



Banc Ceannais na hÉireann
Central Bank of Ireland
Eurosystem

Signed Article

Vol. 2026 No. 2



Contents

Abstract	3
1. Introduction	4
2. Payments and money: Defining terms	5
3. European clearing and settlement mechanisms	9
TARGET	9
EURO1.....	11
EBA clearing	12
4. Traditional payment methods	12
Commercial banking and the two-tier monetary model.....	13
Settlement of payments using bank deposits.....	14
Correspondent banking	16
E-Money.....	18
SEPA.....	20
Card networks	22
5. Blockchain	24
Single chain	24
Smart contracts	26
Tokens	28
Wallets and ownership.....	29
Multiple ledgers and interoperability.....	30
6. Blockchain-based payments	30
Stablecoins.....	30
Incorporating stablecoins into the financial system	39
Tokenised deposits and deposit tokens	42
7. Conclusions	44
Abbreviations	46
Glossary of Key Terms	47
References	50

Money and Payments Infrastructure: understanding the plumbing

Dr Rhys Bidder¹

Abstract

This article provides a comprehensive analysis of the infrastructure that underpins both traditional and emerging payment systems. It establishes a consistent framework for comparing different modes of settlement, distinguishing between public money (cash and reserves) and private money (bank deposits and stablecoins). The paper begins by describing traditional European infrastructure, focusing on the TARGET framework and the two-tier monetary model, where commercial bank deposits expand upon central bank reserves. It details how these traditional systems—including card networks and correspondent banking—ultimately rely on central bank money for final settlement. The paper then explores the disruption caused by blockchain technology and stablecoins, highlighting a fundamental difference: while traditional payments require coordinated interbank adjustments in reserves, stablecoins operate as bearer assets that settle directly on-chain without immediate recourse to central bank systems. Finally, the paper discusses the interaction of these frameworks and the modernization of the two-tier model through tokenized deposits and central bank-run DLT initiatives.

¹Central Bank of Ireland Research Affiliate. All opinions and all errors and omissions should be interpreted as those of the author and not those of the Central Bank of Ireland, the Eurosystem or Chainlink Labs. The author thanks - without implicating - Anne-Marie McKiernan, Gillian Phelan, Fergal McCann, Maria Elena Filippin, Rob Davis, and Mikela Trigilio for useful comments.

1. Introduction

The domain of payments has seen enormous innovation in recent years. Many of the changes are clearly observable to users, in the form of new products or cheaper services. However, many changes relate to systems that operate in the background – the “plumbing” for the movement of value. With the advent of new payment methods, such as stablecoins and tokenized deposits, it can be helpful to understand how (or if) their plumbing differs from those of traditional systems. This *Article* attempts to analyse the plumbing of payments in traditional and emerging systems – so that debates over different payment options can take place within a consistent framework.

Comparing different modes of settlement is at the heart of many current debates in payments. The advent of blockchains has raised difficult questions over the definition of settlement and what is, or should be, a settlement asset. As such, in the first section, we define terms and lay out some generic concepts. Having defined core aspects of clearing and settlement infrastructure in theory, in the second section, we lay out the real-world elements of payments infrastructure within the Eurosystem. We focus on the TARGET (Trans-European Automated Real-time Gross settlement Express Transfer) framework but also discuss other settlement and clearing systems.

We then discuss how various “traditional” payment methods rely on the structures previously defined and explain the two-tier monetary system, whereby bank deposits expand upon underlying narrow money created by central banks. This then allows us to delve into how banking rails underpin common forms of cross-border payments, within Europe, and globally. We then discuss card networks and e-money. All these traditional methods have long relied, directly or indirectly, on central bank systems and central bank money for ultimate settlement. That is, the “plumbing” leads back, in the end, to central banks.

Stablecoins make use of different plumbing. Typically, they operate on blockchains – many of which are public, permissionless systems beyond the control of governmental or central bank authority. This has important implications for the mode of settlement. A key point to be emphasised is that stablecoin-based payment methods do not directly rely on central bank money in RTGS (Real Time Gross Settlement) systems for secondary market use. Nevertheless, our focus will be on centralised collateralised stablecoins where for primary market (issuance and redemption) the RTGS system, or traditional banking rails based on it, may come into play. Other stablecoins are far more detached – in some cases completely – from traditional systems, even for their issuance and redemption.

While we use the term “stablecoin” throughout, this term may be interpreted very differently, depending on audience and the particular asset in question. Many would question whether describing these assets as “stable” is appropriate. Furthermore, in the European context, [MiCA](#) provides a more precise terminology (and definitions) for distinguishing certain assets that are sometimes referred to as stablecoins: [Electronic Money Tokens \(EMTs\) and Asset-Referenced Tokens \(ARTs\)](#). Nevertheless, for the level of detail adopted in this document, the term “stablecoin” is useful: it is succinct and, broadly speaking, aligns with common parlance across multiple jurisdictions and in academic literatures. Our use of this term, however, should not be

interpreted as an assertion that all digital assets that claim this moniker are, in fact, stable. The term encompasses a wide variety of digital assets with different types and degrees of risk to price stability, in normal times and under stress.

It is important to note that this document is intended to be *primarily* descriptive without taking a stance on the relative desirability of various payment rails and types of money. There are very active debates over these issues. This *Article* attempts to provide a *factual basis* for this debate and an introduction to the key issues, infrastructure and players.

2. Payments and money: Defining terms

We begin by informally defining some key terms that recur frequently in debates over payments. These definitions are by necessity simplified but provide a firm basis for our later discussions.

Clearing

After a financial transaction is initiated, it goes through the process of clearing, whereby counterparties and/or intermediate systems transmit, enrich, verify and reconcile the underlying information required for settlement to occur. As part of this process, there may also be netting of exposures – arising from the aggregation of multiple transactions between the counterparties. The clearing process may be arranged bilaterally, with the counterparties handling the various administrative steps and reconciling data with each other. However, in many cases clearing institutions will undertake these activities. For example, card networks will typically provide clearing services to member banks – notably ensuring that payee funds are available and perhaps also applying policies (such as anti-fraud checks) as part of the transaction enrichment process. As another example, for bank-to-bank payments that are less time critical, an *automated clearing house* will often be used to net and batch payments ready for later settlement.²

Settlement

From a simplified perspective, settlement of a transaction occurs when payment has been completed or, more generally, when assets have been exchanged between buyer and seller. In most of the contexts we consider, settlement occurs after clearing, although how long after will depend on the precise details of the clearing and settlement mechanism. One subtlety that should be considered is whether the settlement is legally final, as technical settlement (the settlement system has incremented accounts or records of ownership of the counterparties) may not align with the occurrence of legal settlement (after which the transaction becomes legally binding and irrevocable). In fact, technical settlement may precede or succeed legal settlement, depending on the counterparties involved – and the systems used – in various stages of a transaction. These issues become especially important in the blockchain context and also feature in some instant payment schemes, as will be discussed below.

² Somewhat confusingly the [ACH Network](#) in the United States is a *particular* example of an automated clearing house, administered by [NACHA](#), but the [automated clearing house concept](#) is more general.

Settlement assets and their risks

When people meet and exchange cash in a transaction, cash plays the role of a settlement asset. However, in Ireland (and other developed economies), most transactions feature some form of digital money as the settlement asset.

Cash is a bearer asset and legal tender, such that exchange of it is identified with final (and immediate) settlement. Central bank reserves (see below) are also commonly used as a settlement asset in transactions between banks, for example. In these cases, no risk arises from the nature of the settlement asset, *per se*.³ However, unlike cash, privately-issued digital monies may feature risks that could disrupt settlement and lead to further damage to the financial system and the economy. For example, credit risks may arise from the failure of the institution that provides the money, or liquidity risks may arise from the money fluctuating in value in a way that makes transactions less efficient or necessitates other costly mitigations to be put in place. Alternatively, an operational failure in a money issuer's systems could prevent settlement from occurring.

Central bank reserves

Central banks issue two types of money – cash, which all parties can hold (households, businesses, financial institutions etc.) and reserves, which are held by banks in accounts at the central bank.⁴ Both cash and reserves are legal tender – loosely meaning that the money cannot be refused as a means of extinguishing a debt – but only cash is available to households and firms.⁵ Reserves are in nominal terms the safest and most liquid of all money assets. It is the safest because a central bank that can issue money essentially cannot default (it can issue money to pay any debt – even if this has severe consequences for price stability). It is the most liquid because it is legal tender and defines the unit of account – so that it always transacts at par and settlement between banks is instantaneously final when settled in reserves. Traditionally, central bank reserves in [fiat](#) systems are regarded as the benchmark settlement asset, with no risks associated with them. For a thorough discussion of the role of reserves in payments, see [CPSS \(2003\)](#).

Real Time Gross Settlement (RTGS)

Most countries, or collections of countries within a currency zone, rely on a central bank(s) to administer systems to settle payments between financial institutions. Key among these are real time gross settlement (RTGS) systems which rely upon commercial banks' reserve accounts with the central bank. When a bank, say Bank A, is to make a payment to another bank, say Bank B, then Bank A's reserve account will be debited, and Bank B's reserve account credited, by the appropriate amount. In real time gross settlement systems, this occurs immediately, for

³ There are other risks in any physical exchange – such as theft or physical violence, but these are not intrinsic to the money being used, even if they may be more likely in those contexts.

⁴ [Some jurisdictions](#) allow non-banks to join the systems (often payment service providers, CSDs and government fiscal accounts). However, banks are the principal account holders in any simple model of reserve systems.

⁵ Of course, typically other forms of money are frequently used to transact – notably bank deposits – but this *per se* does not mean that they are legal tender. For interesting FAQs on cash in Ireland and for the Eurosystem's cash strategy, see [here](#) and [here](#).

each transaction – there is no bundling and netting out of multiple transactions or delays in settling (for example, to end of day).⁶ In recent decades most prominent central bank systems have adopted the RTGS approach, as opposed to a deferred net settlement model, which is now regarded as unacceptably risky for the largest value and most systemically important payment systems.⁷ A key point to note is that settlement in central bank money is typically taken to imply ultimate legal finality of settlement.

Note that the liquidity of reserves as an *asset* does not automatically mean that the reserves *system* for settlement is the most “liquid” in a broader sense of enabling the efficient and high throughput of transactions. Traditionally they have been – but there are multiple components to RTGS schemes beyond the settlement *asset* alone, and these can influence the liquidity characteristics of the *system*. If they entail frictions, then the system’s liquidity may in turn be adversely affected.

Liquidity facilities and collateral

Central bank reserve systems eliminate many risks by enabling ultimate settlement in a money (reserves) that is free of liquidity or credit risk. However, clearly this assumes that banks have enough reserves to settle at all. It could be that towards the end of a day a bank has an unexpected outflow of deposits (leading it to owe another bank a payment in reserves). This could perhaps coincide with overall market stress that makes other banks reluctant to lend reserves or even with an operational failure of their internal systems – making the bank unable to settle its dues by end of day. In this example, central banks will typically lend reserves to such a bank, allowing settlement to occur. In the absence of such liquidity backstops banks would presumably hold inefficiently large buffers of reserves, reducing the risk of these problems arising – though there may remain a risk that they are caught short.

Central banks differ in their precise operating procedures and which facilities they offer ([Arseneau et al \(2025\)](#)). They are frequently paired with other infrastructure such as liquidity savings mechanisms, to further enable smooth functioning of the interbank market and, by extension, the broader financial markets and economy. Traditionally, these facilities have been used primarily by banks, but in recent years – particularly since the Global Financial Crisis – facilities have been set up by various central banks to serve non-banks, thus broadening access.

