and fall in yield) on the most liquid assets such as US Treasury bonds. Such episodes are characterised by an ‘endogenous’ shortage of liquidity, where the demand for liquidity, because of uncertainty about the economic environment and concern about increased risk of counterparty failures, leads to falling prices for illiquid assets and further demand for safe liquid assets¹⁷;
3. A role for the public authorities in providing additional outside liquidity in the event of a large shocks which exhaust the liquidity of the private sector (as a whole or of individual firms). This provision is both fiscal and permanent (government-backed insurance against major shocks that cannot be covered by private insurance) and monetary (temporary provision of outside liquidity to cope with endogenous but temporary liquidity demand, e.g. the central bank acting as ‘lender of last resort’).

Another issue, full discussion again goes beyond the scope of the present paper, is the implications of a widespread shift to tokenised money for monetary operations. The long-established mechanisms for central bank control over overnight money market rates of interest depend on the tiering of money and the demand for holding central bank reserves, for the purpose of settlement of interbank payments. A widespread shift from tiered to tokenised money therefore raises concern about the operating arrangements and transmission of monetary policy.

Intra-day and overnight liquidity and liquidity management operations thus cannot be totally separated from the challenges of liquidity management during periods of economy and market wide financial stress or from the operation of monetary policy. Day-to-day demand for liquidity, and the regulation of intra-day and overnight liquidity, are partly determined by expectations of, and associated regulation affecting, the ability to access liquidity during such stress periods. A shift to tokenised money for financial market settlement of the kind we advocate in this paper, will need to be accompanied by very detailed consideration of the implications for monetary policy operations and transmission and for systemic financial risk.

¹⁶ These terms, “inside liquidity” and “outside liquidity”, are taken from Holström and Tirole (2008).

¹⁷ Work on this “endogenous liquidity risk” can be traced back to the classic statement of the role of lender of last resort by (Bagehot, 1873); modern contributions, both before and after the global financial crisis, include (Adrian & Shin, 2010; Brunnermeier & Pedersen, 2008; Bruno & Shin, 2013; Danielsson et al., 2012; Eisfeldt, 2004).

2.3 LESSONS FROM DECENTRALISED FINANCE AND WEB3.0

The second key feature of tokenised money, one that we argue can address the challenges of intra-day and overnight cash management, is that of being “directly addressable”. This subsection explains this idea and how it relates to the operation of advanced internet (‘Web 3.0’) and decentralised finance (‘DeFi’) technologies. Appendix C provides further supporting detail.

Two terms much used in and around things crypto and digital assets are ‘interoperability’ and ‘programmability’. The latter term is widely associated with Ethereum based ‘smart contracts’; code that checks when certain conditions are met and then executes. Or it might allow something called ‘earmarking’: for example, system A asks system B if client P has enough widgets and instructs them to reserve them to meet an obligation to deliver 10 of them to client Q versus a payment of USD 995’000.

In Traditional Finance (‘TradFi’) we use the term DvP or Delivery vs. Payment. In some systems both the asset, the widget, and the cash are held on the same system. In others, there is an interaction between two discrete systems. Switzerland is an example of where interaction has been a feature of the TradFi landscape for many years. There, the securities settlement process in the local CSD, SIX Securities, starts by asking: “Has the seller got the securities? If yes, reserve them for this specific transaction.” It then interacts with the payment system, SIC, and asks “does the buyer have CHF to pay for the purchase? If yes, then move the money, and then move the earmarked securities. If no, wait and try again on the money side shortly.” This is what is meant by programmability and interoperability.

This capability is very powerful; a settlement system is orchestrating the interaction and ensuring that the exchange of securities and money is atomic, a term much used by those in digital assets. Atomic settlement is a synonym for DvP; either both things happen, or nothing happens. This reduces risk. Reduces, but does not eliminate. If the two parties to the securities trade are direct members both of the securities settlement system and the payment system, then risk is eliminated; if ZKB sells 100 shares of Nestle to UBS for CHF 10’400, shares and money are exchanged without settlement risk, and there is no further credit risk. UBS does though have some market risk.

Now, if instead UBS is the Swiss custodian for an institutional client, say Fidelity Fund #967, there is an amount of credit risk, because UBS has paid ZKB, but the system does not know if the Fidelity Fund has the money, it just knows that UBS has “fronted the cash”. If UBS has the right documentation in place, with a lien over securities position, then it has secured risk, and the exposure is the mark-to-market position of Nestle shares. Or, it has an unsecured receivable of CHF 10’400.

This example illustrates the example of what we refer to as money being ‘directly addressable’. The idea is already widely used in decentralised finance and holding of crypto assets. Assets can be held through a wallet, which provides the interface and private key security. The most secure approach being a cold wallet which is connected to the internet only when making a transaction. But unlike a deposit at a bank, either of securities or money, the wallet provides only a technical service, the assets are

controlled directly by the holder and, provided there is no security breach of the wallet, cannot be accessed by anyone else. The assets are thus directly controlled (a key aspect of tokenisation discussed in Appendix B).

Directly addressable takes this concept and carries it a step further. It is already used in decentralised finance, allowing a holding of a crypto asset or a stablecoin to be ‘ear marked’, i.e. to be reserved for a transaction, one of the functionalities made possible by smart contracts in DeFi. Earmarking of this kind, based on an account being directly addressable, can resolve the risk exposure problem faced by UBS in this example. If the account, for Fidelity, is directly addressable then SIX securities can ask the question not “does UBS have the money for settlement” but instead “does Fidelity the customer and principal to this trade have the money for settlement, held as a tokenised settlement money, not as a tiered deposit with UBS” and SIC will then only action DVP when the principals on both side of the trade have confirmed they have the money and securities ready for final exchange.

Direct accessibility is also a requirement for managing liquidity i.e. ensuring balances are available in securities accounts. This will be clear from our discussion of scenarios in the following Section 3. Current arrangements, holding securities indirectly with custodian banks (depots), could shift to direct holding and direct accessibility with parallel benefits for management of securities account in settlement, as those stemming from direct holding and direct accessibility replacing money held indirectly with commercial banks (nostros). The issues are slightly different in that securities held with custodian banks are not fractionally reserved; but for settlement to take place DVP it must be clear that the seller of securities has possession and control of those securities, i.e. that they are not for loaned out or pledged, just as it must be clear that the buyer has possession and control of the money.

We leave as an open question whether this requires a shift from the current tiered ownership arrangements for holding securities with custodians to individually segregated securities accounts, though the latter would be much more in line with Web3.0. Unlike the case of tokenised money, where in order to remove credit risk and ensure legal finality, 100% reserving or direct holding of central bank money is required, it is conceivable that the operating systems of custodians could support the necessary earmarking of securities for settlement. On the other hand, there are further advantages to customers of moving to individually segregated accounts with the CSD, with the custodian operating as a wallet offering an interface to these accounts, not themselves as a provider of security accounts. This would for example make it much more straightforward for a client to shift to an alternative provider, facilitating competition, and promote greater transparency of costs. These issues are though not central to facilitating better intraday and overnight cash management.

2.4 SINGLE POOLS OF LIQUIDITY: SPOOLS

The ideal settlement asset or means of payment is central bank money. This subsection discusses the features required for tokenised version of central bank money to be fully effective in liquidity management. Such accessible central bank money might come in one of two forms:

1. A public sector solution: a “wholesale” wCBDC for financial market participants, issued by the central bank.
2. A private sector solution: sCBDC, a “synthetic” variant, designed to support legally final settlement.

Does the difference between these matter? In our view the difference is not of great concern provided that there is an appropriate regulatory regime for the sCBDC, ensuring that it has four features: (i) 100% backed by fiat balances held with the central bank in that currency; (ii) interoperable with any external or third-party payment or settlement need; (iii) providing settlement finality – the transfer for purpose of settling a security trade what happens is final and cannot be unwound in a bankruptcy event; and (iv) open to ‘remote’ participation by foreign financial institutions participating in domestic markets.

These requirements on a sCBDC can be summarised by saying that it must be a regulated liability accepted and its operator must be overseen as a financial market infrastructure (FMI) to provide assurance that it meets all these requirements. Conversely any wCBDC will have to be designed to ensure that it provides both (ii), (iii) and (iv). Any solution, wCBDC or sCBDC, that provides these features can be a “Single Pool of Liquidity” or SPool and used for real time intraday and overnight liquidity management.

Ultimately there is likely to be a choice in any particular jurisdiction between wCBDC and sCBDC, but there is no need to have both for cash flow management. Some express concern with sCBDC because of potential failure for operational or other reasons¹⁸. There may naturally be a preference amongst regulators for a central bank operated and owned solution. Central banks worldwide are exploring wCBDC solutions¹⁹.

On the other hand, wCBDC solutions have not yet reached full development and some sCBDCs are already up and nearly running. There is a range of potential solutions. An example is Fnlity International, which started operations in the UK on a restricted basis in late 2023.²⁰ It is a designated payment system and the transactions on its systems fall under the UK settlement finality law. Fnlity does not use blockchain but uses a private Ethereum based ledger. It is licensed in the UK and started restricted operations in December 2023. Fnlity aims to set up similar structures in other countries and currencies. RTGS.global is heading in a similar direction, though its regulatory arrangements are not yet publicly announced.²¹

Considerable attention is now also being paid to the possibility of recording holdings of both central bank money and regulated commercial bank money (and e-money) using a single ‘unified’ record system that will support automated monetary exchange regardless of whether money is state of privately issued. These ideas are being

¹⁸ e.g, (Adrian & Mancini-Griffoli, 2019).

¹⁹ Much of this work is done through the BIS Technology Hub, a recent example being Project Mariana for the exchange of wholesale CBDC (BIS Innovation Hub, 2023). There are also individual central bank initiatives: the Swiss Central bank has launched a pilot project (SNB, 2023); and the ECB is engaged in extensive consultation on new technologies for wholesale settlement (ECB, 2024).

²⁰ Described in (Fnlity, 2023)

²¹ The most recent RTGS-global white paper is (RTGS Group Limited, 2024).

explored by both the Bank for International Settlements and also by a consortium of global banks and other institutions participating in the so-called Regulated Liability Network (RLN).²² Potential balances on such as system might be commercial bank money or backed by central bank money.

The ‘Single Pool of Liquidity’ SPool proposed in this paper could be implemented using any of these solutions, a central bank issued wCBDC or a private sCBDC fully backed by central bank money. It could also work with a unified ledger such as that being explored by the Regulated Liability Network, provided the SPool is fully reserved in central bank money (to remove counterparty credit risk) and holdings with individual financial institutions are bankruptcy remote.

Other ‘tokenised’ money solutions may not serve so well as wCBDC or sCBDC. These ‘tokenised’ money solutions include tokenised deposits, narrow banks and stable coins. Tokenised deposits are commercial bank deposits placed on a distributed ledger to facilitate real time transfer from one holder to another and offering inter-operability with a range of transaction systems. JP Morgan with its JPM Coin is the standout example.²³ Citi is also piloting tokenised deposit services²⁴. But as currently developed they are not 100% reserved, so exposing holders to credit risk and do not support legal finality of settlement. Tokenised deposits have the same credit risk as a fiat balance in a nostro account: an unsecured receivable. Potentially, pursuing the thinking developed by the Regulated Liability Network, these could develop to include all the characteristics necessary for tokenised money to effectively becoming sCBDCs. This would require that these individually issued tokenised deposits, such as JPM Coin, Citi coin etc., were all: (i) 100% reserved; (ii) bankruptcy remote from the banks that issue them; and (iii) freely transferrable from one issuer to another. Without these features holders would need to keep track of the issuer, because they would need to be clear on who to make claims on in the event of a bankruptcy and rely on further operational processes for legally final settlement.

A narrow bank is defined as one holding all its customer deposits with the central bank and not providing credit to customers. Since the 1990s several e-money solutions have emerged which also do not provide credit and maintain a high-quality reserves to back their private money. With a narrow bank or e-money provider, there is always a risk of a change its business scope, or of operational problems, either of which could trigger failure, though the resulting deposit risk could be mitigated with a bankruptcy remote structure. However, this still falls short of sCBDC for the same reason as a JPM Coin or a Citi coin and, as it is not regulated as a financial market infrastructure it would not provide assurance of settlement finality.

Stablecoin is a loosely defined umbrella term covering several distinct arrangements. The most discussed are those held on permissionless distributed ledgers and used to represent fiat value in trading of cryptocurrencies and in DeFi (hence the term coin). These fall well short on all the three requirements for a tokenised money to support

²² The work of the BIS is reported in (BIS, 2023; Garratt & Shin, 2023). The thinking behind the Regulated Liability Network was first proposed in (The Regulated Liability Network, 2022) and the technological, business and legal issues have been further explored by network participants in both the US (EY, 2023; RLNUS, 2023b, 2023a) and in the UK (EY, 2023; UK Finance, 2023a).

²³ The JP Morgan initiatives are reported in (JP Morgan Onyx & Oliver Wyman, 2023). Their work has received extensive media attention, for example in (Coindesk, 2019; Crawley, 2023; Pymnts, 2023)

²⁴ See (Perper, 2023).

cash management in securities settlement. One problem is lack of transparency of their reserves, though this could be addressed by providing a publicly visible real-time reconciliation of central bank holdings vs. balances held by clients²⁵. This is exactly what they would do internally at the end of the day, and it is exactly the standard the stablecoin Tether has to date failed to meet²⁶. They also fall short on interoperability, which is problematic to achieve because they do not maintain a 1:1 value against fiat currencies, and do not offer settlement finality.

Other forms of stablecoin, for example the proposed and subsequently failed Facebook Libra and Diem are more like money market mutual funds but held on permissioned distributed ledgers. As we discuss briefly in our conclusions, there is some possibility of settlement solutions being based on money held in money market mutual funds, but this would be difficult to adopt given present settlement arrangements. The term stable coin can also be applied, somewhat loosely, to what are essentially narrow banks or e-money issuers, which do not necessarily use distributed ledger technology.

In summary, cash management in support of domestic securities trading could very much be helped by being able to use a form of tokenised money as the payment asset. We refer to this as a single pool of liquidity or SPool because it replaces a variety of different indirect or tiered deposits held in nostro accounts with commercial banks. As discussed in the next section such a SPool can serve all payment related needs: P for Payment, both in DvP for Delivery vs. Payment and PvP for Payment vs. Payment.

We have identified both public and private sector solutions – wholesale or wCBDC and synthetic sCBDC which could provide the necessary functionality. These functions (100% reserving, interoperability and addressability, legal finality) are more important than who the issuer is and whether it is held on a permissioned distributed ledger or on a conventional centralised database. Whether market participants then hold their balance as a wCBDC or regulated liability sCBDC, this is the only balance that they would need. The involuntary fragmenting of liquidity would be avoided.

This is an immediately feasible step that is already being explored as both wCBDC and as sCBDC. There are further possibilities in the tokenisation of securities, although much of the functionality can be embodied in existing arrangements for tiered securities holdings which is not necessarily ‘tokenisation’.

²⁵ While outside the scope of this paper, it is also arguable that these traded stable coins fall also well short of the requirements for use in retail payments as an alternative to bank payments and cards.

²⁶ Thus, inviting close regulatory scrutiny, and agree after regulatory sanction, to provide regulators with reports of reserve holdings (Bossone et al., 2020; De, 2021).

3. LIQUIDITY USE CASES

This section explores the challenges for intra-day liquidity management, and how these might be addressed using ‘tokenised’ payments, held in a single pool of liquidity SPool as described in Section 2.4. These three scenarios are: first domestic security transactions; then cross-border payments and finally in derivatives trading.

The discussion of each scenario identifies the practical problems, how current processes create challenges for intra-day and overnight management of cash and securities accounts; and examines how ‘tokenisation’ of cash and of securities accounts could address these problems and what functionality would be required of such ‘tokenisation’.

We are consciously not basing our analysis on viewing ‘tokenisation’ in financial market operations as a cross-market shift to combining trading with settlement into integrated processes taking place in near real time on permissioned distributed ledgers. The discussion of this paper is restricted to more immediate possibilities: the limited form of tokenisation in a SPool for each currency, supporting the intra-day and overnight liquidity management functions that are embedded in the existing business models of financial market participants. We also take a technologically agnostic position, leaving open the question of whether this tokenisation is based on distributed ledgers or more conventional centrally operated databases.

The broad vision of ‘tokenisation’ – in which cash and securities exchange completely and finally at the time of trade as if they were bearer instruments through virtual peer-to-peer exchange – is attractive. It can be labelled as ‘atomic trading and settlement’, a helpful term distinguishing it from the more imprecisely used term ‘atomic settlement’ which we already have today in the form of DvP Delivery vs. Payment, or Payment vs. Payment, where either both things happen or neither happens.

Universal adoption of atomic trading and settlement for all market transactions as a single ‘big bang’ reform of current market practice is neither practical nor realistic. There are specific kinds of transaction which are by definition for settlement at a later date: forwards, the far leg of swap or repo trades. And some market participants will want to trade now and settle later. Much more credible is limited adoption of the kind proposed here, solving pressing practical problems such as those in intra-day and overnight liquidity management examined in this paper. For example, we find supporting real-time exchange of currencies through foreign exchange swaps has significant potential value. We believe there will also be a place for trades done for future settlement, with warehouses and settlement services providing the coordination over the lifecycle of the transactions. This is further described below.