Liquidity facilities are invariably secured by collateral, where the type of collateral is closely restricted, and where haircuts will typically be applied. In addition, penalty rates may be applied to the borrowings. For an insightful discussion of many of these issues see [Fisher \(2012\)](#) but some of the core debates go back to the classic [Bagehot](#) dictums of lending freely and against good collateral in times where liquidity is scarce.

⁶ Though some transactions sent through these systems already reflect netting of retail and small business payments, say, that have occurred “during the day”, and which have been handled by clearing systems. With the spread of instant payments systems (such as [TIPS](#)) increasing shares of retail/small value payments are being settled in RTGS, effectively transaction by transaction.

⁷ Nevertheless, net settlement systems do appear within the broader payments infrastructure of most economies – particularly where liquidity is to be economised (netting can dramatically reduce the magnitude of reserves required to settle a given set of transactions) and where safety is somewhat less of a concern.

Public vs private money

In modern economies, a large majority of transactions use bank deposits as money, rather than cash. Although deposits are denominated in euro, they are not, in fact, euros in the way that cash is. A euro coin or banknote is public money in the sense that it is issued by the central bank and, as is typical for such monies, it is taken as the unit of account in the economy, so that other goods and assets are denominated in it.⁸ Bank deposits are denominated in euros in the same way that many non-money assets are denominated in euros. And yet, we have come to think of 100 units of bank deposits at Bank A and 100 units of bank deposits at bank B as equivalent to 100 euros – because a unit of each bank’s money is valued at a 1:1 exchange rate with cash, reserves and – if it is issued – a digital euro. As such, 100 units of bank A’s deposits have the value of 100 euros (or 20 five-euro notes): €100.

Later in this document we will discuss how this comes about, but the main point to note is that much of the money we use is private money – issued by banks. If one were to go to an ATM and withdraw cash, we are converting our private money (bank deposits) into public money. Other examples of private money are popular e-monies such as balances with PayPal and, in some peoples’ eyes, stablecoins. These assets may be used as monies – but are not issued by the central bank.

Singleness of money

“Singleness of money” is less a property of money, than of a set of monies. It is commonly defined in the most literal of ways – that every asset being used as money in an economy should trade at a 1:1 exchange rate with each other, or “at par”. The unit of account in a country can reasonably be taken to be the unit of central bank issued money, so this is typically a question of how private monies trade in relation to the face value of cash and central bank reserves.

Traditionally, money is defined as an asset that plays three “classic” roles: a unit of account, a store of value and a medium of exchange. There can be variation in how effective an asset is in any one of these dimensions. Of course, if it fails dramatically to satisfy any of these properties then perhaps it is unnatural to think of the asset as money.

Whether a money trades at par is not a fundamental property of money in the sense that the “classic” features are broadly accepted as being. However, it is a widespread and desirable property of the monies we use for much of the time – that is, commercial bank deposits, cash and (for financial institutions) reserves. An asset can be a money even if it does not satisfy singleness always and everywhere but, all else equal, trading as close as possible to par is a desirable property – welfare losses and risks arise from exchange rate volatility. We will revisit this concept when we discuss stablecoins.

⁸ One could equivalently say that a unit of reserves is the unit of account, since the central bank maintains a 1:1 exchange rate with cash between a Euro coin and a unit of reserves. Note that central banks typically operate a domestic “fixed exchange rate regime” where different denominations of public money (5 Euro notes, 10 Euro notes...) are always aligned in terms of the value of a given number of units of that money (see [Andolfatto \(2015\)](#)).

3. European clearing and settlement mechanisms

The core of European settlement systems is the [TARGET](#) framework, operated by the [Eurosystem](#). In one way or another, almost all traditional digital payments rely (directly or indirectly) on ultimate settlement in central bank money through TARGET. The system comprises a variety of sub-systems, which we discuss, and is at the heart of unifying and enhancing European payments and many other aspects of the financial system and economy. While this section focuses primarily on TARGET, we also then go on to discuss the [EURO1](#) settlement system, which also handles a non-trivial (but far less than TARGET) share of settlement. As we shall see, however, it also relies on TARGET in important ways.

TARGET

The Trans-European Automated Real-time Gross settlement Express Transfer system (TARGET) is the principal settlement system for the Eurosystem. It comprises four key services: T2, TARGET Instant Payment Settlement (TIPS), TARGET2 Securities (T2S), and the Eurosystem Collateral Management System (ECMS).

These services are overlaid with a [shared Central Liquidity Management \(CLM\)](#) system, through which participants may interact with a National Central Bank (NCB) and allocate liquidity across various activities in TARGET. The CLM functions via a Main Cash Account (MCA) held by participants with an NCB. The MCA is used to settle interactions with the NCB (such as receiving lent funds from a monetary operation or from intraday credit). It can then be used to allocate liquidity to Dedicated Cash Accounts (DCA) used in the various TARGET services. As such, the MCA is the central point at which central bank provided liquidity enters the accounts of entities in the TARGET system

The ECMS consolidates collateral management for credit operations, replacing separate coordinated systems previously run by the NCBs. Here we focus on the other components: T2, TIPS and T2S.

T2

[T2](#) is the Eurosystem's RTGS for wholesale payments in central bank money, related primarily to monetary policy operations and interbank transactions. It is intended to provide fast, certain and final settlement of payments throughout the eurozone. In 2023, 90% of transactions settled within 38 seconds and only around 0.1% took longer than 5 minutes (see [ECB \(2023\)](#)). It currently operates Monday to Friday and from 7am to 6pm CET.

It is worth noting that within the RTGS component of T2, there are also "Ancillary Service Technical Accounts" (ASTAs). Ancillary services are, for example, things like clearing houses and retail payment systems, that use TARGET for final settlement, possibly of netted positions. Funds flow between DCAs and ASTAs according to T2 participants' obligations arising from their activities in the ancillary services.

TIPS

TARGET Instant Payment Settlement ([TIPS](#)) is also a real-time gross settlement system. However, unlike T2 RTGS, it is 24/7/365 and designed to enable settlement in less than 9 seconds (and often faster – in fact 99% of payments are settled in less than 5 seconds). TIPS allows transactions to be settled immediately in central bank money, rather than being aggregated and netted during the day, and then ultimately settled within an overall transaction in T2.

TIPS' speed makes it a compliant mechanism under the SEPA Instant Credit Transfer framework (discussed later in this document). Participants use DCAs in TIPS to provide instant payments services for retail users (people and non-financial businesses). As such, it is a core element of the EU drive towards providing low cost, fast and reliable cross-border payments within Europe. As in T2, ancillary services also have technical accounts within TIPS.

Interestingly, while some institutions are direct participants (with DCAs), other institutions can participate indirectly in TIPS as a reachable party, by relying upon a direct participant with a DCA. Other institutions may interact with TIPS as instructing parties, acting on behalf of direct participants or reachable parties in administering the messages directing payments within TIPS. An example of such a party might be a clearing service that orchestrates settlement in TIPS on behalf of its members, who are direct participants or reachable parties.

T2S

Although our primary focus is on payments, [T2S](#) is still relevant, due to collateral operations in other more explicitly “payments-focused” parts of the TARGET system, T2 and TIPS.⁹ Performance of these payment systems can be enhanced with judicious provision of collateralised credit (from other banks or from the central bank(s)). Furthermore, as discussed in [ECB \(2024a\)](#) *monetary* operations implemented through repo, such as main refinancing operations, require an efficient collateral framework.

The ECMS framework, supporting CLM, coordinates with T2S to mobilize/demobilize eligible collateral, in appropriate amounts. Of course, the system is also key in safe settlement of securities for cash, according to a delivery-vs-payment (DVP) model. Participants will have securities accounts at approved Central Securities Depositories (CSDs) [connected to T2S](#). T2S links these accounts with DCAs, enabling the DvP pattern.

Messaging

Interaction with the TARGET system is achieved via the Eurosystem Single Market Infrastructure Gateway ([ESMIG](#)) via GUIs (Graphical user interface) and also programmatically. Overall, TARGET uses ISO20022 messaging standards (discussed later in our section on correspondent banking) and the messaging solutions include [SWIFT](#) (also discussed later), but

⁹ Distinct from credit facilities in T2, T2S implements an [auto-collateralisation](#) service that economises on liquidity required to execute transactions, by providing intraday credit as required, where the purchaser's DCA does not have enough funds at the point of the transaction.

also [NEXI/COLT](#). In anticipation of our discussion of blockchain-based payments, it is worth noting that in TARGET the message is separate to the underlying transaction.

Access

Traditionally, it has essentially only been bank payment service providers (PSPs) who were permitted to have MCA/DCA accounts within TARGET. However, non-bank payment service providers (NB-PSPs) have [recently been granted access to the system](#), though with the restriction that funds in these accounts be held during the day solely for the purpose of allowing settlement of payments (rather than for storage of value or custody).

Given the rapid emergence of new players in payments, outside the traditional banking domain, this reform is of particular importance. Key justifications for the expanded access have been described as: “*enhancing the efficiency of the European retail payments market, fostering competition and innovation in the European payments landscape, and supporting the uptake of instant payments in the European Union*” ([ECB 2024b](#)).

EURO1

EURO1 is a cross-Europe privately-run settlement system operated by EBA Clearing. In a sense, it is an alternative to TARGET, but with features designed for settling high value payments between banks, at somewhat lower frequency (same day) than T2. The lower frequency, higher value and participant profile of EURO1 are all related: it is because banks have such a need for large value settlement, while still needing to economize on liquidity, that a real time gross settlement approach is not taken. The immense liquidity demands of gross settlement are such that a (highly optimized) net settlement system is instead adopted.

Of course, one of the main downsides of a naively implemented net settlement system is that it entails settlement risks. This is mitigated in EURO1 in various ways. First, despite being a net settlement system, settlement is immediately legally final – rendering EURO1 “RTGS-equivalent” in some respects.¹⁰ Payments are processed immediately, even if the full technical settlement sequence is not complete until end-of-day, when final net positions for each participant (which are defined in relation to the system, rather than with respect to particular counterparties – a [Single Obligation Structure](#)) are settled in TARGET (in T2 RTGS). As such, while the system is ostensibly private, it still relies in an important respect on the safety of central bank money. Second, reflecting its designation as a Systemically Important Payment System (SIPS) there is [demanding oversight](#) and regulation applied to EURO1 and its participants. Third, EURO1 implements a system of caps/limits, combined with payments into a [liquidity pool](#) held as deposits with the ECB, to mitigate exposure to a participant failing with an outstanding position before end of day settlement in reserves.

Notably, EURO1 uses SWIFT messaging, in line with ISO20022. This is consistent with TARGET and thus promotes harmonized payments processes within Europe. It also provides enhanced

¹⁰ Another example of an ostensibly “instant” settlement system that relies on a deferred net settlement system is the UK’s [Faster Payments Service](#) which (relying on the Settlement Finality Directive) gives end users the effect and legal safety of immediate settlement, even though the full settlement process does not immediately complete (relying on net settlement cycles over the day).

resilience in being an alternative rail for RTGS-equivalent settlement for some types of payments, in case TARGET were to ever experience difficulties.

EBA clearing

EURO1 is part of the suite of clearing and settlement mechanisms run by [EBA Clearing](#). These are key in underpinning many of the pan-European payment rails we will consider. Other than EURO1, most of the remaining systems run by EBA Clearing are concerned with SEPA payments – be they the core Credit Transfers (SCT), Direct Debit (SDD) and B2B Direct Debit, or instant credit transfers (SCT Inst).¹¹ Aside from the pan-European systems provided by EBA clearing, various national systems that handle SEPA-compliant transactions may also be used, such as CORE in France or RPS in Germany. Here we focus on the pan-European schemes.

STEP2-T

[STEP2-T](#) comprises the various EBA Clearing systems associated with SCT, SDD and SDD and is itself overseen as a Systemically Important Payment System. As a pan-European ACH, it allows credit institutions and approved payment institutions (PIs) or electronic money institutions (EMIs) to reach each other within the network, along with many other institutions indirectly connected to the system via a member. To be a member, it is necessary to have an account in TARGET (or access via an institution that has a TARGET account) and to adhere to SEPA rulebooks in its offerings of payments services to its customers and counterparties.

The system provides state-of-the-art [clearing services](#), including various netting, scheduling and liquidity saving mechanisms. It also provides (through the STEP2 SCT service) some [anti-fraud monitoring](#) for SEPA payments and adheres to elaborate [resilience standards](#), as befits a SIPS. In plugging into TARGET and EURO1, it allows continuous gross settlement of cleared payments.

RT1

[RT1](#) is the EBA Clearing system associated with instant payments or, specifically, SCT Inst.¹² Settlement in this case will ultimately be through TIPS (or possibly through an ASTA associated with RT1) and, as such, the various elements of the clearing process are typically faster even than in STEP2 – typically completing in somewhat over one second. Naturally, in line with the requirements of SCT Inst, the system runs 24/7/365.

4. Traditional payment methods

We use the term “traditional” in a very particular sense, here in the context of discussing digital money and payments. We don’t necessarily mean that the systems are “old” – many are

¹¹ EBA clearing also run [STEP1](#) which is a system that plugs into EURO1, to allow smaller financial institutions to access the same sort of framework that EURO1 offers, though with tighter constraints on net positions (reflecting, in part, less demanding membership requirements) and with ultimate access to T2 settlement only available indirectly, via a EURO1 participant.

¹² The system also deals with international credit transfers where the Euro leg is processed instantly – so called One-Leg-Out Instant Credit Transfers ([OCT Inst](#)).

undergoing enormous upgrades and modernisation and are highly advanced technically. Loosely, we mean it to refer to payments system paradigms that preceded the advent of distributed ledger technology. As we shall discuss later, many of the core precepts of these systems and the pivotal role of central bank money in fact can be preserved within frameworks using novel distributed ledger paradigms.

Commercial banking and the two-tier monetary model

We previously defined and discussed central bank reserves, the difference between private and public money, and the RTGS system in which banks can transact in reserves with each other, and with the central bank.¹³ The central bank controls the *total* amount of reserves, aggregating across all reserve account holders, while the distribution across banks is largely outside its control, resulting as it does from interbank transactions and interbank borrowing/lending of reserves.¹⁴

Typically (and in the Eurosystem) banks are required to satisfy minimum reserve requirements in the sense that they must have a minimum fraction of their assets held in the form of reserves (as opposed to corporate loans, mortgages, securities and so forth). At times, and in some countries, there have been calls for a “narrow banking” system, where banks are essentially required to hold 100% of their assets as reserves (or extremely safe short-term assets – such as high grade and liquid sovereign debt). More typically, economies feature “fractional” banking systems where only a fraction (less than 100%) of banks’ assets need be held in reserves. Banks can still choose to hold more than the minimum reserves (and often do – particularly in recent years), but they are not obliged to do so.

An old-fashioned model of banking would envisage depositors (households or firms) bringing funds from outside the banking system, leaving them with the bank – with the right to demand their money back at any time – which are then used by the bank to finance investments. A more modern view sees the activity of lending by banks as the source of deposit creation (see [Bank of England \(2014\)](#), for example). A bank makes a loan to a firm or a household and in so doing credits their deposit account, while simultaneously creating an offsetting asset (the loan) that balances the balance sheet. Regardless of which paradigm applies, deposits are created without being fully backed by reserves. Instead, they are backed (in large part) by loans, and possibly other, more complex, types of asset – of varying credit and liquidity risk.

Implicit in these processes is the creation of money circulating in the economy (outside the interbank system). A certain amount of reserves is initially created by the central bank. In a narrow banking system, banks then create a different form of money (bank deposits) of equal value. In contrast, in a fractional banking system, banks create money more than one-for-one with reserves: the “extra” money is backed by other (less liquid) assets. These assets can typically be sold rapidly only at a discount, in contrast to the immediacy with which banks promise to redeem at par deposits that a customer wishes to withdraw into cash, or into

¹³ Within the Eurosystem, national central banks may transact with banks in their own jurisdiction.

¹⁴ In fact, the central bank controls the total amount of reserves and cash combined. Requests to exchange bank deposits for cash (leading to banks exchanging reserves for cash) may cause a small degree of randomness in the amount of reserves, in the absence of offsetting actions by the central bank.

another bank.¹⁵ This leads to important liquidity risks, that we will discuss further later in this note, but also credit risks in the sense that some bank assets – such as loans – will go bad, in a way that reserves cannot.

The creation of private money by commercial banks, distinct from public money, reflects what is typically referred to as the “two-tier” monetary model. The first tier is reserves and cash, and the second tier is bank-issued deposits.

This discussion should make clear how the reserves system is not only an interbank payment rail but is also intrinsically related to monetary policy implementation. In many jurisdictions (and most macroeconomics textbooks) open market operations entail outright purchases and sales of assets from/to the private sector – in the first instance, from banks. These transactions are effected by the central bank using reserve accounts. A purchase with reserves (created by the central bank for this purpose) increases the supply of reserves among banks, while sales reduce the supply of reserves among banks. In the Eurosystem, reserves are injected by the central bank by secured lending operations, as well as outright purchases, as described in [ECB \(2025\)](#).¹⁶

The actions of the ECB and the response of commercial banks ultimately affect how much money circulates within the broader economy and influences interest rates. Thus, monetary policy is transmitted to households and firms, influencing inflation and activity (hopefully) according to the ECB’s intent. How *predictable* is the pass through of interest rates and the creation of private money by banks is another matter. Central banks are constantly assessing how the passthrough of their policy decisions may vary over time, depending on the state of banks and the wider economy.

Settlement of payments using bank deposits

Suppose Aoife and Brian both have accounts with bank A. Suppose also that Aoife wishes to buy a vase worth €30 from Brian using her deposits with bank A. In this case settlement only requires bank A to deduct 30 units from Aoife’s account and increment Brian’s account by 30 units. There is no need for any auxiliary settlement in an RTGS system as the transaction can settle immediately on bank A’s balance sheet. This model of settlement is typically called “on us” settlement as the single bank with whom both counterparties have an account can complete settlement on their own books.¹⁷

Now suppose instead that Aoife has an account with Bank A and Brian has an account at Bank B. Assuming clearing and settlement occur correctly, Bank A will debit Aoife’s account by 30 units and Bank B will credit Brian’s account by 30 units. That is, Aoife will now have a nice new vase but will have 30 fewer units of Bank A money. In contrast, Brian no longer has the item in stock but will have 30 more units of Bank B money.

¹⁵ In this simplified discussion we abstract from any other non-money liabilities of banks, such as bonds.

¹⁶ The use of main and longer-term refinancing operations is one reason why the TARGET systems requires such an efficient collateral framework.

¹⁷ Note this “on us” settlement also occurs in the case of closed loop transactions enabled by e-money providers discussed later.

Has the settlement process completed at this point? From the perspective of Aoife and Brian, the answer is essentially “yes”, but there are some important subtleties at play. First, the [Settlement Finality Directive](#) ensures that the settlement is legally final for the two of them regardless of any ongoing settlement activity *between the two banks* (which could conceivably be disrupted by a bankruptcy). However, the broader settlement *process* has not yet completed until the banks have squared away their respective obligations.

Bank A has deducted money from Aoife’s account and Bank B has given Brian more money. This cannot be the end of the story as Bank B has lost out, while Bank A has gained. The banks are not the ultimate counterparties in the purchase of the vase – those would be Aoife and Brian, of course. The banks are simply enabling the payments. Ultimately, Bank A must make a payment to Bank B so that Bank A’s liabilities (deposits) and assets (reserves) decline by equal amounts, and Bank B’s liabilities and reserves increase by equal amounts – leaving their net positions unchanged.¹⁸ This payment is made in *reserves* between the two banks in the central bank-run RTGS system.¹⁹

Note that our phrasing is careful here. In normal times, we think of Bank A money and Bank B money as just “money” – essentially the same as cash, or any other form of money used within Ireland. This reflects the fact that they maintain a 1:1 exchange rate with cash, such that 30 units of Bank A (or Bank B) money has the value of €30. To be even more careful, we note that Brian does not receive any of Aoife’s Bank A money – he receives more of Bank B money. This contrasts with what would happen if they were using cash, where Aoife and Brian are using a common money. Banks create their monies (deposits), and “payment” with bank money entails a coordinated set of changes on different ledgers – Bank A’s, Bank B’s and the central bank’s.

In fact, while we chose to use a familiar retail transaction as the basis for our example, interbank settlement of this sort is typically regarded as defining final settlement in a broad array of financial transactions – particularly those where large value payments and wholesale finance are at play.

Let us briefly return to the example where both Brian and Aoife banked with the same bank. In this case, clearly, there is no need for any interbank activity. As such, final settlement would have been instant at the point where Aoife and Brian had their accounts debited and credited by Bank A. As we shall discuss later, the concept of a “closed system” within a given financial institution is key in understanding e-money providers’ business models and how some systems can deliver rapid and low-cost settlement – by avoiding additional settlement steps and overhead that arise from interfacing with outside systems.

¹⁸ This simple example assumes that both banks have reserve accounts, which might not be the case for small banks in some countries who may hold accounts within a larger bank that does have a reserve account, and which can settle some interbank transactions on their own balance sheet. Additionally, note that there may well be netting at some point (perhaps if the transaction is initiated with a debit card payment and thus netted and cleared within the card network) though in other systems, as in the case of instant bank-to-bank payments, transactions will be gross settled immediately.

¹⁹ We abstract here from the possibility that smaller institutions may use accounts with larger banks, in which case settlement could occur on the balance sheets of those larger institutions.

Correspondent banking

In the example from the previous section, we implicitly envisaged the counterparties (Aoife and Brian) banking within the same national banking system, or perhaps even with the same bank within that system. In fact, many transactions are cross border. Merchants and companies may produce a good in Country 1 for purchase by people or firms in Country 2, where the banking systems are distinct.

Of course, many of our transactions take this form – and for good reason. The ability to make international payments quickly, safely and cheaply is an important component of thriving international trade – allowing wider choices of products for consumers, better risk sharing opportunities, deeper trade links, and greater ability of people from underprivileged countries working in the developed world to send remittances home to their families.

One of the most used rails for such payments is known as the “correspondent banking” approach. In this section we will briefly discuss the basics of the model, touching also on the widely used SWIFT messaging protocol. We then discuss some of its problems and ongoing work to ameliorate them.

Traditional model

We will begin by sketching the most basic example necessary to understand correspondent banking (see [here](#) and [BIS \(2024\)](#) for more elaborate examples). Suppose Hank is based in the USA, banks with US-based Bank H and wants to make a payment in USD to Aoife, who banks with Bank A within the Eurosystem. Let us assume that Aoife has a business that sells goods or services, invoiced in USD, to American firms or citizens. The banks, in the first instance, do not have access to the payments infrastructure of the Eurosystem (in H’s case) or the USA (in A’s case). Notably, Hank cannot make a direct USD payment through the Eurosystem’s TARGET infrastructure.

Now, suppose Bank A opens an account with Bank H. This account, from A’s perspective is known as a *nostro* account, while from Bank H’s perspective it is known as a *vostro* account. Bank H in this situation is a *correspondent bank*. Now that A has this account, it has indirect access (via H) to the US payments system. Hank can now make a payment in USD to Aoife, whereby his account with Bank H is debited, while Bank A’s *nostro* account is credited. Bank A then credits Aoife’s account by the appropriate value. We could envisage Aoife having a USD-denominated account with Bank A (a Eurodollar account, in effect) or, if her account is euro-denominated there would of course need to be a currency conversion. We ignore (important) issues regarding exchange rates and fees at this point. Of course, we could envisage a similar relationship whereby Bank H has an account with Bank A, such that the operation is possible in reverse.