3.1 SCENARIO 1 – DOMESTIC SECURITY MARKET TRANSACTIONS

The objective of intra-day cash management in financial markets is to ensure that trades – agreements to exchange financial assets – are settled and payments are made “on value date” and that they then take place with “legal finality”; with no possibility of the transaction having to be unwound, for example as part of a bankruptcy process.

There are two types of risk associated with every settlement process. The first is “settlement risk”. I don’t want to just give you some money and hope you give me the securities, or the other currency. The solution to this is something that is an integral part of financial transactions and in the case of securities trading is known as Delivery vs. Payment or DvP.²⁷ Either both things happen or neither does.

The other risk is ‘counterparty credit risk (‘CCR’). This is created by time. Typical securities and FX settlement today is T+2; two parties meet at a marketplace and agree to settle in two business days’ time (some settlement, including the settlement of US equities from May 28th, 2024, is T+1; this shorter cycle reduces but does not eliminate CCR). Even if I know that I will settle a share purchase on a DvP basis, so I am not going to lose my principal, I am still at risk of loss if the seller fails to deliver the shares and, when I replace the purchase with a new trade the market price has gone up. This is also referred to as ‘replacement risk’. As described in Box 1, shared arrangements play an important role in managing this replacement risk.

Box 1. Shared arrangements in securities settlement: CCPs and CSDs.

In many securities markets, and in much derivatives trading, central counterparties (CCPs) are now used to limit replacement risk. SIX X-Clear and LCH, the London Clearing House are examples of CCPs. In the US, the National Securities Clearing Corp (NSCC), which is part of the DTCC, is another. A CCP becomes the buyer for every seller and the seller for every buyer. They mutualise replacement risk because, in the event of default, the members of the CCP are responsible for making good the loss. Not every firm which is an active trader will be a member of a CCP. Some firms, instead of accepting the obligation of members to protect other members, will settle through a General Clearing Member (GCM).

The CCP employs several risk mitigation tools; it first asks for Initial Margin (IM) to cover its risk of having to liquidate a position if a participant defaults; then subsequently it works out who is winning and who is losing based on the latest market prices, collecting variation margin (VM), i.e. the loss on the trade from the loser and passing that money on to the winner.

This mitigates but does not eliminate risk. Importantly though, the CCP role is simply to help deal with the time gap between trade date & settlement date. If there were no time delay, there would be no CCR to manage.

Another market wide arrangement in securities settlement is that of the central securities depository (CSD), the designated institution where securities are issued, held and settled. The CSD – examples are DTCC in the US, Euroclear UK and Ireland in London and Dublin and Deutsche Borse Clearstream in Frankfurt – maintains the ultimate record of securities issuance, sometimes referred to as the notary function, settling transfers resulting from trade settlement and ensuring that the number of securities held by investors and on which income in the form of dividends or coupons due matches the number of securities issued to which income is paid.

²⁷ There is an equivalent in Foreign Exchange, FX, settlement called PVP, payment of one currency vs. payment of another.

In some jurisdictions it is usual practice for investors to hold securities directly with the CSD. Such ‘individually segregated accounts’ are already tokenised (in the directly held sense of tokenisation as elaborated in Appendix 2). More commonly though – this is the practice in the markets of Europe and North America – investors hold securities indirectly with a custodian bank (major global providers of these custodian services include State Street, Bank of New York Mellon, JP Morgan, and BNP Paribas). For each security, the custodian then holds a single omnibus account with the CSD, representing exactly the total number of securities in its customer accounts for the same security.

There is a partial analogy between this tiered or indirect holding of securities in a custodian bank and the indirect holding of money in a commercial bank. The omnibus accounts held by custodian banks at the CSD are analogous to the reserve accounts held by commercial banks at the central bank. In both cases, as happens frequently, a transfer of ownership between accounts held at different institutions requires settlement at both levels – at investor level debiting one account and crediting the other and at central level debiting one reserve or omnibus account and crediting the other (all with legal finality). The analogy is though only partial: custodian banks hold, or should hold, 100% of their clients’ securities holdings in a single client omnibus account. Clients’ cash holdings are not reserved. Their banking partner can “use its balance sheet” and extend loans.

Some preliminary analysis is needed before we can lay out how cash management might change if the means of payment, or the transfer of securities for that matter, were tokenised. We first need to fully understand what happens in today’s world of retail clients, institutional clients, brokers, marketplaces, CCPs and CSDs. The 2021 issues with the US broker Robin Hood and retail trading in shares in Game Stop (GME) provide exactly the lesson and the insight we need – see Box 3B.

The key point that emerges from this example is the pressure that can be placed on intra-day cash management, even in the simplest situation of domestic securities settlement, by CCP margin calls. This example might be dismissed: after all the meme stock at the centre of this episode only ever represented a tiny fraction of the US market; but this would be a mistake. This example captures, clearly, the impact of our financial market infrastructure on intra-day liquidity and illustrates the potential for similar problems to recur on a much greater and more widespread scale.

In this particular case, the problem was that while Robin Hood had reserved funds from its retail clients in order to settle trades, the separated systems of the CCP and consequent margin calls did not recognise that funds were already earmarked for trade settlement; client asset segregation rules prevent client funds being used as margin payments in Robin Hood’s own cash management. In principle, the margin calls might have recognised this mitigation of the counterparty credit risk associated with these Robin Hood meme stock purchases; but in practice this was not done.

As we explain shortly, earmarking these funds in a tokenised form could have resolved the conflict in current arrangements between client asset segregation (protecting Robin Hood customers in the event of the financial failure of Robin Hood) and margin calls (protecting the counterparties of trades conducted by Robin Hood on behalf of its customers).

Client asset segregation rules are not the only reason why CCP margin calls supporting securities settlement create challenges for intra-day liquidity management. There are two broad problems, both of which are accentuated at times of market volatility:

- *Recycling of funds to meet variation margin (VM) calls* Margin calls by CCPs need to be met according to a strict timetable. So, not just “anytime on value date Wednesday”, but “by no later than time X on value date”. The effect is that CCP participants are dependent on their nostros and the availability of intraday overdrafts to make these payments. This increases the reliance on intraday credit, along with the cost of both taking it and giving it.
- *Impact of price volatility.* Price volatility today will always affect variation margin; somebody wins, somebody loses. It also affects the risk models which reflect historic price volatility. The risk model drives both Initial Margin (IM), and Default Fund contributions; how much might the price move if the CCP must trade out of a position after a participant defaults?

In what ways might tokenised money help meet these intra-day liquidity demands? The problem is not so pronounced when the clearing member is a bank with direct access to central bank reserves in the currency of the margin call.

Here tokenised money, held directly by the underlying client, and which can be immediately transferred to a new holder, can help reduce the resulting challenges of intra-day cash management. The key requirements for this tokenised money, differentiating it from money held with a nostro, is that such tokenised money can be transferred in near real-time to the CCP and then onwards as a legally final settlement of the margin payment.

Box 2: Case Study of GME Game Stop and Robin Hood

In the US, retail clients typically hold their individual securities investment via a broker. Older readers will know of Charles Schwab, younger ones will have heard of Robin Hood. The latter was and is targeted at the mass retail market. People who might buy \$50 or \$100 in shares at a time.

When a client of a retail brokerage submits an order to buy \$100 of any stock, the broker checks the client has the funds and blocks those funds to avoid any “double spend”²⁸, then the order is sent to be executed. There are various ways this can happen. For Robin Hood, their clearing member was Citadel. Clearing takes place at the NSCC. As soon as trades are submitted to NSCC there is a calculation of IM and then until value date there are calculations to reflect the impact of market price movements. These result in movements of VM.

To keep everybody in the chain protected; CCPs as a rule will hold their members to impose the same discipline and margin requirements on their clients. So, the NSCC asks Citadel for margin and in turn they ask for margin from their clients, including Robin Hood. Now there is an important nuance. Robin Hood knows that its clients can pay for their purchases; they have blocked the money. But they can only use those funds on value date, T+2, when they deliver the purchased shares to the clients’ accounts. The delay in settlement means that Robin Hood must meet any margin demands from Citadel from its own liquidity, be that capital or borrowed money. It is part of the deal, well understood by Robin Hood and all the other retail brokers.

Game Stop became what is known as a meme stock. Fuelled by social media channels, many retail investors came to believe in the prospects and future value of Game Stop, which was then a retail outlet for video games. Other people’s views differed. At the same time, there was some significant institutional ‘short interest’. In simple terms, somebody thought the price was too high, so sold it with the plan to buy it back cheaper later.²⁹ GME became a ‘philosophical football’ and with that came a rollercoaster of price movements. In January 2021, the price moved up by a factor of 30x.

Robin Hood came unstuck on two fronts. Firstly, its clients were pretty much all buyers. If you have enough \$50 and \$100 orders, they soon mount up to a significant amount of money. And at the same time the price of GME moved massively. Price volatility is a major driver of the margin requirements that CCPs impose. And in turn, those requirements were passed on to Robin Hood. Margin demands went up from a previous high of some USD 250 million to over 3 billion.³⁰ Now remember that under current practice, Robin Hood must use its own funds to cover that. It may not use the clients’ funds, even though all the executives at Robin Hood, at Citadel and even at the NSCC and the DTCC know that Robin Hood will have locked up the money to make those purchases settle on value date on T+2.

²⁸ We are ignoring margin loans or the use of Lombard credit. Simply put, we assume that a retail client has \$100 in place when submitting an order.

²⁹ Standard market practice is that if you want to “short sell” securities you have to borrow or at least locate them before placing the order. In other words, you need to know you will be able to deliver to the buyer.

³⁰ Readers might want to read the longer version of the story in (Mezrich, 2021).

A margin call of 12x the previous high was too much for Robin Hood to meet. To avoid a default, Robin Hood had to suspend purchases in GME and some other "meme stocks". The stock crashed, the shorts covered some sales and Robin Hood's retail clients lost out.

Both these features of tokenised money are required: for legal finality that they are directly held and for near real-time transfer that they are directly accessible and processed inter-operably with the CCP's systems.

3.2 SCENARIO 2 – CROSS BORDER SECURITIES TRANSACTIONS

The next scenario we consider is that of cross-border securities settlement. Cross-border investment & trading is an integral part of today's capital markets. We must remember that domestic settlement is co-mingled with cross-border settlement. The two things are not discrete activities; in any marketplace completing a day's settlement activities requires all trades to be settled on the same timetable, whether these are purely domestic transactions or involve foreign investors. The US equity market is some 40% owned by non-US investors.

Cross-border portfolio and trading transactions are in turn a major part of foreign exchange turnover. The foreign exchange markets are important, both in their own right, and as the enabler of activities in other asset classes. Already today, they are a significant driver, if not the most significant driver, of both counterparty settlement and of intra-day liquidity risks.³¹ While the establishment of CLS Bank in 2002 has supported a common PVP payments solution, this does not eliminate all counterparty settlement risks, these are rising especially because of growing exchange of emerging market currencies outside of the core CLS settlement services. In April 2022 the reported average daily value of OTC FX transactions settling without PVP, or other loss protection, was \$2.2trn out of a total of \$5.6trn.³²

Even where there are settlement risk protections, the absence of same day exchange settlement means that foreign exchange transactions pose significant challenges for the management of intraday liquidity in global banks. There are two dynamics to consider in relation to cross-border; firstly, whether some form of payment tokenisation aids liquidity and secondly how this might interact with the move to T+1 settlement.

The features of payment tokenisation we need to address these liquidity challenges should have the exact same characteristics as tokenised money when used to address cash management challenges in domestic security settlement. We require a single pool of liquidity (SPool) which is both:

1. Inter-operable and 'directly accessible', serve any payment need: P, PVP and DvP, across all domestic and cross-border transactions.

³¹ A useful source of informed discussion are the CLS 'FX ecosystem web pages' (CLS, 2023), see in particular (Bullman, 2023) on developing solutions to FX counterparty settlement risk.

³² (BIS, 2022, Table 27, pg 74)

2. Direct holding of central bank and not commercial bank money, not restricted by the opening times of legacy banking systems and providing legal finality in settlement transactions.

In theory, a wCBDC, central bank digital currency, would be a solution in any one currency and they could be connected as so called mCBDC, a multi-CBDC solution.³³ However this raises questions about whether such a product will be inter-operable with many other marketplace and settlement systems. A solution based only on exchange of central bank money is clearly limited in application. In our view the appropriate solution, for implementing the SPool is a clear separation of the roles of public and private sector. The central banks and regulators need to set out the rules and risk oversight, including access to central bank money for final settlement, leaving the design and product management to the private sector.

However achieved, interoperability is central. This means that there are standards which enable any one part of the ecosystem to interact with the other parts. Then it becomes relatively low cost for marketplaces to emerge that interoperate with a securities settlement system and the SPool; for example, to support real time trading and settlement for the intraday-liquidity management. This real time trading is not a replacement for current arrangements with deferred settlement of trades done in the past: for the foreseeable future these current arrangements will still be needed, deferred rather than real-time settlement, in order to limit the need for pre-funding. This is supplementary real-time trading to address the challenges of intra-day liquidity management.

Does the SPool concept require us to have a single global system? Simple answer: no. If we design things well, there could be a wCBDC solution in one currency, a sCBDC e.g. Fnality solution in another and perhaps others such as RTGS.global for further currencies. But in any one particular currency, the two participants would both need to have an account in the same system. So, for USD / GBP, both might be with RTGS.global for USD and both with Fnality for GBP. That would work.

What is much harder would be if one party wants to use Fnality for GBP and the other wants to use RTGS.global for GBP. Enabling such preferences would require an inter-operability between the payment system. In the world of TradFi, we have this in CCPs. However, the foundation of such a capability is that each CCP is a member of the other CCP. Where this is available, this has taken years to achieve, and limits the potential risk protection CCPs can offer.

In operations having many ways of doing the same thing is almost never a good thing. Another example of this was in international iCSDS, with the resulting complexities of the Euroclear vs. Cedel bridge, a thorny issue. As with CCP interoperability, this required the systems becoming members in the other system, creating additional costs and risks. For this reason, competing solutions for intraday or other transactions in one currency are unhelpful; the industry should agree on a single SPool solution, and, if necessary, encouraged to reach agreement by central banks and regulators.

The cash management challenges resulting from interaction between domestic securities settlement and cross-border currency exchange become much more

³³ See: (Auer et al., 2021; He et al., 2022).

pronounced with the move from T+2 to T+1 securities settlement, such as is taking place in the US. Without the intervening 24 hours between T and T+2, it becomes extremely difficult for a foreign participant, those further East and whose working day therefore finishes ahead of the domestic settlement cycle, to locate and provide the cash required for next day settlement. While CLS Bank provides PVP replacement risk free exchange of central bank money, their daily cycle imposes very specific timing restrictions. These restrictions in turn make it difficult, or nearly impossible to settle FX trades for sameday PVP settlement even if the necessary foreign exchange liquidity can be found. For detail see Box 3C.

The cash management challenge is even more difficult if one of the currencies involved is not CLS eligible, or a counterparty insists on settlement outside of CLS. Ideally the management of cash cross-border should be supported by a SPool in the different currencies, for 24/7 settlement, together with the liquidity to support the currency exchange when it is needed.

The key issue here, one which does not arise to the same extent with domestic securities transaction, except through the associated CCP margin calls, is the need for same day close to real-time foreign exchange. At present this is not supported. CLS is designed on T+1 or T+2 settlement which is enough to meet most of the requirements of market participants when securities settlement is also T+2. But these increased challenges of liquidity management from the shift to T+1 will increasingly require an exchange, outright spot or foreign exchange swap, with the initial exchange taking place in near real time.

Box 3: The challenges of cross currency cash management with T+1 domestic settlement.

We should start by understanding where we are today. For illustration, we will use the US equity market.

The majority of trading activity is in the last two hours of business, so 14:00 to 16:00 in New York. For businesses processing transactions anywhere East of New York, whether in Europe or Australasia, this means trades will typically be processed locally on T+1. So, the trade date is T, the booking date is T+1 and the settlement or value date under current practice is T+2. From a purely funding or liquidity point of view, for all non-US FIs, this is all very manageable. On T+1 they work out where they plan to be on T+2 and can determine any FX needs for T+2. FX markets are expecting these trades, so there is trading liquidity at the right time and there is time to submit eligible FX trades to CLS Bank for Payment vs. Payment (PvP) settlement.

If we add a tokenised means of payment in USD to the mix, then non-US FIs would benefit alongside the US FIs if tokenisation leads to the Single Pool of Liquidity as discussed above. The easier it is to manage liquidity; the less likely things are to go wrong and the lower the costs of intra-day liquidity might be.

However, if the only change is to have tokenised USD, then we would expect that there will still be a reliance on intra-day credit. Recall that this is formally measured and has an impact on the intra-day liquidity buffers that regulators impose on both credit takers and credit givers.

Let's consider UBS Switzerland in its role as one of the biggest asset managers in the world. It has many clients, both retail and institutional, placing orders in US equities which UBS executes and then settles for them. Today, for trades done on T, UBS has time on T+1 to understand the net funding needs in USD for T+2. Some of its clients will have USD, many won't, so let's allow that if UBS is a net buyer of equities, it needs to sell CHF and buy USD. Today, that trade will be done T+1 for settlement one day later on T+2 with settlement via CLS Bank. Settling the trade has some impact on UBS's cash balance with its US nostro; CLS is based on net funding, gross settlement, so there is less money being moved than if each underlying trade settled gross. Note that it does not make any difference if its nostro is UBS New York. In any case, there is an intra-day impact, but other things being equal, no *a priori* need for any overnight overdraft. In this sequence of events, UBS Switzerland has been able to swap what it has, Swiss Francs (CHF), for what it needs, US dollars (USD). And this is without settlement risk.