SWIFT

An important player in international payments is the Society for Worldwide Interbank Financial Telecommunication or [SWIFT](#). SWIFT is a messaging protocol that is widely used to convey the information necessary to enable domestic and cross border payments involving banks. At the outset, it is important to note that SWIFT does not implement settlement. It does

not “move money”. Instead, it conveys information required for settlement – acting as an orchestrator, in some sense. In this model, *the message isn’t money*.

Banks within the SWIFT network are assigned a SWIFT code (also commonly referred to as a Bank Identifier Code (BIC)).²⁰ This then allows payment messages to be directed to appropriate institutions within the network. Membership of SWIFT has traditionally been regarded as necessary to participate fully in the international financial system and, as such, exclusion from SWIFT has been used as a form of sanction against some nation states – to make payments via their banking rails prohibitively difficult.

Internationally, SWIFT messages are routed to various intermediary bank institutions, as part of the correspondent banking chain. Significant [fees](#) may be involved in this process and, even more problematically, they can be unknown at the point of initiating a transaction. As the payment progresses, perhaps through an unpredictable number of correspondent banking relationships, fees of varying amounts may be deducted by the intermediaries.

One can indicate in the payment message whether fees should be paid by the sender, recipient or somehow shared (determining whether the recipient receives the notional amount, reduced by the fees, or whether the sender finds that more than the notional amount has been deducted from her account). Regardless of who pays, the actual amount paid is somewhat random, which additionally may make reconciliation of received and invoice amounts difficult between the ultimate counterparties. Implicit fees may also arise from disadvantageous exchange rates used by banks at various points in the payment chain, especially if less developed countries with less liquid currencies and less competitive banking systems feature in the transaction.

Reforms and enhancements

Correspondent banking has traditionally played a key role in cross border payments. However, the system is regarded as ripe for improvement. Not all banks provide correspondent banking services as it typically requires expensive infrastructure in multiple countries, operational sophistication and familiarity with local regulations. Simply put, it is not practical to have bilateral relationships among all pairs of banks throughout the world. As such, payments made via the correspondent banking system typically go through chains of intermediary banks, with possibly different correspondents being used to bridge across multiple jurisdictions.

As noted in [BIS \(2024\)](#), at each stage of the correspondent banking chain, there may be various information processing and regulatory checks, ideally automated but frequently not.

Traditionally, the process has been slow, opaque and costly due to the number of ([fee-charging](#)) parties involved, a lack of automation, and conflicting operating hours. Payments between institutions in prominent countries may reach their destinations very rapidly ([SWIFT \(2024\)](#)). However, on less frequented routes, the process can be much slower. Furthermore, processing

²⁰ There is a very minor distinction between SWIFT codes and BICs. If an institution has a SWIFT code, then that code is also a BIC. A BIC, however, can be obtained by a company that is not a bank in the SWIFT network. It follows the same format however, according to the ISO 9362 standard (as suggested by the BIC and SWIFT code being equivalent for SWIFT members). An IBAN, which is commonly used in Europe and the Middle East additionally will contain information on a particular account to which a payment is to be made, and is [distinct from SWIFT codes](#), though may be used in conjunction with them.

after the final bank in the chain receives the payment message can also add substantially to delays before ultimate settlement.

Market power enjoyed by some correspondent banks likely also contributes to costs and messaging formats have, until recently, been limited in the data they can carry – making compliance and fraud detection difficult without costly manual work. Furthermore, in recent years there has been a retreat by correspondent banks from many emerging market jurisdictions, apparently owing to compliance costs and declining risk appetite ([Rice et al \(2020\)](#), [Everington \(2023\)](#)). As such, making payments to and from many emerging developing and emerging economies can be difficult and expensive.

Mitigating such problems have been an important component of the [G20 Cross-border Payments Roadmap](#), the progress on which is well summarized in [Panetta \(2025\)](#). Two key reforms are the rollout of ISO 20022 and the introduction of SWIFT GPI.

[ISO 20022](#) is typically referred to as a messaging standard, though formally it is better thought of as a recipe for messaging standards. Schemas for important use cases can be developed that take advantage of the greater richness and complexity of messaging that ISO 20022 allows (see schemas published by the BoE for CHAPS and other systems [here](#)). Larger, as well as more structured, messages can be used, carrying more information for automated compliance and administrative actions, enabling a greater degree of straight-through-processing and greater harmonization of approaches at different stages in the correspondent banking chain ([SWIFT \(2019\)](#)). The wide and continued adoption of ISO 20022 is playing an important role in improving the traditional correspondent banking systems (and other financial market infrastructure).

[SWIFT GPI](#) (SGPI) is designed to enhance the traditional SWIFT systems in four key dimensions ([BIS \(2022\)](#)): increasing the speed of settlement (aiming for within one day – but in many cases a matter of minutes), improving the visibility of the transaction status (with real time monitoring of the payments at each stage), enhancing transparency on fees (they are still set by banks but the idea is that more information and clarity helps promote competition), and ensuring remittance information remains stable through the whole process (so the reason for the payment and other metadata persist through the steps, reducing the likelihood of failed compliance and difficulties in reconciliation across ledgers, and promoting consistent automation). In operation since 2017, SGPI enables final settlement within a matter of minutes in the case of core payment paths, such as between Europe and North America. However, settlement can be much slower when they involve counterparties in less developed countries – though much of this delay occurs after the payment instruction has reached the ultimate beneficiary's bank. This may reflect the higher prevalence of capital controls (with additional compliance steps) and less sophisticated processing technology.

E-Money

In recent years, people and businesses have become familiar with e-money providers, such as PayPal and some issuers of pre-paid cards. Early use cases revolved around P2P payments within the e-money provider's network. That is, for counterparties both with accounts with the e-money provider, one party could send the other a payment, and this would settle essentially

immediately as the provider would simply adjust the counterparties' balances in their proprietary ledger. Increasingly, these systems can also be used to send payments to counterparties outside the e-money network and receive payments to an account in the network from someone outside the network. Many of us have become used to seeing e-money as an option to pay within online transaction flows (such as buying from an on-line retailer).

When a user joins the network, they will typically do so by funding their e-money account from a commercial bank account (distinguishing this approach from credit, for example). The e-money provider will hold these funds in segregated bank account(s) and credit the user with the equivalent sum in their e-money account. As such, e-money providers do not expand the overall money supply under this funding approach. However, they do, in effect, create an equivalent value of private money, matching the amount that was deposited with them.

Closed vs open loop settlement

Let us consider a situation where two counterparties both are within the e-money provider's network. In this case, the network can operate as a "closed loop" system, whereby all clearing and settlement can occur through the e-money provider's own infrastructure and accounts. As such, settlement can be effected and finalized rapidly since it only requires the e-money provider to debit and credit the relevant counterparty accounts on the e-money's balance sheet. This applies whether the counterparties are in the same country or currency zone, or whether they are making cross border payments. Of course, in the case of parties with accounts denominated in different currencies, some sort of currency conversion must be implemented.

If the e-money provider allows payments into or out of their members' accounts from or to external accounts (such as those at banks or at another e-money provider) then we refer to this as "open loop". In this case, they will make use of other rails we have discussed to enable the payment and to achieve settlement. For example, there may need to be a payment out of PayPal's bank account to an out of network merchant's bank account, via standard clearing networks, ultimately to be settled in central bank money.

If the payment requires international rails, then correspondent banking networks will typically be used, as previously discussed. That is, they may use chains of intermediaries, instructed through SWIFT messages. Indeed, the e-money provider may operate a network of its own accounts in banks in various countries to avoid using a chain of intermediaries.

When connecting counterparties where at least one is outside the e-money's network, the system operates according to an "open" format. Clearly, this allows a broader set of counterparties to be connected. However, it also entails reliance on clearing and settlement processes that may be slower and more expensive (at the point of transaction) than "on us" settlement solely on the balance sheet of the e-money provider.

The precise rails used by e-money providers to enable transactions are quite opaque and complex. Likely a large-scale e-money network would avail itself of multiple systems, depending on the local rails available in the jurisdiction or currency zone used by the

counterparties being connected. For example, they could make use of SEPA rails, instant payment systems, and various clearing house solutions.

For *ultimate* open loop settlement, e-money has traditionally relied upon central bank reserves, directly or indirectly. Nevertheless, there are hints that blockchain-based solutions – notably stablecoins – may provide an alternative. The most prominent e-money issuer, PayPal has issued its own stablecoin and e-money issuers can use other stablecoins to make open loop payments without touching the banking system or, indirectly, RTGS systems.²¹ Whether this approach will be adopted at scale is yet to be seen and would raise difficult policy issues around financial stability and market efficiency. Furthermore, solutions such as Wise have shown that existing correspondent banking rails can be used in innovative ways to lower costs for the end user.

Essentially, Wise localizes their service by setting up a presence in many different jurisdictions. Note that this is not a physical presence from the perspective of a user, but a matter of being able to operate a regulated financial business in the countries in question and have access to their local payment rails. As such, “international” payments are implemented via Wise’s transactions effected in local bank accounts in the sender and recipient’s countries, coordinated by Wise’s back-end ([Wise \(2024\)](#)). Wise will typically also establish partnerships with banks in various jurisdictions, and direct connections with countries’ instant payments systems, further accelerating settlement times ([Wise \(2016\)](#), [\(2025\)](#)). This consolidation of local chains of intermediary banks, into a smaller set of local partnerships further reduces overheads and clarifies business processes.

SEPA

The [Single Euro Payments Area \(SEPA\)](#) is a framework designed to harmonize and improve cross-border digital payments within the European Union.²² The goal of the scheme, which is administered by the [European Payments Council](#), is to ensure that cross border payments made by citizens and businesses within the zone are no more costly or difficult than domestic payments. The aim is for there to be a unified Euro-denominated payments rail within the zone, contributing to overall efficiency and accessibility of payments – and to ultimately promote greater economic integration.

SEPA is not an infrastructure *per se*. Instead, it requires that participating payment providers adhere to common protocols and standards in providing payments services, while remaining somewhat agnostic on how those services are implemented. While the system is administered by the European Payments Council (EPC), a non-profit group of payment service providers, it is underpinned by the [Cross-border payments Regulation and the Payment Services Directive](#), reflecting underlying legislative and regulatory support from EU policy institutions.

²¹ This of course does not mean that stablecoins are *completely* detached from the banking system (and, indirectly, reserves) as possession of a stablecoin partly derives its value from the fact that, if the holder chooses, it can be redeemed for – typically – a digital bank deposit. This, however, is a primary market transaction, distinct from settling a secondary market payment.

²² Despite no longer being a member of the European Union, the United Kingdom remains a member, along with a small number of other non-EU members, including Iceland and Norway.

Payments under SEPA

At the heart of SEPA are account-to-account (A2A) “credit transfers”, initiated by a payer, and direct debits, initiated by a payee according to a pre-arranged agreement or “[mandate](#)”.²³ SEPA credit transfers (SCT) are, in the first instance, intended for isolated payments, while direct debits are intended for recurring payments, such as subscriptions and regular loan repayments. Within the class of credit transfers, there is included a particular type of “instant” transfer, typically referred to as SCT Inst, which settle within seconds. In contrast, standard credit transfers are designed to settle by end of day, on business days. Notably, SCT Inst is also designed to be available 24/7/365. SEPA direct debit (SDD), in contrast, may take several days.