Let's now consider what happens when settlement is moved to T+1. On the US side, nothing changes; normal trading stops on T at 16:00 local time which is 22:00 over in Zurich. The computers at UBS Switzerland will have moved or rolled to the next business day. In theory, UBS staff somewhere in the world could still book all the equity trades, and they could work out the net funding requirement for the settlement on T+1. Again, let's assume that they need to sell CHF and buy USD. Until now they have been able to execute that trade sometime on T+1 for settlement the next day T+2. With the move to T+1 settlement, they have some different challenges:

They need to find somebody with whom to do that trade at just past 22:00 CET in Zurich. At that time, there isn't much if any liquidity because there isn't much if any demand. They would also like to settle that trade via CLS Bank. In theory they and whoever they trade with have up until 0630 CET, another eight hours, to submit and match the trades. But there are some obstacles: (i) If UBS's trading counterpart is not a Settlement Member, they might not be able to submit so late; (ii) Between 00:00 and 06:30 there is a funding operation inside CLS Bank called "In-Out Swaps" which help make funding positions more manageable. If new FX trades are submitted after that point, the funding will be more awkward.

We should also understand the edge case of what the impact would be if UBS Switzerland were to do nothing. To settle the trades, they will be reliant on intra-day credit from their custodian. Recall that this has an impact on the intra-day liquidity buffer requirements for both credit givers and credit takers. These are implicit, fixed costs which are not associated with activity on any one day. If that intra-day credit were to turn into an overnight overdraft, there is an impact on the balance sheet of both parties, and an explicit cost to UBS Switzerland, which we would expect will lead to some implicit costs for the underlying retail and institutional investors.

If later on T+1, UBS were able to find a counterpart willing to sell USD vs. CHF, that trade would not settle in CLS. So, to exchange what it has, CHF, for what it needs, USD, there would be settlement risk. Added to that UBS has a particular interest; it really needs those USD now and not later. USD which arrives at the end of the day are only somewhat useful; by then, the damage has been done in terms of intra-day overdrafts and their impact.

There are thus two significant obstacles for cross-border securities settlement associated with a move to T+1:

- The availability of an intra-day liquidity marketplace to support the FX needs. Fintium is an example of a new capability in the space, but it remains to be seen if this, or similar solutions, can attract the necessary participation to support 24/7 real time foreign currency exchange.
- The ability in terms of interoperability / programmability to settle those FX trades instantly, in other words atomic trading & settlement. *The exchange of what I have now for what I need now.*

The realization of such atomic trading and settlement, not just the atomic settlement at T+2 which is already provided effectively by CLS Bank, will in turn depend on access to the direct addressability of a SPool of tokenised money by market participants. We can envisage a virtuous circle of increasing liquidity in same date foreign exchange, with the ability to find counterparts for immediately exchange in the marketplace for example through Fintium, enhanced by wider adoption of tokenised directly addressable monetary deposits, which in turn brings greater liquidity to the marketplace, all incentivised by the shift to T+1 securities settlement.

Whatever solution is used to overcome these obstacles, it will have to comply with the relevant regulations and be consistent with the FX Global Code July 2021, a set of global principles of good practice in the foreign exchange market.³⁴ The foreign exchange market participants sign up to the code are committed to avoiding settlement risk (Principle #35) and to strictly measuring and managing it (Principle #50).

3.3 SCENARIO 3 – DERIVATIVE TRANSACTIONS

The final scenario we consider is that of derivatives. For these purposes, let's not be too pedantic about "when is a trade a derivative?", rather let us just think about the cash flows that come from these instruments and more importantly when the parties involved know about them.

Item	Type	When does cash or securities collateral flow?
1.	Cleared derivatives – IRS, interest rate swaps / equity swaps / CDS credit default swaps	Initial Margin (IM) on trade date – can be met with securities. Variation margin (VM) daily from trade date +1, based on prior end-of-day.
2.	Un-cleared derivatives-	IM only where applicable Variation margin (VM) daily from trade date +1. May be subject to some thresholds or minimum amounts.

³⁴ (Global Foreign Exchange Committee, 2021)

3.	Options	<p>Premium payment from buyer to seller on value date, normally at least T+1.</p> <p>Potentially plus the treatment for un-cleared derivatives above.</p> <p>If the options result in a deliverable event at expiry, then this is usual T+1 or more days.</p> <p>If the option is cash settled, then this too is typically due T+1 or more days.</p>
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Table 1: Types of payments associated with derivatives.

In simple summary terms, there are two kinds of payment or cash movement. Firstly, those we know about today and must make “in the future” and secondly those we must make today. In both cases, market participants will generally have the means to determine these commitments as market prices change, often using the same models that their clearing house or CCP uses. So far this is very similar to the requirements discussed above for cash management for domestic securities settlement. The difference with derivative transactions is that the contract can be as long as 25 years or more, not limited like typical securities settlement to day T+2. However, for intra-day and overnight cash management it is not material whether the incoming margin payment request is for a short- or long-term contract; what is required is visibility of these demands and the wherewithal to quickly locate the necessary funds.

In the world of cleared derivatives, there are some very strict rules about the time frames for meeting VM calls. For example, in the UK, LCH requires members to use its protected payment scheme. This forces a member who is not themselves a clearing bank to ask a local clearing bank for support to make these “timed payments”. Timed in the sense that the requirement is not to pay anytime, but to pay no later than a certain time. In other words, the construction removes the flexibility to choose when to pay. Settlement related payments, unlike VM payments, are not timed, they are due on value date rather than at a specific time.

As a rule, correspondent banks / nostros charge on an ad valorem basis for timed payment facilities; so, it is not GBP 2.00 a payment, but maybe 15 bps or more of the amount being paid. Some nostro providers are very strict; if a client is long USD 100 and must pay USD 80 in a margin call, they will still charge some basis point amount on the VM payment of 80 because they no longer have any discretion and are forced to make it at a certain time. Those payments add to the reliance on intraday credit / overdrafts, which in turn drive the requirement for intraday liquidity buffers.

VM calculations and payments are something which is done one, maybe two times a day. The processes we have available today are simply not able to adapt to a more frequent cycle.

Box 4: reactive v. proactive margin management

In 2022, before its demise, the crypto firm FTX took steps to change the way margining is done in derivatives. FTX had an existing approval as a DCO, a derivative clearing organisation. That approval comes from the CFTC, the Commodity Futures Trade Commission, a US regulator. There is convergence here between the old world and the new world. Even though crypto currencies are not regulated, derivatives are, so FTX had to obtain this approval. Initially, that approval was for fully collateralised positions with no leverage. So, the margin questions were not a feature.

In 2022, FTX wanted to evolve the model and move away from that 100% collateralisation to a more traditional TradFi approach. This required them to make an application to change the rules of engagement. In their filings, FTX suggested a new margining process. Clients would be asked to keep margin on-hand with FTX to cover margin calls. Even if the positions stayed the same, FTX proposed to recalculate margins really frequently and then call for collateral from the pre-funded accounts. If collateral calls could not be met, a portion of the positions would be closed out until equilibrium was re-established. Only partially, but enough to bring margin positions back into line. No friction, no human intervention.

Essentially, FTX wanted to move the task of collateral management from being a reactive one to being a proactive one. The TradFi process is re-active or ex-post; calculations are made, the parties react and post collateral reasonably quickly, but with some delay. The DeFi process which FTX proposed would have changed that; it puts the burden on the clients to monitor events and ensure their collateral accounts are ready.

Opinions differed on whether this was a good or a bad thing and might perhaps lead to over hasty declaration of defaults³⁵. At least technically it would have worked, but only if funds to cover the margin calls were posted in advance with FTX. Now, about a year later, we all know that depositing anything with FTX did not end well.

A further feature of TradFi, distinguishing it from DeFi, is that the management of margins is *re-active* rather than *pro-active* (See Box 4 and Appendix C). In DeFi, and in the replication of DeFi margin management proposed by FTX before its demise, the realignment of a margin position with exposure is undertaken automatically by code. If margin is not immediately available then positions are closed to reduce risk exposure. This however removes the role of intermediaries in the management of cash and asset balances, along with the possibilities for regulatory oversight of cash management and the provision of public liquidity as a lender of last resort.

What is also missing today, as already discussed in the previous sub-section, is any easy ability to do FX trades or repo borrowing for same-day near real-time settlement. If FIs were more readily able to exchange what they have now for what they need now, then there would be less reliance on intra-day overdrafts and with that less need for intraday liquidity buffers.

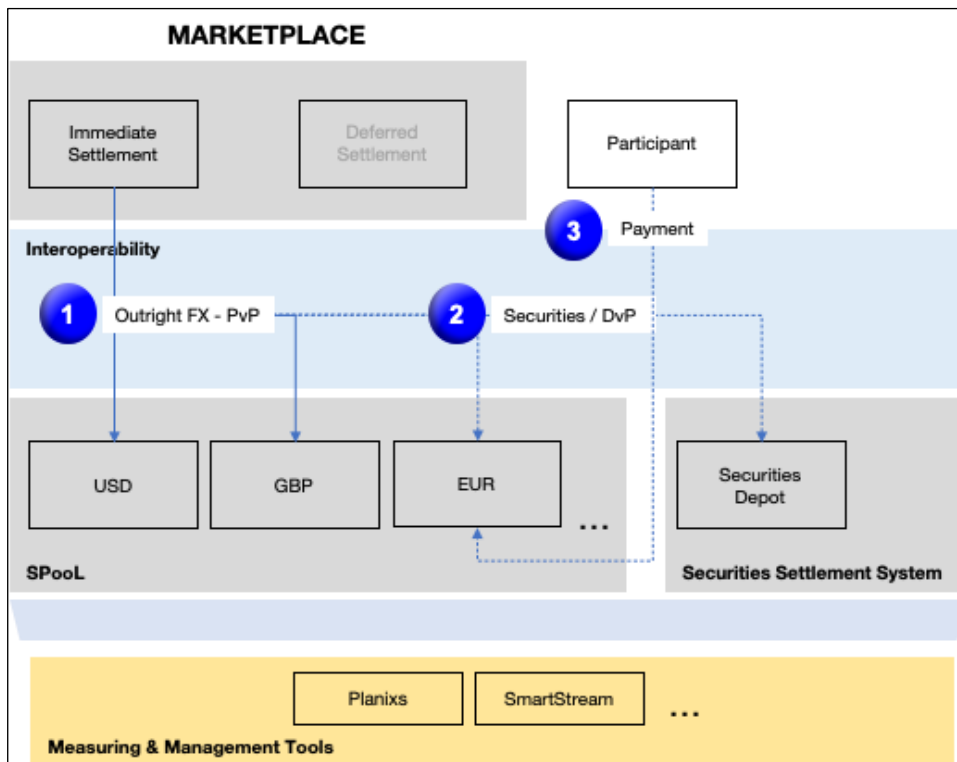
New infrastructure which supports this funding need would help mitigate risk: easier use of FX, more frequent margin calls. The key part here is to avoid fragmenting

³⁵ See: FTX, 2022.

liquidity. This brings us back to the concept of the SPool, a single pool of liquidity, which can serve any payment need: P, PvP and DvP.

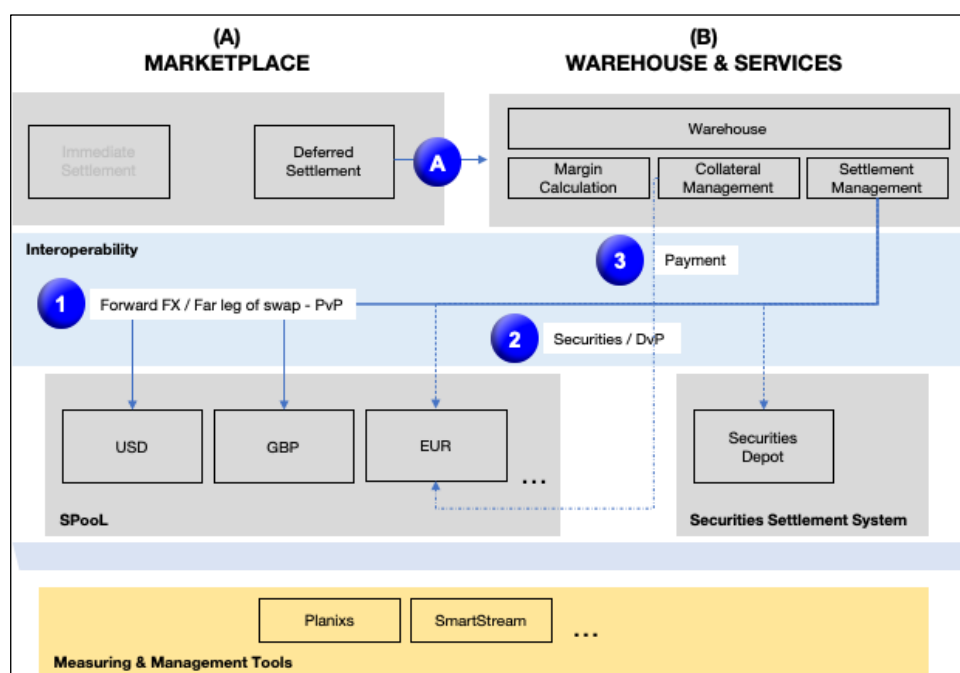
Two further diagrams can illustrate what we envisage. **Error! Reference source not found.**, illustrates how the various forms of P might interact with other systems. For an Outright FX (1), there needs to be interoperability with two currencies in a SPool. Theoretically, each currency could be on a separate platform, however for any one currency payor and payee would need to be on the same platform. For a securities trade (2) there needs to be inter-operability between a SPool and a securities settlement system. This is the way that securities settlement works in Switzerland today. That “system” could also be individual Web 3.0 wallets, owned by individuals or legal entities. For a one-way payment (3) an instruction is simply issued by an authorised party. All this rests on the combination of direct holding and direct accessibility.

Figure 2: Instant Settlement Interactions



For transactions which are not for instant settlement, which applies to pretty much all derivative transactions, we will need a series of services to manage the lifecycle (cf. 3). An ideal way to manage this is firstly, transactions need to be fed to a repository or warehouse (A) (we prefer the word warehouse to avoid confusion with the trade repositories mandated in Dodd Frank and EMIR). To manage the transaction across its lifecycle, the warehouse can provide various essential functions: margin calculation, collateral management, and settlement management. Where a Central Counterparty (CCP) is involved all, of these functions are integrated. Outside of a CCP for example with uncleared derivatives, different actors might perform the roles, or one actor might perform all of them.

Figure 3: Deferred Settlement Interactions



In either case efficient processing rests on systems interoperability, based on standardisation of contract terms as well as of messaging, which can in turn feed into the monitoring tools used by cash managers and treasury in financial institutions. Such arrangements can also potentially support improved regulatory oversight of credit, liquidity and market risks. Ideally there should be a convergence of interest, with sufficient operational benefits from improved systems to justify investments which also ensure more effective regulatory compliance.³⁶

³⁶ McNulty et al., 2023 make a broader argument for the benefits of having firm’s operational systems aligned with regulatory objectives across all areas of financial regulation.

4. REALISING THE BENEFITS: THE BUSINESS AND POLICY CHALLENGES

This section considers the benefits, in terms of reduced need for liquidity buffers and of settlement failures, from a shift to tokenized money or what we prefer to call SPoolS (single pools of liquidity) in the form of directly held and directly accessible settlement money along with the business and policy challenges that arise if the industry is to move in this direction.

4.1 OPERATIONAL REQUIREMENTS

In the introduction, we highlighted the very high costs associated with liquidity buffers generally and intraday buffers specifically. We start with the working assumption that intraday liquidity buffers cost 100 bps.³⁷ Then if we assume that a regular big bank has USD 100 billion in buffers and just 10% of that is for supporting intraday, then on January 1 there are fixed costs for the year of USD 100 million. Just to support settlement, just for one bank. That makes the nirvana of a SPool and the interoperability it supports well worth striving for.

Similar benefits can be achieved from interoperability in the securities legs of trading and settlement. There would need to be interoperability between the marketplace, the asset custody, and the means of payment. And both parties would need to have custody accounts which are operationally compatible. There is more flexibility here, hence using this term “compatible”: the two parties do not have to have the same custodian as long as their systems support immediate and final transfer reflected in both the investor accounts held with the custodians and the omnibus accounts held by the custodians with the CSD.

On the ‘cash side’ though being operationally compatible is not enough because tiered monetary deposits are not matched 1:1 by an omnibus reserve account with the central bank used for settlement, instead accounts are only fractionally reserved. Both parties would need accounts in final settlement money. Together these innovations would substantially reduce the occurrence of trade failures which introduce additional frictions throughout the trading process, and which jump substantially at times of extreme market stress because of difficulties in obtaining funding.

It might be thought that these benefits could be obtained simply through private sector initiative. This possibility is evident in the ‘tokenised deposits’ we already have. JP Morgan and JPM Coin, which now includes some ‘programmable money’ functionality and similar initiatives at Citibank (discussed above in Section 2.4)

Essentially these are ‘new payment rails’ inside the major banks that offer ‘always on’ access and first versions of ‘programmability’. This might be as simple as “pay as long as balance will not go down below USD 100” or “Pay Counterpart X if payment Y from X is received”.

³⁷ This is the spread between long-term funding cost for the capital and any short-term returns. The fair cost of liquidity in ‘normal times’ for most FIs.

These new rails are effective at moving money between clients of the same bank. Depending on the scope of the new solution, they might also enable clients to make conditional fiat payments to payees who use other banks. In this case, there is a cross-over from the new to the old; in the new system a decision is made to make a payment, which is then executed over the fiat rails. Perfectly acceptable for a simple one-way payment.

As we examine these developing ideas, it is important to note that it is not the money per se which is programmable, rather the payment systems which enable conditions or dependencies to be attached to a payment.

This is not though interoperability; it is transacting inside the four walls of the bank. Not able to do more sophisticated things like 'Siemens wants to make payment X to counterpart Y only if unsecured risk exposure to Y would stay below 100'. This is because the risk exposure is inside the Siemens systems and, as such, does not help with an order to a marketplace to buy or sell 100 Apple shares, or to swap CHF for USD. That needs inter-operability protocols, and it needs a means of payment that uses central bank money.

What this shows is that a purely private proprietary money, even if tokenized in the sense of supporting quite sophisticated automated transactions, cannot support a SPool. Consider JPM Coin, the much-discussed tokenised deposit solution being developed for customers by JP Morgan (JPM), processed on blockchain, albeit a private, permissioned one. JP Morgan is one of the strongest financial institutions in the world, the positions of holders of JPM Coin and account holders with "old fashioned" long cash balances are identical; every single one of them is an unsecured creditor for every single dollar.

So, it is easy to see that a bank issued stablecoin is the same as a tokenised deposit is the same as an IOU. They are all commercial bank monies and – without a system for interbank settlement in central bank money – are not practical for transfer outside the four walls of any bank that issues them. It is also easy to see that the nature of the claim, or the liability, is not dictated by the technology which is used. The product is commercial bank money. That said, the technology can change the process, so a digital product may have a process which offers advantages that a traditional or TradFi product process cannot. In India for example, JP Morgan is offering local banks a new way to settle USD claims between themselves using its blockchain based ONYX system³⁸. This new digital product is a new internal JP Morgan technology solution which is available 24 * 7 * 365. But it only works if all the parties have an account with JP Morgan. The improvement is that the digital product delivers an 'always on' capability but without interbank settlement in central bank money.

Stablecoins are not a solution to either. USDC is like a mutual fund; it invests in a portfolio of assets and only has some of its assets in cash. And, that cash is with a commercial bank. There is risk that at a particular moment in time, the fund cannot offer redemption at par. The assistant governor (financial system) of the Reserve Bank of Australia expresses this as follows: "The enduring challenge for private money is to

³⁸ See (Crawley, 2023; Das & Sircar, 2023).

closely replicate the special features of safe public money so that they are interchanged at the same rate, thus preserving the ‘singleness of money’”.³⁹

A payment system infrastructure would appear to be the logical choice for a SPool in any particular currency, whether this in the form of a wholesale CBDC or, delivering the same functionality, an upgrading of RTGS large value payments and rules on holding reserves with the central bank. Provided this support 24/7 immediate payment and interoperability through being directly accessible to the various settlement systems then it can be SPool in that particular currency.

SPools though need not be standardised at a global level. Payment systems are a very specific species: as critical ‘financial market infrastructure’ they are regulated locally in each country. They are subject to a large body of rules, much of which is driven by the Principles for Financial Market Infrastructure (PFMI). It is also possible that individual jurisdictions might choose to prefer a SPool in the form of a licensed private entity in their currency. As discussed in Section 2.4 above, these could be forms of proposed synthetic sCBDC such as Fnality or the RTGS.global or it could be a development of the current work on the Regulated Liability Network RLN on which many institutions are co-operating to provide SPool functionality.

In short, addressing the challenges of intraday and overnight liquidity requires a new foundation of tomorrow’s payments infrastructure, offering for each currency a SPool, whether this a wholesale wCBDC or a private sCBDC equivalent, that is established or licensed by the relevant authorities, and for this SPool to offer both the required direct accessibility for settlement systems to automate the required payments for transaction settlement together with intraday access for ‘remote’ members: i.e. foreign institutions using this system as their SPool in each particular currency.

4.2 THE INDUSTRY CHALLENGE: CRITICAL MASS

Our analysis of the challenges of intra-day and overnight cash management suggest that there can be strong demand for holding SPools. We then anticipate that new marketplaces will evolve, for intraday FX, and existing marketplaces such as Repo to adapt to the new capabilities and allow institutions to obtain the balances of cash and of securities to fulfil all their settlement obligations relatively seamlessly when compared to what is required today with large liquidity buffers to cope with uncertainty, buffers that can still be exhausted at times of extreme market stress.

This though runs into an all too familiar problem in innovation of financial infrastructures, both wholesale and retail. Adoption and usage are significant challenges. There are two substantial barriers to adoption.⁴⁰ Co-ordinating change is difficult: adopting new standards, connecting to a SPool, whether as a user or a supplier of liquidity, is not costless. These costs will only be borne if firms are confident that other firms are doing the same. Some firms, e.g. those with substantial nostro business, may be more reluctant than others to ‘get on board’, seeking instead for their customers, and the revenues they bring, to wait until making any change.

³⁹ (Jones, 2023).

⁴⁰ For a theoretical discussion, in the context of retail payments infrastructures, see (Milne, 2006)

Without adoption across the market, usage then is also limited. With only partial adoption and limited usage, liquidity will be more rather than less fragmented. We have seen this in the recent past with ForexClear and the adoption of NDF clearing, with a “half in, half out” situation being unsatisfactory for all participants.

Times are changing. We are in a different place from other when The Payments Risk Committee advocated the establishment of global collateral pools.³⁵ Across the industry there is a recognition now that was not there ten or even five years ago: technological developments can now support a step improvement in the efficiency and safety of global capital market operations. We have the impression that the costs of new technology are noticeably lower than a couple of decades ago, with interoperability far more easily achieved than in the past because of the adoption of common standards such as ISO20022 and the widespread use of application programming interfaces. The most recent rallying cry, that of ‘tokenization’, has shown that it is possible to get much of the industry behind a common agenda for change. Still, this is far from enough. In contrast to many consumer industries (home entertainment, mobile phones, photography to name just three which have been through digital transformation over the past quarter of a century) change of infrastructures will not follow, automatically, from technical break throughs. It is not enough to simply propose solutions, whether this is the SPoolS outlined in this paper or some other arrangement for effective intraday liquidity management. There has in addition to be a collective focus on practical solutions, what they will actually cost as well as the benefits they will bring; and a major effort is then required to persuade all involved, not just the digital technology teams but all of senior management right up to board level, of the need to make the necessary investment in change. From this it will be apparent that a paper such as ours, even if persuasive in principle, will need to be followed by further detailed analysis to bring everyone along.

4.3 THE POLICY CHALLENGE: ACCESS

However, this develops another crucial role will be placed by ‘access rules’, where the responsibility for change lies with central banks not industry. Access rules are the enablers of the required interoperability for effective intraday liquidity management.

Let’s use the example of UBS needing to access US dollars and Commerzbank (CoBa) being willing to swap USD for Swiss francs (CHF) as collateral. Typically, UBS will use local repo markets to raise secured funds. Those funds will be in CHF. Today UBS can use the combination of FX markets and CLS settlement to trade today with settlement tomorrow in order to obtain the required US dollars. This is often done on a swap basis and referred to as a tom/next swap.

If there were a new marketplace where participants could trade and settle instantly, the marketplace would want to be sure that each of UBS and CoBa have what they are selling, what we have referred to as “atomic trading & settlement”. Settlement would be part of the trade; following the matching the earmarked funds are moved. For this to happen the two parties need to operate accounts on the same system. The USD and CHF do not have to be on same system, rather in each currency the two parties must have accounts in the same system. So, one part of this is simply a technology challenge; are there licensed payment systems, can they inter-operate with

marketplaces, with systems of asset custody and with other payment systems in other currencies?

The technological requirements are relatively straightforward and could be implemented in several ways, perhaps with permissioned distributed ledgers but also likely equally well with traditional centralised databases. The more fundamental challenge is access and that is the policy question. Neither UBS nor CoBa are directly regulated by the Fed and CoBa is not regulated by FINMA, the Swiss regulator. So, can they get the SPoolS in US dollars and CHF which they need for effective intra-day cash management?

Access restriction is regarded as a key element of monetary policy control. And it enables the two-tier system with commercial banking to function properly. The ability to hold reserves, to those banks given access to the central bank balance sheets for settlement, is what determines the overnight money market rates of interest (the 'opportunity cost' of holding reserves which must adjust to bring the demand for reserves into equilibrium with supply of reserves provided by the central bank. Therefore, a central policy issue is what impact would there be on the demand for reserves and on monetary policy operations from moving to global access for regulated financial institutions to central bank reserves.

What also worries every central bank is 'run risk'; if anybody or any entity was able to hold central bank money, in a crisis everybody would use that facility. Wholesale banking could be extremely fragile, with a danger of rapid collapse at times of stress.

In short, when all of us who are trying to change the system and build tomorrow's infrastructure find ourselves talking to central bankers about our latest and greatest idea, we are certain to be asked: "Who has a claim against whom for what?" They are gauging the potential impact of our "new, new thing" on control over monetary policy and systemic financial risk. Their starting point is that they are reluctant to give any wider access than they already do today. For the most part, that is a concern about end-of-day positions, although there is an issue to be managed around the impact of an intra-day issue.

There is a clear case that all this new infrastructure is all about settling trades, so allowing wide access is important. Going a bit further, allowing wholesale market participants to hold limited overnight balances, at least regulated ones, would be a very good and sensible thing from the viewpoint of FIs' operational staff. Just maybe some central bankers might agree with this, but suggesting we make such a big change would be highly scrutinised. A conversation with say the Bank of England, might go like this:

"So, you'd like to create a new designated payment system, which operates with settlement finality, and you'd like that system to have a reserve account with the BoE?"

"Yes."

And you propose that financial institutions the BoE doesn't regulate could hold a balance of GBP in the ledgers in your system during the day and overnight?"

"Yes"

“Let’s say one of those institutions is ZKB from Switzerland, whom we do not regulate. If they have a balance of 100 GBP in your ledger at the end of today, what do they have a claim on?”

“They would have a claim for a 100 slice of the GBP in the omnibus account at the BoE.”

“That would be outside the current scope of our access rules. Only those who are under the Sterling Monetary Framework are allowed to hold overnight balances.”

“But we only want to settle trades.”

“What would you propose?”

“How about we allow those ‘foreign’ regulated institutions to hold a limited amount overnight. Maybe one amount for G-SIBs, another for D-SIBs⁴¹ or some other simple structure.”

“Just supposing we were to allow that, perhaps a cap of GBP 200 million for G-SIB and 50 million for a D-SIB. How would your system work if one day, ZKB decided to simply sell CHF vs. GBP 1 billion and sit long the GBP?”

“We assume market participants are rational actors and ZKB will only do that trade to settle trades today.”

“But, with what you propose, they could be irrational, could they not? What about if your system goes bankrupt during the day and stops operating before ZKB can use those GBP?”

These are complex issues which go well beyond what we can fully address in this paper. A successful SPool requires wide access. With that it must have a structure which fits within monetary policy norms. Of course, we need new infrastructure and the same time the settlement arrangements must respect the operational requirements of monetary policy. Without fully resolving the issues, we offer the following considerations and possibilities:

- A structure which allows unfettered access to the risk-free asset to all globally active institutions is not obviously necessary. Just maybe, central banks will agree to allow foreign institutions some limited intraday holdings, without access to any intraday borrowing. That will require payment system operators to design a structure which ensures control. One possible combination is to require that foreign institutions have a domestic sponsor. If there is an intraday event, the rules would say the reserve balances belong to the sponsor, who in turn has a liability to the foreign institution. At day end, there would need to be a process to “sweep” any balance, or excess balance, to the sponsor. In effect an automated unsecured money-market loan by the sponsor to the foreign institution. The result is then much the same as the situation today if a foreign institution uses a correspondent bank. The institution can proactively manage its end-of-day balance seeking as today to be flat. If it does not it has a credit

⁴¹ D-SIB is domestically systemically important bank. ZKB in Switzerland is an example of a D-SIB that is not a G-SIB.

balance, which in accounting terms is an unsecured receivable vs. its nostro. Access rules could limit the size of intraday balances held by the foreign institution for settlement purposes.

- This proposed solution would allow monetary operations to continue as they do today, based on matching the supply and demand for reserves. Such domestic sponsorship of foreign institutional access to central bank money would clearly increase the demand for overnight reserves by the domestic sponsor, they would need to be in a position to restore the foreign institution with direct access to central bank money at the beginning of the next day; these unsecured deposits would need to be fully not fractionally reserved. But this additional demand could be easily met, if required, by increasing the quantity of reserves.

The argument for central banks considering such arrangements is strengthened by further policy benefits. First and most obviously, such wider access to central bank money used as SPoolLs will ease the intraday liquidity challenges in RTGS systems. Timed payments would be made from intraday balances, preceded as necessary with 'atomic trading and settlement' for a funding transaction either in forex or repo markets and near real-time crediting of the necessary funds. There would no longer be any incentive to delay payments and put liquidity pressure on the RTGS system.

Second, such SPoolLs combined with intraday markets for liquidity, based on atomic trading and settlement and real-time receipt of credit balances for forex and repo transactions, would provide the central bank with new tools to address systemic liquidity risk. The need to lend directly to individual institutions with the burden of assessing the value of collateral offered by a wide range of global institutions, can be replaced by overnight lending to the major domestic institutions (perhaps with a series of intraday auctions to capture shifts in the overnight interest rate reflecting intraday movements in liquidity demand) who can then in turn be in a position to lend to those other market participants, domestic and foreign, who need to increase their SPoolLs to meet their settlement obligations.

4.4 HOW MIGHT WE GET THERE?

We have described what we think nirvana for the means of payment may look. We are technology agnostic. We think having a SPoolL in each currency, with wide access for wholesale market participants is the right foundation for the financial market infrastructure of tomorrow. We are neither alone, nor completely new in our thinking. Back in 2003, Barclays' then Treasurer, Richard Pattinson highlighted the need for a "Cross-Border Collateral Pool".⁴²

Moving to anything new has one inherent challenge; initially, every new settlement and payment system adds to fragmentation of liquidity before it improves anything. A so-called "J-curve effect." Unless a new solution can quickly gain widespread traction, we will not be better off. So, how might we move to a new tomorrow?

In GBP, for example, Finality International has made a start with its Sterling Finality Payment System (£FnPS).⁴³ That system can interoperate with other parts of the

⁴² (Pattinson 2003)

⁴³ (Ledger Insights, 2023)

financial market infrastructure. Initially, with only one currency live, it could and likely will be used for one-way payments for margin requirements. The next logical step would be to add DvP, delivery vs. payment to support re-purchase / repo trades for liquidity management, with HQLAx the expected marketplace. The latter could allow participants to exchange what they have, securities collateral, for what they need, cash, which can then be used to make payments.

This is a start. What is missing?

- Widespread access to GBP accounts in the £FnPS.
- Compatible payment systems in other currencies, specifically with the status of designated payment systems deemed to offer settlement finality under local laws.
- New marketplaces and settlement systems.

Multiple currencies are important. If readers agree with us that all FIs want to fund their settlement and payment needs efficiently and effectively, then we would expect they will make use of FX markets that allow them to swap the currency they have now for the currency they need now. If marketplaces emerge which facilitate that exchange, then there is no ex-ante need to hold balances in “foreign” currencies, so such new infrastructure should not fall afoul of regulators’ desire to be re-strictive on who may hold overnight balances in their currency.

From a conversation with a European regulator, we have had the observation that once such marketplaces exist, the requirements for intraday liquidity buffers would change⁴⁴. Today, the requirements force banks to hold buffers aligned to their payment needs and use of intraday overdrafts in foreign currencies. Once they are able to exchange their home currency for foreign currency intraday, the requirement would be either eliminated or at least significantly reduced.

As soon as we have multiple currencies and wider access, we necessarily enter the realms of “cooperative oversight”; the regulator in any one currency wants the formalities in place to enable them to supervise any institutions to whom remote access is given. CLS has just such an arrangement; all 18 currencies are represented, together with several Eurozone countries,⁴⁵ the Fed has the Chair.

The speed and spread of adoption might be accelerated if the G-20, perhaps under the FSB, laid out a mechanism for such cross-border oversight, together with appropriate standards or guidelines. Currencies, or payment systems would then be clear on what they need to do to ensure inter-operability and potential participants would understand what they would be allowed to do in foreign currencies.

⁴⁴ Source: off-the-record discussion with a G10 regulator.

⁴⁵ (CLS, 2022)

5. CONCLUSIONS

This paper has considered the possibilities for employing 'tokenised' money (whereby tokenised we mean holding of cash and non-monetary assets using modern communication and security technologies) to support intra-day cash and transaction management in global financial institutions. The status quo is very much dependent on access to intra-day credit, the cost and risk of which is becoming increasingly obvious to all participants.