SEPA payments are designed to be transparent, with a simpler fee structure than the typically opaque and sometimes unpredictable fees associated with inter-bank SWIFT-based systems. The scheme aims to provide an additional option to card networks that function across Europe. SEPA mandates the use of ISO20022-compliant messaging standards and thus allows extra remittance information to be included with transfers. The allowance of bulk/batched payments (including multiple simultaneous transfers) also makes the scheme suitable for firms, rather than simply for households. Indeed, the EPC also manage a business-to-business (B2B) direct debit scheme.

Interfaces and underlying rails

Users have various options to make SEPA payments, depending on use case and context. In our discussion, we will focus on credit transfers, which are most comparable to the other payment approaches and monies discussed in the rest of this document.

As aforementioned, SEPA relies largely on EBA clearing systems and ultimate settlement within TARGET. SCT relies on T2 RTGS while SCT Inst relies upon TIPS. In addition, there are important SEPA-compliant national clearing schemes, such as CORE in France, that may handle within country payments, while interacting with pan-European clearing systems (STEP-2) in the case of cross border payments.

As an A2A system, SEPA requires the payer to provide IBAN and BIC information for the recipient’s account and bank. This may be entered manually through their own bank or payment service provider’s interface.²⁴ It may also be added at a data enrichment step immediately after the initiation of the transaction or be supplied in an initial “request to pay” step launched by the merchant. Since such details are difficult to remember, when they must be provided by a customer, proxies may be used that associate a memorable mnemonic (such as a phone number) with an account. The [SEPA Proxy Lookup Scheme](#) standardises such an approach. There is ongoing work to allow mobile devices, combined with NFC and QR codes as an interface.

²³ SEPA request to pay sees a request initiated by the payee, but the ultimate *payment* is initiated by the payer, using a SEPA credit transfer. As such, it is different from a SEPA Direct Debit and does not involve a mandate.

²⁴ In the case of a bank with physical locations, the “interface” need not only be an app but could entail filling out forms in person.

While there were hopes that cards would also be a method of making SEPA credit transfers (core or instant), there has been [relatively little success](#) in this dimension, despite the existence of a [SEPA Cards Framework](#) and some private sector solutions (see Visa's [VPay](#) system, for example). However, recently there have been interesting developments in that Visa has begun to offer “pay-by-bank” [A2A solutions](#), apparently with protections [akin to chargebacks](#).

Private solutions are building on the European interface for SEPA. One example of this is the [Wero](#) scheme, run by a consortium of European banks (under the aegis of the [EPI](#)). Wero essentially is a digital wallet that allows payments to be made in several European countries (with plans to expand reach further), based on underlying SEPA schema – notably for instant payments under SCT Inst. While currently limited in terms of services – offering currently a P2P payment service – the Wero app is expected to broaden its offerings in the future.

Card networks

Many of the payments we make go through card networks. The most dominant of these are the well-known US schemes that are globally ubiquitous: Mastercard and Visa. Visa enjoys a market share of 90% in Ireland, for example, while in the Netherlands, Mastercard has an 87% share ([Statista \(2025\)](#)). In many other European countries, the market shares are similarly high, though in countries where there is a local card scheme, such as in Germany, the shares may be much lower. Overall, however, these two companies dominate the payments landscape and, as emphasised by [Cipollone \(2025\)](#) represent a familiar and reliable cross border payment rail within the euro area. But that reliance - and associated lack of diversity in payment rails - also raises questions around resilience, which have been discussed in debates over enhancing cross border payments under SEPA and the introduction of a digital euro. In this section we focus more on the technological and infrastructure aspects of these card schemes.

Four corner model

Card payments (debit or credit) rely on the “four corner model”. Two of the corners are the ultimate counterparties: a customer and a merchant. The other two corners are the acquirer bank (used by the merchant, to receive card payments) and the issuer bank (that issues the card – and thus manages the underlying bank account or line used for debit or credit). Connecting these players is the card network.

In terms of the process of a transaction, let us first consider a simple version of the debit case. The payment flow is essentially the same in the credit case though on the issuer side, it is the decision to extend credit, rather than the checking of funds currently in the customer's account, that takes place.²⁵

At the initiation of the transaction (be this at a physical Point-of-Sale or online) the card details are provided by the customer, they are secured/encrypted by a payment gateway and conveyed to the merchant's acquirer bank. The acquirer then uses the card network to send this information to the issuer bank. On receiving the information, the issuer bank checks there are adequate funds available and sends an approve or deny response back to the acquirer,

²⁵ We ignore overdrafts associated with bank accounts which could be used in an ostensibly debit transaction.

again through the card network. This is then forwarded back to the payment gateway and the transaction front end (or screen on a physical PoS) will indicate the authorization status.

In the background, various other steps are occurring, such as the reserving of funds by the merchant bank (if the transaction is approved) in anticipation of settlement. Other services may also be delivered by the card network, such as fraud checks. These will likely also be done by the issuing bank also, though the card network – with its broader view of payment flows (historical and real time) – may be able to provide augmented services.

There is, of course, a clearing process that takes place before (typically) net settlement occurs. Netting is enabled by a deferred settlement model in which, in the first instance, the merchant's systems will create a batch of approved transactions from the day's trading, say, and then send them to the acquirer, who will convey them to the card network. This happens for all acquirers in the system. The card network will send these transactions to the issuer banks and will also calculate netted positions among banks. Acquirer banks and issuer banks will prepare to adjust their internal ledgers by appropriate amounts – which are partly determined (of course) by the underlying value of goods or services purchased, but also adjusted for fees, which we discuss below.

Ultimate settlement may then occur. Approaches vary by jurisdiction but frequently much of the settlement will be across the balance sheets of important “settlement banks”, at which other banks hold accounts. Card networks will choose settlement banks according to scale, international connectivity and operational excellence, with a small number of institutions handling this role in a given region ([Herbst-Murphy \(2013\)](#)). To fund these accounts, or if there are imbalances across the settlement banks, RTGS systems will typically be used, though small institutions themselves may not have direct central bank access. For cross border settlement, typically correspondent banking networks will be used.

Fees

At the clearing stage – when the batch of transactions is sent by the acquiring bank to the card network, interchange fees are calculated. These fees are paid by the merchant acquirers to the issuer banks, according to precisely defined criteria (see [Visa \(2024\)](#) for an example of Visa's in the US in 2024). As such, the amount of funds that issuers transfer is somewhat less than the amount that the customer has paid, reflecting an implicit fee. The acquirer may also deduct a fee, ostensibly from processing, again reducing the amount that a merchant receives, relative to the amount that the customer has paid.

Card schemes also tend to levy assessment fees (low rates, but on the very large volume of transactions) for banks to use their networks. This is typically passed through, to an extent, in the fees charged by the acquirer to the merchant. The interchange and card scheme fees constitute the base cost and any further deduction from the amount received by the merchant, determined by the acquirer, represents a form of acquirer markup. Thus, from the perspective of the merchant, the “merchant discount” (relative to what the customer paid) reflects interchange, card scheme and merchant markups. In reality, the fee structures involved in card

payments are more complicated and are notoriously opaque, but the essential elements are as described here.

Whether interchange fees, for example are justified by cost, rather than excessive card scheme market power is a matter of great debate. Bundled services such as anti-fraud systems and the convenience of chargeback functionality, can make it difficult to make clear calculations of markups. However, prominent cases in the [US](#) and [UK](#) illustrate a degree of merchant and regulator scepticism over card schemes' pricing, and the (now absorbed into the FCA) Payment Systems Regulator [launched a review](#) into changes to cross-border interchange fees following Brexit.

5. Blockchain

Distributed ledger technology (DLT) has disrupted many aspects of finance – particularly in the areas of digital money, payments and tokenisation. Blockchains, as a special case of DLT have so far been at the forefront of these trends.²⁶ In this section we briefly discuss some general features of blockchain infrastructure, to create a foundation for our later discussions of stablecoins, tokenized deposits and tokenized money market funds. For a more elaborate, but accessible, discussion of blockchain fundamentals we refer the reader to [Drechsler \(2022\)](#) and [Lipton and Treccani \(2021\)](#).

Single chain

Blockchains first entered public consciousness with the advent of the Bitcoin blockchain and its native cryptocurrency, bitcoin (note the upper and lower case of the first letters!).²⁷ The Ethereum blockchain with the native cryptocurrency, Ether, is another widely used blockchain. The vast majority of blockchain development and activity relates to these blockchains or associated systems. These chains run as public permissionless networks (anyone with an internet connection can participate, in any capacity, pseudonymously) of computers all around the world, running software that communicate and record a set of transactions.

It is important to note that the common interpretation of the word transaction implies an exchange of value. In the case of Bitcoin, this is traditionally how transactions have been used, exclusively, in sending value (authority over sums of bitcoin) from one party to another. In other blockchains, notably Ethereum, the transactions are more general. While they may send value (in Ether), they may also contain a data payload, something that will be important when we discuss smart contracts and tokens below.

The data and value included in the transaction messages allow ownership claims and other persistent information to be recorded in a ledger. That is, a blockchain is a database that imposes rules as to how it is updated. Some of these rules are embedded in the underlying

²⁶ There may well be important non-blockchain DLT solutions that emerge. Indeed, [Hedera](#), is a prominent example of a DLT that uses a Directed Acyclic Graph approach, rather than blockchain. In the interests of space, we will focus our explanation of DLT technology on the particular case of blockchain, given its current prevalence.

²⁷ This discussion focuses on the basic public permissionless form of blockchains, ignoring the wide variety of permissioned, private and hybrid chains, with various consensus and other protocols.

protocol of the blockchain – encoded in the software that members of the network run and others are implicit in smart contracts themselves stored in the blockchain, and which contain algorithmic instructions on how the state of the database should evolve.

Importantly, the ledger is distributed – by dint of all the members of the underlying network operating in the same way, deterministically, on a version of the database. The storage and updating of the blockchain across an enormous network of nodes gives many prominent blockchains a highly decentralized format, which has benefits in terms of robustness due to the replication of data and the lack of reliance of a single node or even many nodes functioning properly. The approach also avoids reconciliation of separately administered proprietary databases.

A key requirement for any blockchain to be useful is that eventually (ideally quickly, safely and efficiently) the various network members can agree on what is the ‘correct’ version of the database. That is, they agree on the true history of transactions and the accumulated result of those transaction (implied balances of assets or saved data ‘inside’ smart contracts).

Blockchains reach this agreement via a ‘[consensus mechanism](#)’ which may vary from blockchain to blockchain ([IMF \(2025\)](#)). Ultimately the aim is to achieve agreement on a single consistent ledger without participants having to trust each other – the trust, instead, is in the system’s mechanisms.

Famously, Bitcoin uses a Proof of Work consensus mechanism that assigns the right to add a block of transactions to the existing chain to a network participant who solves a simple but computationally expensive task, the outcome of which can only be attained if the ‘work’ has been done (it cannot be guessed in advance). Despite *solving* the problem being time consuming and expensive, the *solution* can be rapidly and cheaply verified by other network participants – after which they agree on that new block being the legitimate update of the blockchain (they come to consensus) – and the process continues with the aim of adding another block of transactions, and so on. Importantly, blockchains are typically designed in such a way that it is *extremely* difficult to tamper with the database without the tampering being detected and disregarded before any damage is done. This gives the databases captured in the chain, the property of *immutability*. Once something is on the chain – a record of a payment, or the form of a smart contract – it will be on the chain forever, in its initial, untampered state.

Ethereum no longer uses Proof of Work, as it now uses the Proof of Stake consensus mechanism, which is notably far less energy intensive (with important implications for the environment) than Proof of Work. There are other consensus mechanisms employed by various blockchains, with each having different strengths and weaknesses. Proof of Work and Ethereum’s Proof of Stake are regarded as highly secure but, in some contexts, different chains may trade off some degree of security for greater speed. Notably, the speed with which finality is reached can be enhanced by putting greater trust in a smaller set of network participants to choose what transactions are included in blocks, limiting computational and communication overhead as compensation for increased centralization.

While Bitcoin and Ethereum are permissionless blockchains, with no barriers to entry and equal influence among network nodes, some blockchains are ‘private’ and ‘permissioned’. In

such chains, membership might be limited to regulated entities – such as banks – where repeated interaction and the plausible threat of punishment or loss of reputation means that there is more scope for ‘trust’. Permissioning may also limit what roles certain nodes can play – with block construction or validation reserved for a selected subset of nodes. Such chains may be able to use less intrinsically secure (perhaps due to greater centralization) consensus mechanisms than public permissionless chains.²⁸

Until recently, many thought that finalizing transactions quickly might require the widespread use of permissioned blockchains, especially in financial markets. However, recent advances have been made in accelerating settlement on public permissionless blockchains and enabling higher and cheaper throughput on them. This has led many to believe – especially with complementary advances in confidential transactions – public blockchains have the potential to play a significant role in even systemic financial markets (see [Schar \(2024\)](#) and [Bindseil and Malekan \(2025\)](#)).²⁹ Indeed, JP Morgan has recently [completed a transaction](#) in tokenized deposits on a public blockchain. The debate on this topic, however, is far from settled.

Smart contracts

Apart from storing records of transactions purely of value, blockchains – notably Ethereum – may also store software, known as smart contracts.

Individuals control assets they own by retaining secret knowledge of a private key connected to a public address on the blockchain. Knowledge of the private key allows them to authorize transactions that mobilize assets associated with the public address. Smart contracts *also* have public addresses but operate according to the logic embedded in their source code, rather than by a person with a private key.

We have referred to smart contracts as ‘software’. How, then, are they ‘installed’? On a typical computer that we may use at home or at work we often install software by downloading an installer, running it, and then we can use the software. To install a smart contract, one must send a compiled version of its source code (a form of the instructions that can be read and interpreted by a computer) to the blockchain. It is then assigned an address.

Now, to use software installed on our computer in a traditional way, we would click on the icon and things would ‘happen’, according to the logic of the software. In the case of smart contracts, once they are on the blockchain, one can send transactions to the address associated with it, where the transaction indicates which functionality within the contract is to be used and any additional data needed as inputs for the smart contract to use in its calculations.

²⁸ Centralization might arise due to the consensus mechanism requiring computation that is too intensive for the sort of moderate hardware that is commonly used by nodes in large public permissionless chains.

²⁹ Technical finality is formally never reached with 100% certainty in Bitcoin as there remains a positive probability of “[chain reorganizations](#)” – which effectively replace some of the most recent blocks (and the transactions contained in them) with other blocks. Once enough blocks have been added this risk goes to infinitesimally small levels, though it remains non-zero. As such, in practice, [finality in Bitcoin](#) applications often is taken as being achieved after a certain number of blocks have been added. The time it takes to do this and the residual (if small) uncertainty over finality are key reasons why Bitcoin’s consensus is thought by some to be inappropriate for large or systemic financial markets.

Typically, calls to smart contract functions require a transaction to be sent to the contract address, ultimately to be added to the blockchain. The block containing the transaction constitutes the change in the ledger, or database. Frequently the call will update the state of the smart contract, by adjusting a stored value. For example, the contract may make a payment to another address, dependent on the information included as inputs in the transaction (an example might be information on which an insurance payout may be contingent). Notably, a smart contract may – and often will – call other smart contracts as part of the transaction execution.

It is important to note, therefore, that the blockchain is not *only* a database. In fact, many people regard blockchains with smart contracts as being a form of decentralised *computer*. This interpretation is at the heart of Ethereum, which is often referred to as a '[world computer](#)'. A computer stores software and saves information. By using the software (in the blockchain case, by sending a transaction calling a smart contract function), the computer takes actions that yield outputs and update the saved information. This is essentially a model of a computer.

Note that the *overarching* computer implied by a blockchain operates in a decentralised way across multiple *individual* computers participating in the blockchain's network of nodes, rather than on a single *individual* computer on your desk – or at the bank whose app you are using. In the case of decentralised public permissionless blockchains, this is, by some, thought to be desirable in that it removes a centralised point of failure (and possibly control) from traditional financial institutions.³⁰

The merits of decentralisation and its compatibility with reasonable regulation are hotly debated. Another aspect of blockchains that is also somewhat polarising is its transparency. The ability to track transactions and observe the functioning of smart contracts is often thought to be one of the strengths of blockchain. It is notable that unlike in many traditional systems, the logic of software (smart contracts) is exposed for all to see.³¹ Combined with the *immutability* property of blockchains, this means that developers can be confident that they can build additional software that builds upon other reliable software – a property of blockchain software development typically referred to as *composability*.³² Of course, this transparency also brings risks – in terms of the rapid identification of exploitable bugs, which has dogged early blockchain applications, but perhaps more seriously, concerns over privacy and confidentiality.

³⁰ Indeed, the web3 paradigm (of which defi or decentralized finance is a part) emphasizes the removal of centralized entities from positions of authority, such as social media giants who operate 'servers' on which our data is stored. Our interaction with these services, and our data, only coming through approved requests and channels, through which the 'client' software running on our devices interacts with the server. The P2P nature of most prominent public chains is in contrast with the hub-spoke centralized setup of traditional web2 networks.

³¹ It is not automatically the case that source code is made public as only a computer-readable version is, in the first instance, saved on chain. However, for most smart contracts intended for mass usage, there are services (such as [this service](#) from Etherscan) that allow human-readable source code to be proved to be the code underlying the smart contract deployed at a given address.

³² Interestingly, in recent years a software pattern has emerged that allows '[upgradable](#)' contracts which somewhat moderates the immutability properties of smart contracts, by allowing a 'proxy' contract to remain fixed while it points to possibly different 'implementation' contracts that encode updates. Users will always interact with the immutable proxy, but it will direct them to a sequence of (also individually immutable) implementation contracts.

These are areas of considerable research and discussion (see [JP Morgan \(2024\)](#), [BoE-MIT \(2025\)](#), for related discussions) with various privacy and confidentiality enhancements being built into blockchain protocols and applications, reducing the universal transparency or, at least, interpretability of blockchain data.

Tokens

We have established that blockchains are databases and, in many cases, can be used as a form of decentralised computer. These dual capacities can underpin a wide variety of applications, but a key application is the creation of ‘tokens’. There are various types of tokens, which are distinct from the native currencies (Ether, bitcoin) that are embedded in the underlying blockchain protocol. Tokens essentially represent a claim to an asset, or some right, or some payoff – or some combination of the three.

It is common to distinguish fungible tokens and non-fungible tokens (NFTs). Non-fungible tokens are each individually unique whereas fungible tokens are interchangeable with each other. The total number of fungible tokens in a set, rather than which particular tokens are in that set, is all that matters. In contrast, if one replaces a non-fungible token (such as a piece of digital art stored on the blockchain) with another non-fungible token (for a different piece of art) then that is a substantive change. It would not be in the case of a fungible token. Of course, fungible tokens are especially suited to acting as monies, as we are familiar with treating monies as fungible – swapping a €1 coin for another €1 coin is neither here nor there.

It is important to understand that a ‘token’ is defined by a smart contract. It is common to speak about crypto tokens as if they are tangible – as in the case of the physical monies we are already familiar with – but their nature is more subtle. Taking fungible tokens as an example, a smart contract keeps track of balances associated with addresses and – for any sensible token – provides functions to allow transfers of tokens between holders (adjusting the balances in a coordinated way). As such, the token smart contract itself must save an internal ledger, which is conceptually different from (though implicitly stored in) the broader blockchain.³³

Ethereum is currently still the dominant blockchain for smart contract programming and on this and compatible chains, some well-known standards have emerged to coordinate development of fungible tokens. Notably, the [ERC-20](#) standard is at the root of many of the most large-scale fungible tokens. ERC-20 demands (or strongly recommends) certain features of any fungible token. Token designers may add functionality, and the standard does not specify how the core functionality is *implemented*, but an ERC-20 token must satisfy certain functionality. This is important for the broader development of blockchain applications as other software/smart contracts can be developed to interact predictably and efficiently with such tokens. They can assume a consistent set of functions, rather than making allowances for an unmanageably wide range of different tokens – a wasteful and duplicative practice. Clearly, this is key for composability.

The most famous applications in blockchain-based finance – stablecoins, tokenised deposits and tokenised money market funds – typically pursue the ERC-20 approach (or an essentially

³³ Blockchains vary in what sort of storage they provide for persistent information.

equivalent approach on other non-Ethereum chains). For example, the two largest stablecoins, USDT and USDC are ERC-20 tokens, though they add much other functionality. Indeed, all the most prominent stablecoins are ERC-20. New standards, such as to incorporate regulatory requirements (e.g. to place restrictions on what tokens can be sent, and to whom), are emerging to coordinate development further (see the [ERC-3643 “T-REX”](#) standard, for example). However, there is not yet a widely adopted standard specifically for stablecoins. We will discuss stablecoins at greater length later in this document.

To send a certain amount of ERC-20 tokens to a given address one might send a transaction to the blockchain designating the *transfer* function of the underlying smart contract for the particular token (say, the [USDC smart contract](#)), with inputs indicating how much of the sender’s balance of the token should be reallocated, and to what recipient address. Once the transaction is included in the block, the balance of the sender will have been decremented by the appropriate amount, and that of the recipient will be incremented. These changes in balances are what constitute a transfer.

Wallets and ownership

Individuals control assets they own by retaining secret knowledge of a private key. This private key is inextricably linked with a public key, which is derived from it. From the public key is derived a public address that identifies the individual on chain (note that an individual could – and typically will – have many keys and addresses). It is vital to understand that knowledge of the public key (or address) does not reveal the private key. With current technology, it is effectively impossible to invert the mapping from the public key to the private key – thanks to the careful design of [public key cryptography](#).³⁴ As such, keeping ones private key secret is utterly vital. Provided the key is kept secret, only the true controller of the address can authorise use of assets sent to that address, and if an authorization is given, they cannot repudiate that action and claim they did not authorize it. Note also that if one forgets or loses the private key, it will be impossible to recover control of the assets associated with the public address.³⁵

Custodying digital assets is (essentially) equivalent to keeping a private key secret. In practice, some sort of ‘wallet’ is used to store keys as the keys are effectively impossible to remember, due to their complexity.³⁶ A ‘wallet’ could be a piece of paper with the private key written on it in crayon. Clearly this is risky, unless the paper is stored in a high security vault. Even then, there is perhaps the risk of disintegration, fading or fire to deal with. Some people will stamp the key (or a mnemonic for it) on [metal plates](#) – and then store those plates in a safe place. These approaches are known as ‘cold wallets’ as they are not connected to the internet, in contrast to ‘hot’ wallets which are. Hot wallets raise the risk of hacks and exploits, all else equal.

³⁴ Quantum computing seems set to change this, rendering inversion feasible in reasonable time, necessitating new cryptographic approaches in some contexts.

³⁵ If a token has been defined in a smart contract that allows others to transact on ones behalf (such as in the case of “forced transfer” functions embedded in some stablecoins) then it may still be possible to recover ones assets, though at the cost of trusting another party, undermining some of the main appeal of crypto in some people’s eyes.

³⁶ Sequences of words can be mapped to keys (recovery phrases) so that memorizing these, as a superior mnemonic, can be used to recover keys. But it is still convenient to use some sort of wallet.