To really progress, we need to be able to settle trades & make payments between all participants intra-day and in near real-time. We have argued that creating the arrangements for each global institution to hold a Single Pool of Liquidity (SPool) in each currency in which they transact and using this to drive liquidity management in securities, FX and derivative markets is the right place to start. That needs a lot of industry wide cooperation.

There are two aspects of this tokenisation which in our analysis are needed to support this outcome. Blockchain or distributed ledgers are not though necessary to achieve the liquidity benefits of tokenisation:

1. Directly held. Holding money directly in a form which is effectively free of counterparty risk and can be used for legally final settlement.
2. Directly accessible. Universal access and availability, ideally 365/24/7 and globally, and available for automated execution in all the systems for exchange and subsequent settlement, both of money and of securities.

We call this combination a 'SPool' because it would allow globally active financial institutions to hold a single pool of liquidity in each currency that supports financial market transactions for themselves and their clients. The current fragmentation of liquidity, documented in Section 2 and Appendix A, suggests there will be immediate demand for such arrangements.

With this foundation we then envisage the services we have today evolving into new forms. Widespread use of SPools can support the emergence of marketplaces for real-time liquidity markets, with intra-day exchange and settlement, employing collateralised transactions, both foreign exchange swaps and domestic repo. It can also support transaction management services; what we refer to as warehouses, providing both calculation of margin and the tracking of obligations for deferred settlement, to ensure full transparency of settlement obligations. Both require interoperability and immediate access to directly held money in a SPool in each currency, which can be exchanged for securities or another currency, or to be used as a payment. These functionalities in turn reinforce the opportunity for a range of financial institutions to participate as market makers or liquidity providers in the markets for intra-day liquidity.

As today, messaging & standards will be essential. We will need inter-operability solutions and standards to manage the interaction of marketplaces, warehouses, means of payment and securities settlement systems. Some of this work has already started, for example the Secure Asset Transfer Protocol ([SATP](#)). Another element that

can facilitate the transfer and exchange of liquidity will be the fuller adoption of the Global LEI as a standard identifier to support the addressability of SPoolS.

Our outline – or ‘road map’ – for the adoption of technology in intra-day cash management can be compared with the recent account of the technological opportunities in global finance provided by the Bank for International Settlements.⁴⁶ The BIS offer a persuasive description of how new technology (they emphasise ‘tokenisation’) could transform financial infrastructures, reducing transaction costs and risks and supporting the emergence of new financial services unfeasible with current legacy infrastructures. The BIS though do not discuss the challenge of adoption. While stating that the global financial “...system could be on the cusp of a major technological leap.” with substantial potential benefits, theirs is a description of where financial operations could be in two or three decades from now, not of how to get there.

Our analysis complements that of the BIS by sketching out both a business and policy case for ‘tokenisation’ in one important area of application, creating our proposed ‘SPoolS’ for unfettered access to and transfer of settlement money in intra-day cash management. Adoption requires both a return on investment for the firms involved – which in our analysis emerges from the substantial reduction in liquidity buffers held for intra-day transaction management – and a willingness of the monetary and regulatory authorities to accommodate greater direct access to central bank money. We hope that our work can help industry and the public authorities reach a consensus on steps that will allow new technologies to be adopted in the relatively near future in this area of financial transactions.

Achieving this consensus will require further research and analysis, moving beyond the rather general work undertaken to date on distributed ledgers and tokenisation, focusing more on the roadblocks: the practical business and policy concerns that could prevent adoption. Issues that need further attention include: (i) quantifying the reductions in liquidity buffers that could be achieved from innovation of the kind we describe; (ii) exploring fully the implications for both monetary policy operations and financial stability of widened access to settlement money, and developing workable arrangements for access that deliver the potential benefits to industry without unacceptably hindering policy interventions; (iii) distinguishing what actions need to be co-ordinated at a global level (for example messaging and data standards) from those which can be left to individual jurisdictions. For example, we have argued that the choice between direct access to central bank money in the form of wholesale CBDC or a privately provided sCBDC is something that can be decided jurisdiction by jurisdiction, provided these individual solutions support the necessary interoperability.

⁴⁶ (BIS, 2023).

APPENDIX A – A PRIMER ON LIQUIDITY MANAGEMENT IN FINANCIAL MARKETS

To envisage how payment tokens might change how liquidity is managed, we start with a summary of how the cash management function works today in global banking. The role of the cash manager is ensuring, from day-to-day, that the bank meets its obligations relating to payments and settlement. This can be distinguished from the longer-term Treasury activity of ensuring adequate funding. This section describes the typical activities involved in these cash management operations.

Constraints and challenges

Effective cash management must cope with a number of constraints and challenges.

A first guiding theme, for every cash manager, is “fund-to-plan” vs. “fund-to-actual”; what was and is expected to happen vs. what did happen and what could still happen? If everything goes to plan, then the job of cash management is relatively easy. It is simply a matter of ensuring that sufficient balances of cash and securities are available when settlement takes place. But inevitably the unexpected will sometimes happen, so the cash manager must retain flexibility, keeping unused balances of cash or securities or utilising credit lines to cope with unanticipated developments.

A further issue is that these payments originate in two flavours of accounts: directly cleared and indirectly cleared (see Table 1). Direct clearing imposes strict settlement obligations with consequently substantial operational obligations and risks. Indirect clearing, using a ‘nostro’ account or clearing arrangement with another institutions, offers some additional flexibility but at the cost of maintaining a balance or utilising a line of credit with the nostro. Typically, the cash management function will focus where there are the largest flows: normally those cases where the FI is a direct clearer and on the major currencies: GBP, USD, EUR.

Even with this focus, the task is challenging. FIs have many legal entities and even in any one currency there are numerous accounts to be managed. At any moment in time, those accounts are discrete, mutually exclusive. Long funds in one account are not immediately usable to cover shorts or shortages in another. This is referred to as fragmentation. Moving balances between systems in the same currency is not necessarily instant. If you need USD in your Euroclear account, you might need to instruct your nostro to move those funds. How quickly they move depends on your current balance, or your intraday credit line from your nostro, as well as the Nostro’s backlog and available liquidity and the deadlines imposed for payments/transfers. In some systems that movement is easier. For example: in the Euro System, moving cash between securities settlement and payments is instant.

Type	Description
1. Direct Clearing	The FI is a direct member of a payment or settlement system, such as CLS Bank for FX or Euroclear for securities. In payment systems, generally, a participant can only control their payments, but cannot control when monies are received.

Type	Description
	<p>In instant payment systems, the level of control is lower; the FI sets limits for individual users and the system may impose a maximum size.</p> <p>In both cases, there are normally some rules about the amount of liquidity which needs to be in place at the start of business. There may be additional processes requiring certain balances to be maintained or achieving certain volume & value throughput targets.</p> <p>For all accounts, the cash manager needs to actively check that the day's processing is processing "normally". Normal will vary by system, currency, FI. An example is that a cash manager might expect that if the payment system opens at say 00:00 on value date, then by 06:00 50% of the payments have been made. Or for securities settlement, do most trades settle by a certain time?</p>
2. In-Direct Clearing	<p>In this case the FI uses a nostro or Correspondent Bank or a custodian.</p> <p>The working assumption is that payments have been sent to the nostro and that all counterparts will send funds due sometime on value date. Securities are trickier; one trade may fail, causing another trade to fail. The textbook case is that the FI buys two lots of an asset, 800 and 200, and sells 1'000. The 800 is delivered and settled, but the 200 is not received and so the 1'000 cannot be delivered. The cash manager is impacted because 800 has been spent, probably in the form of an overdraft. Funding for securities settlement requires continuous interaction with the settlement team.</p> <p>Usual aim is to be "flat", i.e. zero balance, at the end of the day.</p>

Table 2

A further important facet of the cash manager's life is that intraday currency balances are separate and not exchangeable. No matter how many Swiss francs a Swiss bank has right now, they are of no use to meet any needs in other currency. There is currently no financial market infrastructure which will help an institution instantly or even same-day exchange what they have for what they need without taking settlement risk.

In sum, there are three key challenges for the cash manager in their daily business:

1. *Fragmentation*: the need to hold any one currency in many different, mostly unconnected, places to drive payments and settlements. This adds complexity and naturally results in excess liquidity, because in each place you might have more than you really need.
2. *Reliance on intra-day credit*: at any point in time today what you have in one currency will not help you with what you need in another. You have to have liquid securities collateral or rely on your nostro for an intra-day overdraft. This drives up fixed operational costs.

3. *Accommodating new demands on liquidity*: T+1, greater use of variation margin, more instant payment schemes.

Opening cash reconciliation

With these constraints and challenges in mind, the typical activities of the cash manager can be reviewed. On any day, the starting point is the cash reconciliation; is the amount of money in each bank account what we expected it to be? You might have been short / overdrawn because money you expected to receive did not come in or sales of securities did not settle, or long because payments were not made, or purchases of securities did not settle.

If there are significant reconciling items, the cash manager needs to talk to their colleagues in settlement operations and form a view as to whether those failing items are likely to settle today. If not, there will be a need to either source more cash to cover the short positions or decide to use any long funds. At this stage, following the mantra “maximise interest income, minimise interest expense”, broadly, the cash manager is worried about:

1. The cost of overnight overdrafts.
2. The credit risk of having long balances with the nostro because these are unsecured receivables.
3. The loss of potential interest income on credit balances; in this case the spread between the market rate and the lower rate from the nostro.

FX trade receipts

Attention then shifts to “today”.

Next on the list of things to focus on is FX trade settlement via CLS. If the Financial Institution (FI) is a direct member of CLS Bank, then the cash manager wants to be sure that all the payments are made on time. Those payments cover all the short positions for the trades settling via CLS. Once the shorts are covered, FX trades settle and then CLS re-cycles the funds to the FI’s nostros. The “fund-to-plan” view will be counting on receiving these funds. CLS is almost infallibly reliable. Members make their payments, trades settle, and long positions are paid out. The cash manager can expect that what was planned will actually happen.

Unanticipated payment needs

During the day, there will also be some same-day payment needs, which were not part of any fund-to-plan numbers. CCPs, central counterparts, are the likely source of these demands. Variation Margin (VM), i.e. the mark-to market on open positions is the regular cause. VM demands need to be met intra-day. These lead to a “timed payment”, i.e. one which needs to be made by a certain time rather than just anytime on value date. In uncleared derivatives there will also be bi-lateral payments with trading counterparts. These are driven by something called UMR, Uncleared Margin Rules. In simple terms, if you don’t settle via a CCP you still have to calculate and exchange

margin with many of those counterparts. From a cash management perspective all forms of margin are essentially a “surprise” for the cash manager. You know it’s going to happen, you can do some guesstimating, but when it comes, you must get the money moved and quickly.

Real-time liquidity management.

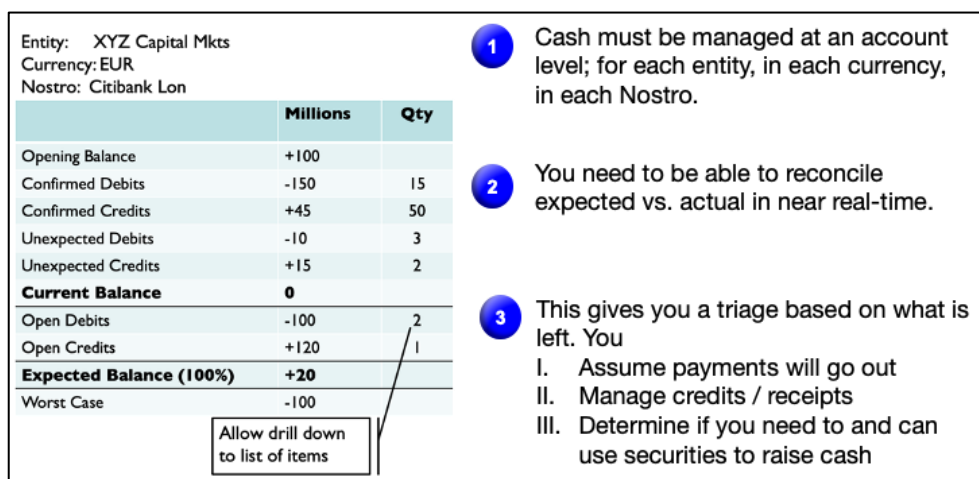
As the day progresses, a cash manager will want to be able to switch from “fund-to-plan” to “fund-to-actual”, in other words to adjust to what has or hasn’t happened. This is what we refer to as real-time liquidity management. To do this properly requires a number of tools or inputs. The first is actual input; you need intra-day status messages both for payments and securities trades. Then you need some software to help you match those messages about what has happened to what you expected would happen. Figure shows an illustration of what a helpful picture might look like.

The cash manager has to have an eye on both cash and securities related accounts and activity. For example, if securities trades are unsettled, the cash manager needs a view from the securities settlement team whether trades may yet settle. Perhaps securities can be borrowed to make deliveries? Or there is an expectation that a large buy trade will settle, and a long balance of cash now will be used.

Recall that there are lots of entities and lots of accounts to manage. As soon as there are multiple nostros involved, cut-off times play a role; different banks have different practices. Another “degree of difficulty” is the corporate structure. Which entity can lend to or borrow from which other entities is another set of rules which need to be understood and followed.

Overall, these complexities means that the tools need to give a clear view and quickly guide the cash manager to the exceptions which need attention.

Figure A1: Expected vs. Actual – an ideal view



Managing any anticipated end of day funds mismatch

At this point in the day, payments and securities start to interact. If there is not enough cash in the payment system, then the next line of defence is the repo market, either with market counterparts or the central bank. That requires eligible collateral. Eligibility is a function of quality; HQLA is the operative term. High Quality Liquid Assets. Assets

are considered to be HQLA if they can be easily and immediately converted into cash at little or no loss of value. Holdings of HQLA are what enables a bank to satisfy a key metric imposed by the Basel Capital Regulations; LCR, the Liquidity Coverage ratio, requiring expected short-term outflows to be backed by HQLA. So, FIs will have HQLA, and other securities collateral. So, the cash manager needs an answer to the question: “what have we got, where is it and what is it worth?”

Importantly it was at this point in the day that a substantial subset of the UK pension fund industry tripped up in late 2022. They had outsized margin demands and were unable to mobilise collateral in short order. In summary: a lack of operational capabilities.

If the projections indicate there will be excess funds, the cash manager needs to decide what to do with those funds. Domestically, leaving large balances in a payment system overnight is not ideal, as quite often balances are not interest-bearing. Leaving long balances with a commercial bank involves credit risk and is something which is actively avoided. A standard approach is to make an overnight investment in a money market fund or to do a reverse repo. In both cases, this mitigates credit risk but adds to the challenges of liquidity management, because the cash manager does not know exactly when those funds will come back in tomorrow. And again, any one currency is separate from all the others. If you are long EUR at the close of business in Europe and need USD, there is no way to exchange what you have for what you need without taking settlement risk. You are reliant on any USD collateral you have or on the intraday overdraft from the nostro.

Visibility of incoming flows. Typically, in a payments system there is no visibility of incoming payments. Kahn & Roberds (2003) correctly observed that this is a significant constraint. The typical flow is illustrated in **Error! Reference source not found.** of Section 2. Inside a Financial Institution (FI), As a general rule, FIs do not pass on information about expected to their nostro provider (B) or, if they are direct participants, to the Payment System (C). This is because it is information that cannot be acted on in any risk-free manner.

Reliance on intra-day credit. Typically, nostro providers grant intra-day credit or overdrafts (see below, especially Figure A2). This is a driver of intraday liquidity buffer assessments for both credit taker and credit giver. The credit check process at the nostro (3) is key, it governs what flows downstream and how much intra-day credit is used.

Regulation. In wholesale banking, there are specific regulations which result in a need to hold liquidity buffers generally, as well as buffers specific to intraday liquidity management. General liquidity buffers are set by the Basel III Pillar 1 requirements.⁴⁷ Additional intraday liquidity requirements fall under Pillar 2 of Basel and are dictated by a subjective assessment by the national prudential regulators following the guidelines set out in the Basel committee document. The buffers are intended to

⁴⁷ The Basel capital guidance developed since the global financial crisis requires banks to hold High Quality Liquid Assets (HQLA). HQLA are “cash or assets that can be converted into cash quickly through sales (or by being pledged as collateral) with no significant loss of value” (Financial Stability Institute, 2018). The quantum is dictated by two key ratios: the short-term focussed Liquidity Coverage Ratio (LCR) and the longer-term focussed Net Stable Funding Ratio (NSFR).

underpin and support each bank's ability to support day-to-day operations: settling all trades and making all payments.

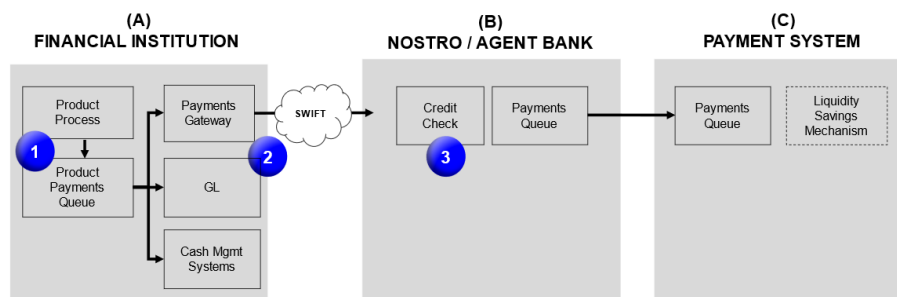
From the established practice set out in the PFMI, we know what good looks like⁴⁸ "Principle 9: Money settlements" states:

"An FMI should conduct its money settlements in central bank money where practical and available. If central bank money is not used, an FMI should minimise and strictly control the credit and liquidity risk arising from the use of commercial bank money."