The advantage of hot wallets is that they are more convenient for enabling activities on chain, such as payments and trading. Typically, these wallets provide various additional services beyond simply securely storing the key – such as helping construct transactions to be sent to the blockchain, providing useful interfaces and perhaps reporting market data.

It is important that users understand the [risks and benefits of picking a wallet](#) appropriate for their risk tolerance, vulnerability to attack, and the amount of value implicitly controlled by the private key. There are many sophisticated approaches to private key security and a rapidly growing industry that caters to financial institutions in providing high grade custody as a service. Our short, simplified and high-level description of the issues should not be treated as reliable advice for how to store private keys or what type of wallet to use.

Multiple ledgers and interoperability

A single blockchain keeps track of transactions made upon it. It is self-referential, in a sense. As a primitive, it knows nothing about what happens “off-chain”. That is, it is unaware of the “real world” or of transactions on other blockchains and ledgers. Within the blockchain/crypto community, enormous research and activity is being devoted to methods that can safely and efficiently connect different blockchains. This activity includes work on the underlying plumbing and technology, but also in abstracting away the presence of multiple chains, to give the end-user a unified experience, such that when they use an app or a token, the use of multiple chains may not even be explicit. Describing the technical methods (which are still evolving) used for interoperability solutions is beyond the scope of this note, but we refer the reader to [Cyfrin \(2024\)](#), [World Bank \(2021\)](#), and [WEF \(2020\)](#) for further discussion.

6. Blockchain-based payments

In this section we discuss various assets that are deployed on blockchains to enable payments. Given their intrinsic novelty – especially in their settlement model – we will focus on stablecoins but also discuss tokenised deposits and deposit tokens.

Stablecoins

One of the most disruptive innovations in payments in recent years is the class of digital asset known as stablecoins. While they emerged from the defi domain, they are distinct from many of the most prominent cryptocurrencies (notably bitcoin and ether) in that they claim to maintain a stable exchange rate with some underlying asset. Most prominent stablecoins typically aim to maintain a 1:1 exchange rate with an off-chain fiat money, such as the dollar or the Euro, though some are pegged to commodities such as gold. As we shall discuss, there is an ongoing debate on how reliably and how closely stablecoins maintain this peg – to the extent that for some coins, the term “stable” is perhaps a misnomer.

Types of stablecoin

It is typical to characterise stablecoins according to certain dimensions. Two important such dimensions are their *stabilization mechanisms* and their *degree of centralisation*. We discuss both in turn.

Stabilisation mechanisms

Stabilisation mechanisms are what are meant to keep stablecoins at their pegged value – what makes them “stable”. In terms of stabilisation mechanisms there are essentially two types: collateralised and algorithmic. Some coins are perhaps best thought of as a blend of the two, but for our analysis it is useful to maintain this distinction.

Collateralised coins essentially promise to allow issuance and redemption at par by connecting the coin to underlying “backing assets” with value. In the simplest illustrative case, these backing assets, it is claimed, will allow coin holders to obtain \$1 (in the case of a USD-denominated 1:1 pegged to USD stablecoin) whenever they wish.³⁷ In the primary market (at issuance and redemption) this can be enforced directly. Such coins are (or should be) designed that the peg is also maintained in *secondary* markets – relying on arbitrage, combined with the possibility of redemption and issuance. The basic idea is that if a stablecoin were explicitly or implicitly trading at, say \$0.99 in secondary markets, one could make enormous profits by buying as much as possible at \$0.99 and then redeeming each coin for \$1 with the issuer (or an agent of the issuer). Similarly, if it is trading at \$1.01 in secondary markets, then the coin holder could exchange a large amount of fiat with an issuer (or an agent of the issuer) at \$1 and demand the issuance of coins, which they could then sell for the higher price in secondary markets.³⁸

Such massive arbitrage is typically something – at least in normal times – that should not be possible, implying that the coin should remain stable at par or extremely close to par. The extent to which this is true in normal times – and especially in times of stress and uncertainty – is a matter of hot debate. Collateralised stablecoins have exhibited significant depegging events on many occasions ([Kosse et al \(2023\)](#)).

Within the class of collateralised stablecoins, it is common to distinguish those that are backed by other crypto assets, and those that are backed by real world assets. Those that are backed by crypto assets are generally *overcollateralised* in the sense that a unit of the stablecoin is only minted if more than a dollar’s worth of collateral provided. USDS (until recently DAI) is an example of an overcollateralised stablecoin. To issue [USDS/DAI](#), one must deposit more than 1:1 other crypto assets. Traditionally this entailed depositing the volatile crypto currency, Ether, to obtain, effectively, a loan in USDS/DAI but in recent years the type of collateral accepted has expanded.

An example of a stablecoin backed by real world assets is [USDC](#), issued on behalf of Circle. USDC is backed by fiat assets such as regulated bank deposits, cash and high-quality sovereign debt. In fact, issuers of such coins typically hold backing assets somewhat in excess of the number of coins issued, so as to yield positive capital that can absorb fluctuations in the value

³⁷ As discussed below, [USDS/DAI](#)’s primary market “overcollateralised loan” model is more elaborate than simply posting \$1 of fiat.

³⁸ As discussed in [Ma et al \(2025\)](#), the precise details on who can redeem and how, may vary across stablecoins. In some jurisdictions and for some coins “normal” holders of the coins (individuals, say) may not be able to engage in these “primary market” operations or may face additional steps and constraints. The operations may be reserved instead for institutional partners or for operations above a certain scale. These details are beyond the scope of this note, however.

of the backing assets, though the degree of “overcollateralisation” is far less than in the aforementioned USDS case and – importantly – is achieved through Circle’s own capital actions, rather than requiring more than \$1 for a unit of USDC at issuance.

People frequently refer to *fiat-backed* stablecoins, typically implying that their assets are denominated in the currency to which the stablecoin is pegged and that the coin promises redemption for fiat denominated assets (cash, bank deposits, or an equivalent value of HQLA, for example). Traditionally, this has meant backing directly by real world assets but increasingly there is a trend towards backing with on-chain assets. Some of these, such as tokenized money market funds are in turn backed by real world assets. However, if on-chain Central Bank Digital Currency (CBDC) or, more plausibly, on chain sovereign debt (such as the [Digital gilt](#) currently being considered in the UK) were to emerge, it could be the case that a fiat-backed stablecoin could be backed by assets that are natively on chain.

Algorithmic stablecoins adopt a different approach to stabilisation. Typically, they are not backed by explicit collateral but adopt somewhat elaborate automated mechanisms for varying demand and supply for the coin, to “ensure” that the market always clears at par. If their systems do have logic, they typically somehow rely on future success of the coin, borrowing against that anticipated success to fund the market operations that stabilise the coin’s price in the near term. Mass adoption of the coin and the seigniorage benefits – and perhaps other income streams – that it could provide act almost as hidden collateral, in a sense. However, these models can be extremely fragile. Aside from fragility, in some cases there have been suspicions of pyramid schemes that rely on late adopters to fund early adopters and issuers, before the coin eventually loses value. There have been many spectacular failures of algorithmic coins – notably the Terra-Luna collapse ([Briola et al \(2023\)](#)). While some algorithmic stablecoins still exist ([AMPL](#) for example) they appear to be unacceptably fragile to operate within systemic systems as a reliable money or settlement asset. We will exclude them from consideration in what follows.

Degree of centralisation

In fact, USDS/DAI and USDC are also examples of different approaches to centralisation. The protocol that issues USDS/DAI is determined by smart contracts. The smart contracts feature parameters that can be adjusted according to decisions made by a [DAO](#) (Sky – previously called MakerDAO) that has authority over USDS/DAI. In contrast, USDC is issued on behalf of a single company, Circle. USDT, issued by Tether, is the largest stablecoin by market capitalisation and its issuance is also centralised.

In the case of USDS/DAI, one interacts with a smart contract, using some of its functions to lock up collateral in a ‘vault’ contract, receiving a ‘loan’ of USDS/DAI in return. That is, “anyone” can mint the stablecoin, according to the smart contract(s).³⁹ In contrast, [USDT](#) is only issued by the “owner” of the USDT smart contract, which is an address controlled by Tether (there are no minting functions accessible by general users). USDC has a somewhat different model.

³⁹ There are ongoing debates over precisely how decentralised such DAOs are, with some arguing that they are consistent with a high degree of centralisation if governance of the DAO is controlled by parties with dominant majorities of governance tokens.

Although Circle has authority over issuance and is ultimately responsible for minting and burning, it partly delegates the *act* of minting and burning to market makers or, in Circle terminology, parties with [Circle Mint](#) accounts.

For the remainder of our analysis, when discussing stablecoins we will (unless explicitly stated) be considering centralised, collateralised stablecoins, backed primarily or exclusively with fiat in the form of high-quality liquid assets or safer. These hold the most promise for satisfying the various properties we expect from money, at least in the near term. Furthermore, they are the sort of coins that are provided for under regulation and legislation that are emerging worldwide.

Comparing stablecoins with bank deposits

It is useful to compare stablecoins with traditional commercial bank deposits (current accounts). These provide us with a digital money that we can use widely – such as when we tap our phone at a Point-of-Sale (PoS) terminal in a shop or restaurant.

We previously discussed the “two-tier” monetary system in which commercial banks create money to be used by the public that is distinct from the money (reserves) created by the central bank. Under a *fractional banking* system, the amount of money in the economy can be expanded beyond the value of reserves. In the strictest form of *narrow banking*, as mentioned earlier, the overall amount of money is pinned down by the amount of reserves backing deposits 1:1.

A somewhat broader interpretation of narrow banking than the fully reserve-backed case acknowledges that in some respects reserves (which ultimately are a liability of the government) are akin to other short term government liabilities, such as short maturity bonds. Such bonds have slightly longer maturities than the “instant” maturity of reserves but have minimal to no credit risk and can be highly liquid. As such, they are often included in the class of assets referred to as “High Quality Liquid Assets” (HQLA).

Consider the following thought experiment. Suppose a traditional commercial bank has deposits that are fractionally backed by reserves and high-quality government bonds, but that the remainder of its backing relies on loans and other assets of varying degrees of credit risk, liquidity risk and opacity. Now suppose that the bank decided to liquidate all the loans and “risky” assets and replaced them with more government bonds, or even reserves.⁴⁰ Many would describe the bank as having, effectively, become a narrow bank or, at least, much narrower. From a safety and liquidity perspective this bank (though not necessarily the wider financial system) has “improved”. Indeed, in terms of their backing, the bank’s deposits now bear a similarity to stablecoins. It is, in fact, common to hear people claim that stablecoins are a form of narrow bank. Is this a fair comparison?

A significant distinction between stablecoins and deposits, however, is their mode of settlement. Stablecoins are best understood as *bearer assets* (akin to cash, though privately

⁴⁰ Clearly this is a stark thought experiment, and it would be immensely disruptive to any bank (and likely markets) to do such a thing. Furthermore, as discussed elsewhere in this note, there are significant issues around credit contraction that would arise from moving to a narrow banking system. We are here simply trying to draw parallels between banks and their deposits, with stablecoins.

issued) rather than *account-based* monies like traditional bank deposits.⁴¹ For bearer assets, settlement is identified with exchange of the asset as, loosely speaking, possessing such assets implies ownership. As such, stablecoins trade freely in multiple market platforms and protocols, without any associated transactions in central bank money in RTGS systems, and possibly at a price different from the targeted par value. This contrasts with bank deposits where the full settlement process associated with a transaction between parties at different banks is only complete once the banks have made appropriate interbank payments using central bank money in an RTGS system, such as TARGET (see our earlier discussions about Aoife and Brian). Bank deposits do not trade freely. Instead, balances in deposits are adjusted in a coordinated manner as part of the payment process that also involves reserves, and this coordination ensures their price in transactions is hardwired at par, even when different banks' monies are used in a transaction.