One other vital quality of settlement is also needed: settlement finality. This means that the settlement process cannot be reversed through subsequent court order: what's done is done. Whatever systems or FMI we do use with tokenised payments, each system needs the formal legal designation of operating with settlement finality.

Intraday credit and 'throttling'. Cash managers have also had to concern themselves with pro-actively managing their intraday positions. Intraday credit is a major ingredient of liquidity. Figure A2 illustrates the usual payment flow involved in nostro payments. A payment need emerges from the product process (Point 1), which is then instructed through the payment gateway (Point 2), and subject to credit cheques by the nostro (Point 3), the payment is added to the payments queue in the payments system; then when the payment is settled through a reduction in the nostro credit balance or an increase intra-day nostro overdraft.

Figure A2 – The usual payment flow for nostro funding



Key Points

1. The product processes control the creation of payment and receipt instructions.
2. Only at the Payments Gateway is there visibility of those payments in the cash management systems. Some institutions are "throttling" payments here.
3. The credit check process at the Nostro is key, it governs what flows downstream and how much intra-day credit is used

1

If an FI is overdrawn during the day with its nostro it is using credit and the nostro is giving credit. Post the Lehman collapse and the global financial crisis (GFC) which followed, regulators recognised that liquidity is the lifeblood of financial services. and they have become more prescriptive about operational liquidity requirements. National regulations have their origins in guidance from the Basel Committee on Banking

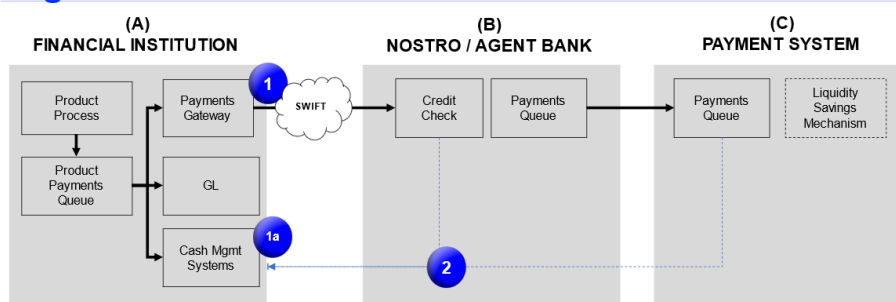
⁴⁸ (Committee on Payment and Settlement Systems. & International Organization of Securities Commissions. Technical Committee., 2012)

Standards (BCBS) and their BCBS 248 guidelines “Monitoring tools for intraday liquidity management (BCBS, 2013). This subjects banks to some quantitative reporting on credit given, credit taken & available liquidity. In addition, there are also qualitative requirements concerning operational capabilities, in other words the tools to measure and manage intraday positions.

At some point during the day, there will be a formal funding of foreign currency requirements for the next day. In simple terms, if a Euro based bank expects to be short USD tomorrow, then today its funding desk, normally via its G10 FX traders, will do a Tom/Next swap of EUR vs. USD. In other words, borrowing USD with EUR as collateral for tomorrow with a commitment to return the USD the following day. The cash manager would see these trades reflected in the expected balances for the next day.

One tool that is now often used to manage intra-day nostro overdrafts is payment control, which is sometimes referred to as throttling (see Figure A3). Under the current guidelines, some FIs now seek to throttle the payments upstream in their own systems (Point 2), with the aim of not relying on the intraday overdrafts from the nostro (Point 3). Once the FI uses any form of throttling, it needs to be actively managed. Overall, the BCBS 248 guidelines lead to the banks having to hold an intraday liquidity buffer. This is estimated at between 10 and 30% of overall buffers. A large bank may have overall buffers of USD 100 billion. The 30 G-SIBs, the world’s largest banks, have an average of USD 235 billion in liquidity buffers. So intraday positions are a very significant influence on the size and cost of those buffers. In the short-term, intra-day buffers are fixed, like the insurance premium for driving your car. Periodically, the intra-day metrics and operational capabilities are assessed by the regulator. Too much usage or giving of credit will lead to increased buffers, as will a view that operational capabilities are inadequate. To continue the car analogy, if you crash your car, the premium goes up. You then have to drive safely for a period. Same when the assessment is negative; buffers go up and stay up. They are not dynamic. Your institution must prove to the regulator that performance over time has been better.

Figure A3 THROTTLING



1. Throttling means: the FI makes a conscious decision not to send a payment to the outside world, passing control to some flavour of “Cash Management System (CMS)” (1a).
2. Intraday messaging from Nostros or if the FI is a direct member, the Payment System, drives the release of further payments.
3. There are two reasons for caution with this approach:
 - a. It only works if a few FIs do it. If all do it, there is a stand -off.
 - b. There is a lot of OpRisk. Lots of messaging which could breakdown and by waiting, any reaction time in the event of an outage is reduced

A similar result can be achieved by asking the Nostro to limit the use of any intraday credit to a maximum amount.

Lessons

That is what is on the cash manager's plate today. On the horizon are more complications: T+1 securities settlement, increased use of instant payment systems, as well as changes brought about by tokenisation / FinTechs / defi.

Top of the wish list for cash managers would likely be:

1. *Tools to support real-time liquidity management.* There is a huge amount of data. The cash manager needs a view of both cash & securities. Turning the data into actionable information requires good tool sets. Cash managers need to be able to quickly assess whether what is happening is normal or not. That needs investment in operational capabilities.
2. *Avoid fragmentation.* As we had new systems and solutions, we need to avoid further fragmentation.
3. *Single Pool of Liquidity (SPool) / Inter-operability.* Nirvana for any cash manager would be to have just one pool of liquidity in each currency and to be able to connect that to any payment or settlement need. Most importantly to FX markets to be able to exchange what they have for what they need. This would simplify cash management and greatly reduce the liquidity costs.

Away from the day-to-day, there is always a question about the cost of liquidity and allocating those costs. It is not an over-simplification to say that as a rule front-office folks "simply assume money"; they agree trades, book them, assume they will settle and then enjoy the P&L. Cash managers mostly have to play the hand they are dealt. Allocating costs is perhaps the only weapon that can influence behaviour. The working assumption is that intraday liquidity buffers cost 100 bps: the spread between long-term and short-term funding rates. If a regular big bank has USD 100 billion in buffers and just 10% of that is for intraday, then on January 1 there are fixed costs for the year of USD 100 million. Just to support settlement. That makes the nirvana of a SPool worth striving for.

APPENDIX B – WHAT DOES ‘TOKENISATION’ MEAN?

There is a rapidly expanding research, policy and practitioner literature on tokenisation of financial and other assets. The catalyst for this interest has been the emergence of crypto assets and decentralized finance defi, as novel cryptographically secured financial assets and contracts held on permissionless blockchains without requiring the involvement of any financial intermediaries and supporting near real time settlement.

Discussion of these questions is hampered by imprecise language and lack of conceptual clarity. There has been extensive discussion of the costs and inefficiency of existing financial arrangements, together with assertions that these costs will be reduced by the adoption of the technologies underpinning blockchains and distributed ledgers with an associated decentralisation of financial transactions. In this context the term tokenisation is widely used as a shorthand for adoption of these technologies with the presumption that this can be a transformative cost reducing disruption of mainstream ‘centralised’ finance. Relatively little of this literature addresses the practical detail: exactly what form will this tokenisation take? How it will be adopted and implemented in practice, within the existing inherited framework of law, regulation and established business models in financial services?

This appendix examines different interpretations of what is meant by tokenisation in finance, in order to support the analysis provided in the paper.⁴⁹

The term token means different things to different people. In the historically long-established English usage the meaning is clear: a token is a low value representation of something else of higher value (in the table this is labelled as interpretation T1). In current fintech speak an entirely new meaning has emerged, referring to assets recorded and held on permissionless blockchains or permissioned distributed ledgers. But these databases vary hugely, so this is a source of confusion. This novel meaning of token can be made more precise, if it is defined as the ability to directly control and dispose of something of value, something which recording on a blockchain or distributed ledgers supports (in the table T2).

Table 1 relates these two meanings of token and tokenisation (T1, T2) to three underlying characteristics of the arrangements for holding and transferring monetary assets, across a number of examples of money and payments.

The first of these characteristics is whether the money or other asset is directly held, rather than being the liability of an intermediary with obligations to support withdrawal or transfer to another intermediary.

An example is that of a central bank money, whether in the form of central bank reserves or note issue. While any indirectly held money e.g. a commercial bank deposit or an e-money deposit, is tokenised in the sense T1, directly held central bank is not tokenised in this sense. Historically under metallic monetary standards, BoE notes under the pre-1914 classical gold standard tokens representing a claim on gold and were tokenised in the sense of T1.

⁴⁹ This appendix draws on recent and current work of the co-author (Milne, 2022, 2023, 2024).

The scenario analysis developed in Section 3 focuses on two forms of tokenisation (out of the seven in this table, numbers 2. And 7. highlighted in italics). These in our analysis offer the opportunity for employing tokenisation to address the challenges of intra-day and overnight liquidity management for financial market participants.

Does the owner have direct control over the asset, able to hold it securely without concern about risk of loss and with the ability to make final transfer to someone else, whether as a gift, as a payment for goods or services or for settlement of a debt?

Historically, prior to the computer age, such direct control was only possible when money was held as a physical object, whether a note or coin. It was not possible to exercise such direct control over money held as an account with a financial institution (whether indirectly with a commercial bank or directly at the central bank. Transfer relied instead on request-based access i.e. submitting a request for transfer to the banks' operating systems, whether through a written instruction, a cheque, or a verbal instruction, through a teller or call centre.

A key characteristic of modern computer based automatically processed monetary transactions is that the holder can now have a degree of direct control over money held as an account with a financial intermediary, e.g. a commercial bank deposit. Subject to limits on size and security checks, they dispose as they wish of their money by interacting directly with the bank's systems.

Money held with commercial banks can also take the form of Certificates of Deposit (CDs), which are fixed term deposits, with the investor or client still facing the credit risk of the issuing bank. In the wholesale markets, there is also widespread use of Commercial Paper (CP), a short-term funding instrument which is not deemed a security. Again, investors take the issuer risk of the bank. For more detail see Aquilana et al, 2023).

In the current usage of the term "tokenised deposit", something else is meant. The word 'token' has, with the emergence of blockchains and distributed ledgers, come to be associated with this second concept of direct control (T2). This is because, inherent to the design of these ledgers, is the ability of owners of assets held on them to directly execute transfers of their assets to other ledger participants. This impressive technical capability has though led to an all-too-common misperception. Much of the interest in blockchain and distribute ledger has rested on the impression that the direct control possible in blockchains and distributed ledgers relies on their operational decentralisation, with no central operator responsible for the execution of ledger operations. Advances in cryptographic and biometric security, and their application in for example application programming interfaces (APIs) means that there is no technical barrier to the same direct control being exercised on more conventional centralised ledgers. The choice between centralised and decentralised depends on other considerations – it may be less costly to build such direct control into existing centralised databases than create entirely new decentralised databases. On the other hand, decentralised databases may promote resilience and avoid the system being exposed to a single point of failure.

Table B1: The (many) different interpretations of tokenised money.

<u> Holding </u>	<u> Control </u>	<u> Law or code based </u>	<u> Token? “representing something else” (T1); AND/ OR “directly controlled” (T2). </u>	<u> Monetary Examples </u>
Direct holding	Physical possession	Law ‘thing in possession’	T2 and also T1 under gold standard; but not T1 under fiat	Bank notes, coins,
<i>Direct holding</i>	<i>Direct access</i>	<i>Law “thing in action”</i>	<i>Not T1, can be T2</i>	<i>Central bank reserves, CBDC</i>
Direct holding	Direct access	Code “controllable electronic asset”	T2 with anonymity; also, T1 in case of stablecoins	Crypto currencies, Stablecoins
Indirect holding	Request based	Law “thing in action”	T1 but not T2 in that a cheque or offline payment may bounce	Cheque, offline card payment
Indirect holdings	Integrated systems	Law “thing in action”	T1 and to a limited degree T2.	Bank deposit in faster payments
Indirect holding, fractionalised	Direct access	Law “thing in action”	T1 and also T2 for transfer amongst account holders with the issuer	Regulated liability network
<i>Indirect holding, 100% reserved</i>	<i>Direct access</i>	<i>Law “thing in action”</i>	<i>Yes. T1 and T2.</i>	<i>Finality Payment System (FnPS)</i>

This table elucidates the different meanings and forms of tokenisation. Of the seven different possibilities for tokenisation of monetary assets, our analysis of tokenisation and liquidity in capital markets focuses on just two: number 3 direct, law based monetary holdings with control by direct access (exemplified by wholesale CBDC) and number 7 direct, law based monetary holdings with control by direct access (exemplified by tokenised or ‘synthetic’ CBDC solutions such as RTGS Global or Finality’s Finality Payment System).

What limits the widespread availability of direct control for all forms of financial asset is simply the business case for the necessary support of investments in intermediary operating systems and industry infrastructure. Over time though this business case can be expected to be made. Indeed, the main purpose of the present paper is to develop the business case for making such investments to support direct, automated monetary transfer in capital market transactions.

The third column of Table B1 turns to the legal definitions of ownership of money under property law. Which of three possible concepts of legal ownership applies to the monetary asset and supports finality of payment? Is legal ownership based on:

1. *Possession*. Money as a “thing in possession”, this concept applies where the value is inherent in a physical object, including monetary instruments such as notes and coin;
2. *Legal obligations of a financial intermediary*. Money as a “thing in action”, where legal ownership rights have to be asserted through the obligations of the provider of the asset, this concept applies to account-based money such as commercial bank accounts, central bank reserves or e-money, but also to traded monetary instruments and collective investments such as money market instruments and money market mutual funds.
3. *Code-based control over an electronic record of value*, without requiring involvement of an intermediary. Money falling under the new legal concept, of a controlled electronic record, a concept that has emerged to deal with the challenging legal issues surrounding of legal ownership and transfer of cryptocurrencies, stablecoins and other assets held and transferred on permissionless blockchains.

The first two concepts of legal ownership are old, they can be traced back at least to the law of Classical Rome as summarised in the Justinian code. The third concept of legal ownership is new, it did not exist at all before the emergence of cryptocurrencies. It was unnecessary until the development of blockchain revealed the possibility of implementing ownership of financial or other assets held and transferred using ‘permissionless’ ledgers, i.e. entirely code-based with no operators responsible for controlling access to or ensuring accuracy of the ledger recording asset ownership and transfers. The possibility of such permissionless record keeping was the breakthrough of the 2008 Nakamoto Bitcoin whitepaper and code and is the key characteristics of the subsequent development of so-called decentralized finance (defi) without the involvement of any financial intermediaries. A new concept of legal ownership was required because these were neither physical objects that could be possessed nor accounts supported by the legal obligations of intermediaries.

Are assets such as cryptocurrencies that are held on permissionless blockchain tokens? Because their ownership is code-based they are directly controlled, i.e. they are tokens in the new sense T2, that of being directly controlled. They are not though usually tokens, in the original meaning of the word token, that of representing something else T1. The exception are stablecoins: these are code-based held on permissionless blockchains, but there is also a mechanism that seeks to maintain a stable value in terms of fiat currency, to date almost exclusively in terms of the US dollar. This mechanism can either be an intermediary buying and selling to maintain a peg, the most prominent examples being Tether Ltd supporting the peg for Tether and Circle supporting the peg for USD coins; or it can also be code based without an intermediary, so stable coins such as DAI directly supported by software in decentralised

finance. In addition to being tokens in these senses, assets held on permissionless assets are also exchanged 'pseudo-anonymously' i.e. identities of recipients are linked to public cryptographic keys not to real world identifies. In this way money transferred on permissionless blockchains reproduces the anonymity of exchange of notes and coin. This further feature, anonymous exchange, may have further encouraged the association of the blockchain based transfer with 'tokenisation'.

Some further points are worth making, that help support the analysis of the paper. An irony that the long-established standard English meaning of *token* T1 is something that represents something else, e.g. tokens at a casino representing real money, so casino tokens are by construction indirectly held liabilities (in this example of the casino). The fundamental characteristic of a directly held asset is that it is *not* a representation of something else. The recent association of directly held asset with 'tokenisation' seems to be because a directly held asset could be held on a distributed ledger, a possibility which has been extensively explored in experimentations with central bank digital currency, and hence are nowadays often but confusingly referred to as tokenised.

This third new but non-monetary application of the term 'tokenisation', which we can refer to as T3, meaning the representation of the ownership of a physical or illiquid financial asset on a blockchain has been applied in many contexts monetary and non-monetary. The usage is often aspirational, associated with the quite widely made claim that such tokenisation, can support a liquid market for the exchange of such tokenised claims, making hitherto illiquid assets liquid. While this may be possible, it is not relevant to the discussion of tokenisation of monetary assets, which are already liquid.

Reference can be made to an old distinction, which applied in the pre-computer age, between accepting a payment based on verifying an object (coin, bank note) and verifying the identity of a person, e.g. through a signature on a cheque presented for withdrawal or accepted. This distinction has broken down with the development of automated digital payments. Now, with some exceptions e.g. payment in physical notes and coins or using a personal cheque, what a payee is accepting is the arrangements of a payment scheme, i.e. a digital platform that supports the payment transaction whether bank, card or e-money based.

When a merchant is presented with a Visa or Mastercard payment, with online connectivity, their ability to accept the payment depends on them being able to access the payment platform, or to be assured of a guarantee by the payment scheme. In this latter case there is an element of accepting the object, a forged card has no guarantee, but a genuine stolen card does. So, this distinction, between verifying a payment instrument and verifying the payee is not relevant to our analysis.

APPENDIX C – LESSONS FROM DECENTRALISED FINANCE

This Appendix reviews some of the capabilities of decentralised finance or DeFi, explaining how it achieves ‘atomic trading and settlement’ and discussing potential application to mainstream financial markets.⁵⁰ DeFi avoids all use of intermediaries as transaction counterparties, thus implementing our proposed ‘direct holding’ for all defi assets. Instead, agreement to exchange assets such as cryptocurrencies and stable coins, held on open ‘permissionless’ blockchains, is made directly between defi participants. The supporting computer code are the defi protocols (consisting of a set ‘smart’ contracts, so called because there is no institutional involvement in contract execution) that only allow a trade when the assets are held ‘on chain’; and then complete an exchange through verification of the transaction on the supporting distributed ledger platform such as Ethereum, Solana or Tron (using a consensus mechanism to ensure consistency across the different instances of the ledger). Because the ledgers use open-source coding, defi assets are also what we have described as ‘directly accessible’. The main difference from mainstream finance is the degree of automation of settlement. As discussed in our main text, mainstream finance supports ‘atomic settlement’, in which the two sides of a transaction either PvP or DvP are settled together, as a single process. This however requires the two sides of transaction to source the necessary assets and money, before settlement takes place, so the settlement is delayed to e.g. T+2 instead of taking place in near-real time. defi, without intermediaries, achieves near real-time settlement through ‘atomic trading and settlement’, i.e. with trade agreement and subsequent transfers PvP or DvP all taking place as a single process, through verification on the supporting blockchain.

Defi protocols automate a wide range of further financial functions, built on the foundation of their atomic trading and settlement. These include (i) ‘decentralised exchanges’, where participants can earn a return (matching the order-book and dealer bid-ask spreads in mainstream finance) by providing liquidity pools, inventories of defi assets, that allow orders execution for other participants; (ii) financing protocols where crypto assets are used as collateral for automatically acquiring holdings of other crypto assets in order to conduct transactions (these are often referred to as ‘lending protocols’ but this is a little misleading because unlike conventional bank loans and bonds they cannot be secured on future income streams); and (iii) a wide range of ‘derivative’ contracts for conditional exchange depending on cryptocurrency prices or on real world data imported into the defi protocol from internet sources using so called ‘oracles’ Governance of defi is governance of the supporting protocols, with decision making involving defi users.

Only a minority of crypto asset exchanges takes place using defi protocols. Most crypto asset exchange is instead through centralised exchanges such as Binance, Coinbase and the failed FTX platforms, simplifying the exchange of crypto assets by offering a combined custody service and marketplace. The convenience of using these intermediaries comes though at the cost of exposing participants to counterparty risk because their assets and money are no longer directly held. While defi avoids any counterparty risk for participants there is still liquidity risk: in stressed market situation, the liquidity to support transactions in a crypto asset may vanish making the asset worthless. Moreover, the complex interconnections of defi protocols can then trigger systemic risk exposure for many participants. These possibilities were demonstrated by

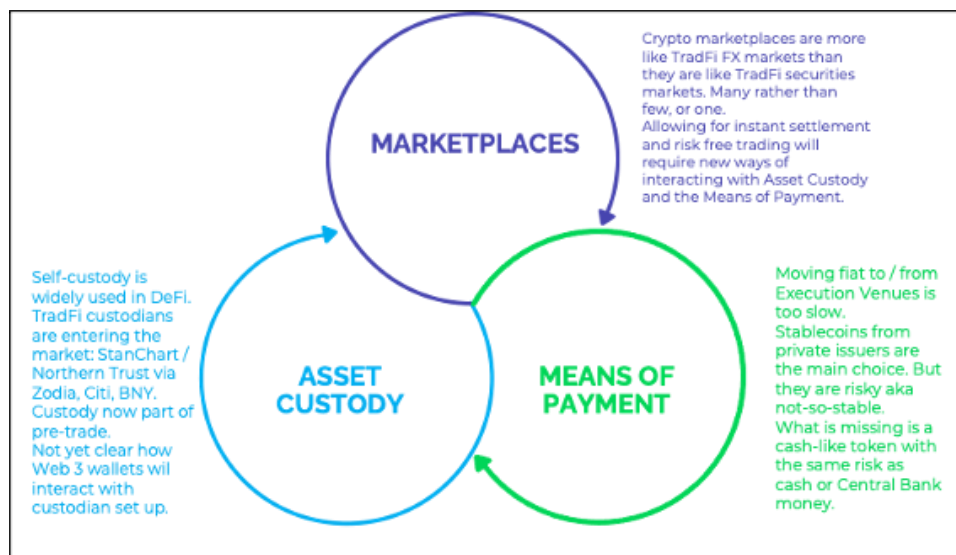
⁵⁰ For review of DeFi protocols see Schär, 2021; Auer et al., 2023.

as the failure of the decentralised stable coin Terra and its associated crypto token Luna in May 2022, during the crypto winter. The absence of intermediaries means that there is no capacity in defi for a lender of last resort as a defence against a market wide loss of liquidity. The need to retain both regulatory oversight and the possibility of providing public liquidity in a crisis argues in favour of retaining conventional intermediary based finance with deferred settlement, but where possible and appropriate using the atomic trading and settlement found in defi.

Can these DeFi capabilities help with supporting more efficient intraday and overnight cash management? One example supporting mainstream participation in crypto markets is technology from the US firm Fireblocks, who provide a secure platform for investors to participate in in the wide range of crypto and DeFi markets see <https://www.fireblocks.com/about/>. This technology allows its clients to earmark or block crypto positions before sending sell orders to crypto brokers or exchange. This is a valuable capability because it means that users / investors can hold their positions directly in their wallets and not have to trust exchanges and brokers to look after their assets without putting their hands in the client asset cookie jar. We know how that ended at FTX and other Crypto exchanges. More broadly in decentralised finance. Anybody who wants to send USDC to Olaf just needs to know Olaf’s wallet’s address. No more “send to UBS a/c Olaf”, just “send to Olaf”.

In our view we can have ‘the best of both worlds’: Defi and TradFI (Traditional Finance). Consider Figure C1, which illustrates the separation of asset custody, market places and means of payment. This separation or rather segregation, is what we already have today in TradFI. It is an essential element of investor protection and robust processes. A major shortcoming of the centralised exchanges used for much trading of crypto assets is that the marketplace, the asset custody and the payment arrangements are not separated as they should be.

Figure C1: The Holy Trinity



At the same time TradFI fails to provide the immediate transfer of ownership of assets and money, following a trade, that is achieved in both DeFi (with genuine atomic trading and settlement) and with trading of crypto assets in centralised assets (where trades are only

conditionally settled, dependent upon the continuing ability of the exchange to honour its obligations).

If we put those things together, what this suggests is that we can have atomic trading & settlement in mainstream finance where we need it. Orders are not matched and executed unless both parties have what they are exchanging, allowing instant settlement, as part of the trading process, without the requirement for separate clearing and settlement. This offers improvements on several levels:

1. No need for a CCP for trades which are atomically traded & settled. This can free up capital and avoids all need for margin.
2. Allows many-to-many connectivity. Consumers with USDC in their wallet could interact with any number of counterparties in many marketplaces or sell their asset to any of them.
3. Gives investors control over the assets in their wallet.

Atomic trading & settlement is actually the promise of new digital asset exchanges such as SDX, the SIX Digital Exchange. However, in the SDX case both the asset and the means of payment need to be on the same platform making SDX an island. At the time of writing, volumes at SDX are negligible.

Of course, there are some nuances and plenty of 'ifs' and 'what abouts' to consider. Let's unpick these changes, and the ifs and what abouts. Instant settlement is the most extremely contracted form of settlement. Many markets, the US equity market first, are moving to T+1 settlement. That shorter cycle has some impact on margin needs, but only slightly better and may be worse in the cross-border case (as discussed in Section 3.2).

If we take away the CCPs, brokers won't need capital to support membership and they won't have to pass those costs on by charging clients for that. Ultimately good for all investors, both retail and individual. To be clear there is still a need for transaction management when there is a transaction lifecycle to manage; for example, an OTC trade done with a future value date, or a repo or a derivatives transaction. Even if this trade is not centrally cleared through a CCP, then as we have argued, a warehouse can support the management of the required exchanges of money and assets.

Many to many connectivity is a plus too; an investor could use USDC to buy ETH or BTC without having to trust a broker or exchange. The assets are directly held by the holder using a wallet and the wallet is directly addressable. The trading and settlement system can simply ask "does Olaf have 100 shares of Apple in his wallet to fulfil for that order?" Very theoretically, you could do this today with an API and Open Banking. But not every bank will support that, and each bank might implement differently. And you want to earmark first and then complete if the order is executed. In a new tech vs. old tech battle, new tech would win that one in terms of ease of use.

Control is something worth having too. Imagine that today you have an account at Robin Hood and want to move to Charles Schwab. You have 29 different securities assets and a balance in USD in your account. Some of those holdings are domestic, some foreign, some are mutual funds and so on. Moving is difficult and far from instant, even if there is a solid process in the

US known as ACATS to support these things. Certainly, in Europe in late 2023, if you are moving your portfolio from Credit Suisse to another bank, and many are, the process takes about a month, is manual and error prone.

If everybody has their own wallet, then perhaps regulated Financial Institution (FIs) have a new role as wallet sponsors. They would take care of all things which are formally regulated; KYC, AML, CTF, Transaction Monitoring, Suspicious Activity Reporting. There would be no compulsion to have a sponsored wallet; however, we'd expect that moving between sponsored wallets would be much easier than to unsponsored wallets. And on-chain, analysis of movements is far easier than in the current TradFi world. Moving between FIs would become as simple as moving your mobile contract from one provider to another. Phone stays the same, number stays the same, apps stay the same. Sponsor in the background stays the same. Nobody you deal with has to change anything.

What about if people lose their smart phone and with it their wallet? If the wallet is sponsored by a regulated FI, we'd expect there was some back-up.

What about if somebody does not want to use USDC? This is where the story comes unstuck, at least a little. Very theoretically anybody wanting to use a marketplace could define what they will accept in payment; I'll take JPM Coin but not Citi. In practice this will not scale; if you have 100 USDC and 200 JPM Coin, you have 300 on your balance sheet but in practice you have two discrete pots of non-fungible money. You do not have what the BIS refer to as the "singleness of money". If you owe somebody 250 and they don't want or will not accept JPM Coin, you are out of luck. Doing an FX trade in advance will not work; you don't know up front who the seller is and what they might be willing to accept. How might we overcome this obstacle?

One possibility would be to introduce an FX mechanism that would allow an outright FX trade where one party could sell what they have vs. what the other needs. In the world of DeFi this would be an AMM, an automated market maker. The AMM would enable atomic trading and settlement of the two assets. Technically this would work, but it would have friction in terms of a trading spread. In a private sector marketplace, it is unlikely that somebody will provide the market and do the transformation for free. There is going to be a spread and that brings explicit costs.

Whilst DeFi does use blockchain technology, we would argue that it is not essential for the means of payment. Rather, it is the capabilities, which we have outlined in the main body of the paper, which are critical.

GLOSSARY

Term	Definition
Access rules	National rules which dictate which wholesale market participants may have a reserve account with the central bank in that country.
Atomic trading and settlement	<p>The simultaneous trading and settlement of a financial market transaction. Requires that the system or platform on which the trade is to take place can determine whether the buyer has the means to pay for what is being bought and the seller has the asset being sold.</p> <p>The expression means that either the trade and the settlement all happen, or nothing happens.</p> <p>A system operating on this basis needs to earmark funds before the execution. This ensures there is no double-spending, i.e. first promising the money and then doing something else with it.</p> <p>Aka pre-funding.</p>
Atomic settlement	This just means that either two things happen or neither happens. For example: in DvP securities are delivered (D) vs. the receipt of a payment (P)
Cash manager(s)	<p>Specialist in a wholesale banking institution who ensures that there is the right amount of currency in the right place at the right time to settle transactions and make payments.</p> <p>May sit in either an operations, or a treasury team.</p>
CBDC	See: Central bank digital currency
CCR	See: Credit & Counterpart Risk
Central bank	National bank, responsible for monetary policy, fiscal stability and ensuring that payment systems function.

Central bank digital currency (CBDC or wCBDC)	<p>Also called digital fiat currencies a digital currency issued by a central bank, rather than by a commercial bank.</p> <p>It is a liability of the central bank and denominated in the sovereign currency, as is the case with physical banknotes and coins.</p> <p>Typically divided into two types: retail or wholesale, hence wCBDC.</p> <p>It is not a Stablecoin.</p> <p>sCBDC is used to denote the equivalent but issued by the private sector, see: sCBDC</p>
Central Securities Depository (CSD)	A national body, also termed a financial market infrastructure, responsible for controlling public securities issuance, settlement and custody.
CFTC	See: Commodity Futures Trading Commission
Commodity Futures Trading Commission (CFTC)	A US regulator covering trading in commodities and futures. Specifically, it does not oversee securities or banking activity. See: https://www.cftc.gov
CHAPS	The UK real-time gross payment system.
CLS	See: Continuous Linked Settlement.
CLS Bank	The banking entity, based in the US, which operates the CLS system. See: Continuous Linked Settlement.
Continuous Linked Settlement (CLS)	Financial market utility owned by the banks that provides settlement services for FX trades. See: http://www.cls-group.com
Credit & Counterpart Risk (CCR)	A bi-lateral view of risk. Could be negative or positive. If you buy Apple Shares from a counterpart, and the price goes up, you have CCR vs. them. If the price goes down, they have CCR with you.
Credit Giver	The institution giving either intra-day, overnight or term credit to the credit taker. Typical usage: a Nostro gives its client an intra-day overdraft. Former is the giver; latter is the taker. See: Credit taker.
Credit Risk	One of the three major risk functions. Deals with the risk relating to counterparts and clients. The losses that would be incurred if the client went bankrupt. This is always a unilateral view; what if something happens to them / the other party, e.g. they do not repay a loan. See also: Credit & Counterpart Risk (CCR)

Credit Taker	<p>The institution receiving either intra-day, overnight or term credit to the credit taker.</p> <p>Typical usage: a Nostro gives its client an intra-day overdraft. Former is the giver; latter is the taker.</p> <p>See Credit giver.</p>
CSD	<p>Central Securities Depository.</p> <p>Each country will have a national institution responsible for custody and settlement of publicly traded securities in its country. It has an international equivalent, the iCSD.</p>
Debit Cap	<p>An intra-day credit facility provided by the Federal Reserve to its participants. Is tied to the capital of the participant. It is un-collateralised. Other facilities are available on a collateralised basis.</p> <p>see: https://www.federalreserve.gov/paymentsystems/psr_overview.htm See also: intra-day repo facility</p>
Decentralised Finance (DeFi)	<p>Decentralized finance (DeFi) is an emerging financial technology based on secure distributed ledgers similar to those used by cryptocurrencies.</p>
DeFi	<p>See: Decentralised Finance</p>
Delivery vs. Payment (DvP or DVP)	<p>In wholesale banking is specific to the settlement of securities transactions vs. an amount of money in a currency.</p> <p>Normally takes place via a CSD, or an iCSD</p>
Directly addressable	<p>The accounts holding settlement assets, both money or securities, can be directly addressed by the settlement system, in order to reserve or earmark funds required for settlement and then subsequently co-ordinate the transfer of money and assets, thus ensuring PVP or DVP. This in turn can facilitate near instant settlement and can serve as a building block for intraday liquidity markets.</p>
Directly held	<p>Settlement money is held directly by financial intermediaries, not as a nostro account with a commercial bank. These settlement assets could be central bank liability such as a wholesale CBDC or a 100% reserved private money. Settlement money is one in which transfer supports legally final settlement, there is no requirement for an intermediary to itself source liquidity to complete payment.</p>
Direct Settlement	<p>Settlement via an account held directly with a central bank, with a payment system, or an international settlement system such as CLS Bank or Euroclear.</p> <p>See: Indirect Settlement.</p>
Distributed Ledger(s)	<p>A record keeping mechanism where there are multiple, but synchronised, copies of a specific set of records.</p>

Distributed Ledger Technology (DLT)	The technology underpinning Distributed Ledgers.
Depository Trust & Clearing Corp	The United States CSD. See:
Designated payment system	A sub-set of all payment systems. The label “designated” means that the government has said that transactions made on that system are subject to local rules on settlement finality and cannot be reversed, unwound or voided by the courts.
DTCC	See: Depository Trust & Clearing Corp
DVP or DvP	See: Delivery vs. Payment
E-money	Balances in a system operated by a licensed e-money operator. Those balances are normally over-collateralised, for example an operator might be required to have 103% of its deposits in assets, in other words it needs 3% of its own capital to support the activity. Note the difference to fractional reserve banking.
Financial Stability Board	The Financial Stability Board is an international body that monitors and makes recommendations about the global financial system. See: https://www.fsb.org
Finteum	Technology company developing trading solutions to support intra-day liquidity management. https://finteum.com/
Finality	See: Finality International
Finality International	Technology company developing solutions to support payments. Finality started operations in December 2023 with the Sterling Finality Payment System (£FnPS). It is a designated payment system. See: See also: Designated payment system.
Foreign Exchange (FX)	The exchange of one currency for another.
Foreign Exchange Swap (FX Swap)	The exchange of one currency for another with a commitment to unwind or reverse the trade at a fixed date in the future. Typically used by a financial institution to fund its commitments by exchanging what it has in one currency for what it needs in another.
ForexClear	An FX clearing service operated by LCH.Clearnet.
Fractionally reserved	The practice in commercial banking where those banks are not required to have all their liabilities to clients backed by reserves at the central bank. In simple terms, if you have a balance of 100, your bank lends out 90 and keeps 10 in reserves.

Fragmented fragmentation /	In this paper, used specifically to refer to the need for wholesale market participants to hold money and securities in various places or systems.
FSB	See: Financial Stability Board
Funding to plan	Managing your funding for a given day on the assumption that all trades will settle, all payments will be made and all incoming money will be received. See: Funding to actual.
Funding to actual	Managing your funding for a given day on the assumption based on determining what has happened vs. what was planned to happen. See: Funding to plan.
FX	See: Foreign Exchange.
FX Global Code	A set of global principles of good practice in the foreign exchange market. See: https://www.globalfx.org/fx_global_code.htm
FX Swap	See: Foreign Exchange Swap.
G20 / G-20	A group of Finance Ministers and Central Bank Governors from the 20 major economies. Aka: the G-20, G20, and Group of Twenty. This was the forum in which many of the principals for the regulations being in forced in the in the 2010's as a response to the Great Financial Crisis were agreed. One might think of it as the Board level, where the BCBS, the Basel Committee on Banking Supervision, is the executive arm; actually, translating direction into principles. See: https://www.g20.org
General Clearing Member (GCM)	A member of a CCP or Clearinghouse with direct access, which settles its own transactions and those of other members or non-members. See also DCM, Direct Clearing Member.
Global Financial Crisis (GFC)	Financial crisis 2007 to 2008 and beyond, immediately pre and post the collapse of Lehman Brothers. See: http://en.wikipedia.org/wiki/Financial_crisis_of_2007-08
GFC	See: Global Financial Crisis
G-SIB	See: Globally Systemically Important Bank

Globally Systemically Important Bank	<p>A designation given by the Financial Stability Board (FSB) to the world's largest banks.</p> <p>At the end of 2023 there were 30 of them, still counting Credit Suisse and UBS as two different entities.</p> <p>See: https://www.fsb.org/wp-content/uploads/P231121.pdf</p>
HQLA	<p>Important element of liquidity management. New regulatory requirements set forth certain ratios that the banks have to confirm to, with HQLA being the type of asset the banks need to do this.</p> <p>Assets are considered to be HQLA if they can be easily and immediately converted into cash at little or no loss of value.</p> <p>See: https://www.bis.org/basel_framework/chapter/LCR/30.htm</p>
HQLAx	<p>A financial technology firm leveraging DLT to provide services in wholesale banking.</p> <p>See: https://www.hqla-x.com</p>
iCSD	<p>See: International Central Securities Depository.</p>
Indirect Settlement	<p>Using a Nostro or custodian.</p> <p>See: Direct settlement.</p>
Initial Margin (IM)	<p>This is a form of collateral normally taken by CCP's or Clearinghouses from members. This is an amount to protect the CCP in the event of a default, if in order to close positions there are trading losses. This is essentially the market risk. CCP's use complex scenario analysis to work out the worst-case loss over a 10-year period.</p>
IM	<p>See: Initial Margin</p>
Interoperable	<p>See: Interoperability</p>
Interoperability	<p>The ability of one system to interoperate with another.</p> <p>Specifically in the paper we cite the existing example in the TradFi world where in Switzerland the securities settlement system (SIS) is interoperable with the payment system or RTGS (SIC). The former uses money from the latter to enable DvP settlement of securities trades.</p>
International Central Securities Depository (iCSD)	<p>This is the international equivalent of a CSD. It is a securities depository capable of dealing with securities in more than one currency. Euroclear, Clearstream and SIX Securities.</p>
Intra-day	<p>Something which happens or is done during the day.</p>

<p>Intra-day credit (lines)</p>	<p>An overdraft granted by a bank to its customer or client for use during the business day. Typically, clients cover this credit as they receive incoming funds during the day.</p> <p>Typically, these facilities are “unadvised and uncommitted”; the Nostro does not tell the client what the limit is and makes no commitment to allow it on any given day. By avoiding the commitment, the Nostro or Credit Giver, does not need to back this with capital.</p>
<p>Intra-day liquidity buffers</p>	<p>These are a requirement imposed by regulators to make sure that banks can settle trades and make payments.</p> <p>They are part of “Basel Pillar II”; a subjective assessment of a bank’s operational capabilities, use or taking of intra-day credit, as well as giving intra-day credit.</p> <p>Buffers are held in the form of High-Quality Liquid Assets (HQLA)</p>
<p>Intra-day overdraft</p>	<p>Same as intra-day credit.</p>
<p>Intra-day repo facility</p>	<p>A repo where both the near and the far legs are settled today. Used to help cash or liquidity management.</p>
<p>Joint Oversight</p>	<p>This is a concept from the CPMI, the Committee on Payments & Market Infrastructure.</p> <p>It is specifically used when the activities of a particular FMI, a financial market infrastructure, in one country will have a significant effect on infrastructure in another.</p> <p>The requirements are part of the PFMI, the Principles for Financial Market Infrastructure.</p> <p>You might think of it like this. If I see financial market activity in my country which is driven by a wholesale market participant in your country, then I want some means of, or route to, being able to make the management team of that entity accountable for what I see them doing in my country.</p> <p>See: https://www.bis.org/cpmi/info_pfmi.htm</p>

JPM Coin	<p>A specific kind of account balance used by JP Morgan. Essentially a USD account balance which can be used on their new blockchain based payment system, Onyx.</p> <p>For accounting purposes balances in JPM Coin are the same as regular USD balances in an account at JP Morgan. They are both unsecured receivables.</p> <p>See: Onyx</p>
LCR	See: Liquidity coverage ratio
Legally settlement	final Settlement of a transaction with settlement finality
Legal finality	See: Settlement finality
Liquidity	Cash or securities which can be used to settle trades and make payments.
Liquidity buffers	Collection of assets held to meet Liquidity coverage ratio (LCR) and intra-day liquidity buffer requirements.
Liquidity coverage ratio	<p>A ratio set out by the Bank for International Settlements (BIS) dictating the minimum levels for short-term funding.</p> <p>Buffers are held in the form of High-Quality Liquid Assets (HQLA)</p> <p>See: https://www.bis.org/fsi/fsisummaries/nsfr.htm</p> <p>See also: Net stable funding requirement (NSFR)</p> <p>See also: High Quality Liquid Assets (HQLA)</p>
Liquidity Effect	The ability for a Nostro / Correspondent bank to settle a payment or securities transaction as a book transfer; if both the paying FI and the receiving FI use the same bank, the transfer is internalised as a simple debit and credit. No liquidity is needed.
Liquidity Risk	The risk that an institution will have insufficient funds to meet its financial obligations as and when expected, although it may be able to do so in the future.
Margin Call	<p>A call by either a Clearing House / CCP or a counterparty to provide either or both of Initial or Variation Margin.</p> <p>See: Initial Margin.</p> <p>See also: Variation Margin.</p>
Market Risk	The risk of losses on financial investments caused by adverse price movements. These might: changes in the price of a security or commodity, interest rate moves or changes in the FX prices.

Messaging	<p>An electronic, structured message. FIX or Swift / ISO20022 messages would be examples from TradFi. the Secure Asset Transfer Protocol (SATP) would be a digital asset or DeFi example.</p> <p>Simply a structured communication from System A to system B: “Please carry out this instruction for me” or “Here is a status update on your transaction”.</p>
Narrow bank	A bank with a regular banking license which by statute does not lend money or give credit and has 100% of its customers’ cash deposits held in reserve either with a central bank or a Nostro.
National Securities Clearing Corp (NSCC)	The CCP for US equity clearing & settlement. Part of the Depository Trust & Clearing Corp (DTCC), the US CSD. See: Depository Trust & Clearing Corp.
NDF	See: Non-Deliverable Forward
Net stable funding requirement	A ratio set out by the Bank for International Settlements (BIS) dictating the minimum levels for long-term funding. See: https://www.bis.org/fsi/fsisummaries/nsfr.htm See also: Liquidity Coverage Ratio (LCR)
Non-Deliverable Forward	An instrument in the FX asset class. A derivative where a currency that is not deliverable is traded versus one that is. For example, KRW / USD. Korean Won vs. US Dollars. The Korean Won is not deliverable. The instrument is settled on a cash basis, with the actual market rate being compared to the contractual rate.
Nostro	An account held with a commercial bank by a wholesale market participant.
NSCC	See: National Securities Clearing Corp.
NSFR	See: Net stable funding requirement
Omnibus account	An account in which assets are held collectively. If in their accounts at Goldman Sachs Hans has 10 shares of Apple and Greti has 20 shares, then Goldman will have a client omnibus account with 30 shares in it.
Onyx	New digital payments system inside JP Morgan. Uses JPM Coin to represent balances in the system.
Option(s)	A contract which gives a party the right but not the obligation to require its counterpart to do something pre-determined either at fixed date in the future (European Style option) or up to but not later than a fixed point in the future (US or American style option)
Pooling Effect	Pooling occurs when the nostro can take advantage of its customers’ incoming flows to cover its own or other customers’ outgoing flows.

Private proprietary money	Any form of balance in a privately operated system which can only be transferred to other participants in the same system. Both Finality and JPM Coin are examples of new means of payment. A balance in a JP Morgan account or Citi account is also private proprietary money,
Programmable money	Money balances held on a system which enables those balances to interact with third party systems. This might be: Pay USD W to Party X if System X says that condition Z has been met. For example, flight delay insurance. An external system X determines a specific flight was more than 2 hours late and pays USD W to Party X.
Real-Time Gross Settlement (RTGS)	Normally used to describe a payments system where funds are transferred in real time. SIC, Swiss Interbank Clearing was the first in 1987. The Fedwire is the US equivalent and Target is the Euro equivalent.
Regulated Liability Network (RLN)	The Regulated Liability Network is a potential new payment system which is in development at the time of writing (Q1 2024) See: https://regulatedliabilitynetwork.org
Repo	See: Repurchase Agreement See also: Reverse Repo
Repository	Another word for warehouse. Specifically not used in this document because the term is mostly used to refer to the trade repositories mandated by US (Dodd Frank) and European (EMIR) regulations.
Repurchase Agreement	A re-purchase agreement means you sell something today and simultaneously agree to buy it back in the future. Imagine your trader thinks German bonds will go up in price. He buys 1mm bonds at 100.0, for €1'000'000. He wants the bank to pay for them. At that point your bank balance is -€1mm. If the bank enters a repo, then it might be given €950'000 for the bonds if it promises to repurchase them back in, say, 3 months. The reason it receives less cash is that the cash giver has allowed for a "haircut" or "margin", allowing for changes in the bond price. The second party to a repo is executing a reverse-repo.
Reverse Repo	See: Reverse re-purchase agreement
Reverse re-purchase agreement (Reverse Repo)	A reverse re-purchase agreement means you buy something today and simultaneously agree to buy it sell in the future.
RLN	See: The Regulated Liability Network

RTGS	See: Real-Time Gross Settlement
RTGS.global	Technology provider building the global infrastructure for a next-generation Financial Market Infrastructure (FMI) designed to solve the liquidity and risk challenges. See: https://www.rtgs.global
Run Risk	Risk that in a crisis money will run in a particular direction. In the banking crisis of early 2023, money ran from the likes of Silicon Valley Bank (SVB) and Credit Suisse (CS)
sCBDC	Synthetic CBDC (see: Central bank digital currency). The synthetic refers to a private system which is 100% backed by reserves held with a central bank. See: Fnality is an example.
Settlement Finality	Settlement of a transaction, either a payment, a DvP delivery of securities vs. payment or PvP, payment vs. payment in a manner which cannot be unwound or reversed by the courts. Typically, local laws require that the system providing the settlement or payment service be designated by a government body, e.g. Treasury or Central Bank, and as such deemed to operate under the local settlement finality law.
Singleness of money	With singleness of money, there is an unambiguous unit of account that underpins all economic transactions in society. See: https://www.bis.org/publ/bisbull73.pdf
Single Pool(s) of Liquidity (SPool(s))	A currency balance in a system which is sufficiently interoperable with other systems in the ecosystem that the currency balance can be used for any combination of P, a one-way payment, PvP, settlement of an FX trade, or DvP, settlement of securities on a delivery vs. payment basis.
SPool / SPool(s)	See: Single Pool(s) of Liquidity
Systemic risk	Risk of contagion across a whole system. In the world of financial services, this is used to refer to both domestic and global risks. For example, when Credit Suisse was taken over by UBS, the regulators were concerned about global systemic risk.
T+1 / T+2 / T+X	Refers to when settlement or value date is for transaction, i.e. the date on which the parties must meet their contractual obligation. Often expressed as T + 'something', with something being a number of business days. T+2 is normal for equities. That 2-day gap is due to be shortened in 2024. The terms T1, T2 are also used.

Throttle	Refers to the practice of systematically delaying the flow of payment instructions to a payment system or to a Nostro.
Tiering	This is the result of Access Rules. If only some institutions may have a reserve account with the central bank, then those who may not need to buy a Nostro or correspondent banking service from one of those who can. See: Access rules
Timed Payment	A payment which needs to be made no later than a specific time on specific date. Widely used with meeting the funding requirements at CLS Bank and for margin calls to CCPs.
Timed Obligation	See: Timed Payment.
Tokenisation	Used inconsistently, most often refers to the holding and transfer of financial assets on decentralised blockchains or distributed ledgers. One finding from our analysis is that technological implementation is less important than the functionality offered by the technology. While decentralised blockchains / distributed ledgers are possible technologies which might be employed to implement our proposal for improved intra-day liquidity management, the outcomes we explore could also be achieved using more conventional centrally operated databases.
Tokenised	See: Tokenisation
Tokenised money	In this paper, tokenised money means money in a form that overcomes the current challenges of intra-day liquidity management.
TradFi	See: Traditional Finance.
Traditional Finance (TradFi)	All the incumbent, old or legacy financial services infrastructure, viewed from a 2024 perspective. Specifically, not the things which are DLT, Blockchain, DeFi, FinTech, Web 3.0.
Un-cleared derivatives	Bi-lateral derivative transactions which cannot be cleared & settled via a CCP. Generally, this occurs when two parties transact something which is some combination of too exotic, not actively traded. There are specific collateral rules for these types of transactions.
USDC	See: USD Circle
USD Coin	USD Coin is a digital stablecoin pegged to the United States dollar. USD Coin is managed by Circle. USDC is issued by a private entity and should not be confused with a central bank digital currency. Circle holds the invested funds in both cash and securities. There is an argument to say it is money market mutual fund. See: https://www.circle.com/en/usdc

Value Date	<p>The date on which the parties to a transaction are required to settle / make their contractual obligations. Aka Settlement Date.</p> <p>Note value date does not mean that the event happened on that date. Often if settlement is delayed beyond value date, there are provisions for interest to be charged.</p>
Variation Margin (VM)	<p>This is the result of determining at a point in time who is winning and who is losing. Moving VM from the “loser” to the “winner” eliminates both market and credit risk.</p>
VM	<p>Most often associated with CCP’s and Clearinghouses. This is a mark-to-market amount that effectively collects winnings from the loser and passes them to the winner. It is a way of crystallizing the P&L. In a bi-lateral contract, the P&L is theoretical, because it has not been collected. In a cleared environment, the P&L is collected and paid on an on-going basis.</p>
(Web 3.0) Wallet(s)	<p>Digital wallets designed for interacting with Web3 applications, which are decentralized applications built on blockchain technology. They enable users to store and manage their digital assets, such as cryptocurrencies, NFTs, and other digital tokens.</p> <p>See: https://www.quicknode.com/guides/web3-fundamentals-security/basics-to-web3-wallets</p>
wCBDC	<p>See: Central bank digital currency</p>
Web 3.0	<p>Web 3.0 refers to the current iteration of the web, compared with the original Web 1.0 of the 1990s and early 2000s. Web 2.0 is the current version of the internet (a term often used interchangeably with web) with which we are all familiar, while Web 3.0 represents its next phase.</p> <p>See: https://www.investopedia.com/web-20-web-30-5208698</p>
Wholesale (banking) (market)	<p>Banking with / for institutions.</p> <p>Generally used to differentiate from retail banking.</p> <p>Definitions vary. Normally includes banks, non-bank financial institutions such as hedge funds and asset managers, financial market infrastructures, and corporates.</p>

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We hope that this paper will inspire debate and discussion. That is a necessary part of the evolution of our financial market infrastructure. We welcome any feedback.

Any remaining errors and lack of clarity is down to the authors.