It is therefore reasonable to regard a stablecoin issuer as being somewhat like a narrow bank, but where the money it issues as a liability is a *bearer instrument*, rather than a *deposit account*. Stablecoin issuers do not tend to have ongoing relationships with the holders of their liabilities, except implicitly through the promise to redeem for fiat if a holder of their coin presents the coin for redemption. Suppose a stablecoin is used to transact with an [Automated Market Maker](#) (AMM) or suppose a stablecoin is sent by one person to another in a secondary market transaction on-chain.⁴² In neither case is there a change in the backing assets supporting the stablecoin or any interaction between the issuer and the recipient. Furthermore, there are no associated transactions between any banks through RTGS as part of the settlement process, even if banks are custodying the backing assets of the coin.

Thus, ultimate settlement for secondary market stablecoin trades does not (in current practice) occur in central bank reserves. Somewhat counterintuitively, this is true even if the stablecoin is reserve-backed as *settlement in reserves* is distinct from *backing with reserves* ([Goel \(2024\)](#)). If a stablecoin is backed with reserves then the issuer would issue coins equivalent to the amount of reserves in their account, and secondary market trading of the stablecoins would not have any effect on this account or require any transactions using it. However, on issuance and redemption (*primary* market operations), there would of course be changes in the balance of reserves backing the coin.

It must be noted that settlement in reserves is typically associated with many other guardrails and infrastructure. As aforementioned, the functioning of the bank-based system is enhanced by additional support systems like lines of credit offered to banks by central banks. This is

⁴¹ There are interesting subtleties in distinguishing tokens on blockchains from accounts, as discussed in [Garratt et al \(2020\)](#). As in [Garratt and Shin \(2023\)](#) we focus our definition of "bearer" on the idea of the holder of the instrument being the owner and the transfer of ownership occurring by transfer of the instrument. We abstract from legal issues arising from, for example, continued ability of the issuer to freeze or delete balances in some cases.

⁴² An automated market maker (AMM) is a form of decentralised exchange (DEX). In the simplest case it is a smart contract that controls balances of two different tokens such that they always respect a particular mathematical relationship. If someone sends an amount of one token to the contract, they receive in return an amount of the other token that ensures that the mathematical relationship continues to hold. That is, one can transact to swap one token for another, without going through any intermediary institutions and without any reference to central bank administered settlement systems.

combined with robust bank regulation and supervision of fractionally backed banks. As such, solvent banks can essentially always be guaranteed to make the interbank payments required to complete the technical settlement process initiated by the activities of their depositors (and by the banks' own proprietary activities). Thus, downstream systems can be designed so that there is effectively no way to transact at any exchange rate between commercial bank money other than par. Existing two-tier monetary systems perform extremely well in terms of "singleness of money".

In contrast, stablecoins exhibit random deviations from par (violations of singleness) because secondary market transactions involving them are not hardwired to the reserves system in the same way. In some cases, stablecoin depegs have been substantial, particularly in times of stress. If stablecoins are to be used at scale in systemic payment systems, the risk of such large depegs should be eliminated. For less systemic systems and lower value transactions it could be that "small" deviations from singleness could be tolerated, if associated with other offsetting benefits.

Aside from performing well in terms of singleness, the two-tier system benefits from clear precedents and rules over what constitutes legal finality of settlement. In contrast to familiar concepts of finality in the case of bank deposits, however, there remains some ambiguity as to what defines final settlement for stablecoins. Partly this ambiguity arises from the differing technical concepts of finality and immutability adopted by different blockchains. However, even when technical finality is achieved, there may still be questions over whether it may be reversed in bankruptcy, for example. One presumes that a consistent legal framework can be (carefully) built to buttress technical finality with a clear legal status. Indeed, in the Bank of England's recent [systemic stablecoin proposals](#) explicit mention is made of settlement finality regulations to close such gaps.

It is useful to lay out a taxonomy of transactions to compare the bank deposit case with the stablecoins case. The first two cases both implicitly settle on a single balance sheet – that of a bank and that of a stablecoin issuer:

Case 1a: Paying with deposits - Customer and merchant have deposit accounts at the same bank

Case 1b: Paying with stablecoin - Customer and merchant both already hold EURC

Cases 1a and 1b are aligned in the sense that both feature closed loop or "on us" settlement (see [van Hee et al \(2025\)](#)). In both cases only one money is used. In 1a, the bank makes offsetting changes to the balances of the two accounts and in 1b the token smart contract's saved mapping of balances to addresses will be updated when a transaction calling the transfer function is added to a block included in the blockchain. Interestingly, 1b can be generalised to the case where the merchant has never held EURC prior to the transaction. If the merchant simply has an Ethereum address then they can still receive EURC (the transaction will induce their address to be added to a mapping of addresses to balances in the EURC smart contract state) without prior contact with EURC or Circle.

This generalisation points to an operational difference from the bank deposit case. The merchant would have had to set up an account with the bank before receiving the payment in

1a. The ability to receive money without the various KYC/AML and other admin steps associated with setting up a bank account is a feature of many stablecoins, raising challenges for compliance. Currently, most prominent stablecoins do not have whitelist or identity checking functionality built into them – though there are emerging standards designed to enhance tokens in this dimension, for regulated use cases (see [ERC-3643](#) and [Bidder \(2025a\)](#)).

Now let us consider more contingencies, beginning with an open-loop transaction, between account holders at different banks or, indeed, between the same person who has accounts at different banks. Such transactions make use of RTGS and central bank money. It is somewhat awkward to envisage the equivalent for stablecoins, but we imagine situations below where a merchant may not accept one stablecoin and only accepts another, or where a single user wants to swap one stablecoin for another. In the stablecoin transactions, there is no (technical) need to use RTGS and central bank money.

Case 2a: Paying with deposits - Customer and merchant are at different banks (banks A and B, respectively)

Case 2b: Exchanging deposits - Abby has accounts at banks A and B and wants to transfer from A to B

Case 2c: Exchanging stablecoins - Abby has EURC and wants to convert to EURS

Case 2d: Paying with stablecoins - Customer has EURC, merchant only accepts EURS

In 2a, three monies will be at play. The customer's balance in Bank A's money will be decremented by, say, 10, the merchant's balance in Bank B's money will be incremented by, 10, Bank A's reserves at the central bank will be decremented by 10 and Bank B's reserves at the central bank will be incremented by 10. The adjustments in reserves are, by definition, worth €10 (negative and positive, respectively).

If we assume singleness of money, the balances in Bank A and Bank B monies can also be assumed to change in value by €10 in either direction, but that is because the monies hold 1:1 exchange rate with cash and reserves, not because Bank A or Bank B monies are "euros" in the way cash and reserves are. They are private monies denominated in euros. Note that these monies are never actually exchanged between the customer and merchant (i.e. the merchant does not receive Bank A money, and the customer does not "pay" in Bank B money).

In 2b we have effectively the same set of ledger adjustments as in 2a even though it features a single person with multiple accounts. Reserves will be involved – three monies.

In 2c, the customer can send EURC into an AMM and will get back an amount (not necessarily 1:1 though likely close in normal times) of EURS.⁴³ Two private monies are at play – no central bank reserves. The customer does not initially need to have any EURS. This case is included as it is somewhat comparable to 2b and will also implicitly be part of how 2d is implemented.

Specifically, in 2d, the customer would need to effect 2c and then send EURS (hoping that the

⁴³ AMMs may offer an exchange rate that deviates from 1:1 owing to [fees and 'slippage'](#) and also because limits to arbitrage may lead to temporary imbalances in the amounts of the coins stored by the AMM's contract (see [Barbon and Ranaldo \(2024\)](#)). These factors vary across AMMs with different design features. See [Aramonte et al \(2021\)](#) for a discussion of AMMs. Also, see [Bidder \(2025b\)](#) for discussions around large depegs, particularly in times of stress, where deviations from 1:1 in some stablecoins have been substantial.

conversion from EURC yields enough EURS to satisfy the merchant).⁴⁴ In fact, these steps could be combined in a single transaction sent to an appropriately designed smart contract. As in 2c only two (private) monies are used. No reserves are used in settlement. Note that depending on the implied price in the AMM step and fluctuations in the prices of the two stablecoins, there may be exchange rate risk – a deviation from singleness of money despite the fact both coins are denominated in euro and aim to hold a €1 peg.

In this second set of cases, therefore, there are substantial differences between bank deposits and stablecoins. In open-loop settlement between counterparties at different banks, there will be 3 monies used in the bank deposits approach (and likely more if this case straddles payment system boundaries/cross-border with different reserve systems and chains of intermediary/correspondent banks). In the stablecoin world there will be no use of reserves, so there may be two monies involved. Note that the model doesn't change depending on whether this is a domestic or cross-border transaction as the blockchain infrastructure on which the trades operate is borderless.

In practice, of course, there are many other important distinctions between stablecoins and bank accounts, but in terms of backing assets and the mode of settlement, the most prominent stablecoins currently are very distinct from commercial bank deposits. Arguably it is the difference in settlement that is the more fundamental distinction. Indeed, under MiCA credit institutions (banks) may effectively back a stablecoin (EMT) with the same assets that back their deposits, in contrast with non-bank EMIs issuing stablecoins. Furthermore, the backing of MiCA-compliant stablecoins with deposits at banks indirectly introduces an element of fractional backing.

Stablecoin regulation and infrastructure

It has long been known that even solvent commercial banks may be vulnerable to runs if the sudden withdrawal of deposits necessitates the liquidation of illiquid assets at firesale prices, with possibly severe spillovers to other financial institutions, markets and the broader economy. In addition to these liquidity risks, there is of course the risk that banks become insolvent for more “fundamental” reasons – mismanagement, excessive risk taking or (very) bad luck.

Owing to the risk of bank runs (even on solvent banks) we observe that most financial systems feature some sort of deposit insurance, to deter mass flight from deposits. Frequently, central banks also provide some form of liquidity support – perhaps in the form of secured intraday lines or discount window lending, backed by high quality collateral or, especially in times of stress, broader collateral with substantial haircuts. Any lending may also be offered at

⁴⁴ There is a subtle question of how merchants would denominate their goods – in euro or in stablecoins. Given the continued importance of central bank money as the nominal anchor (in addition to inertia, simplicity and familiarity) one would expect continued denomination in euro. In that case, there is an interesting question of how the amount of stablecoins delivered will be determined as, implicitly, it will depend on the prevailing price of the coin. If the stablecoin's price is below (above) €1 then more (fewer) than 100 stablecoin units will be required to buy a good or service priced at €100. The “prevailing price” may be contractually agreed in advance or dynamically updated using an oracle service.

somewhat punitive rates, as an incentive for banks to manage their liquidity effectively in the first instance.

It is important to note that such infrastructure is not yet provided to stablecoins.⁴⁵ As such, all else equal, there is arguably a greater risk of runs on stablecoins. However, all else is not equal.

From a positive perspective, some stablecoins hold a high fraction of their assets in HQLA. While these can be run upon, it is perhaps less likely than in the case of opaque and highly illiquid assets typically held by fractionally backed banks. Nevertheless, recent experiences around [LDI](#) in the UK and the “[dash for cash](#)” have ignited concerns over price dynamics in market segments previously thought to be safe havens. [Ahmed and Aldasoro \(2025\)](#) also suggest that mass sales of treasuries by stablecoins under redemption pressure could induce disruptive moves in safe asset prices.

From a negative perspective, stablecoin business models, operations, and transparency are in an extremely nascent state. Some of the most prominent stablecoins operate with relatively limited regulatory oversight. As such, until improved regulation enhances the governance practices of stablecoins, the transparency of the businesses, and the safety (and proper custody) of their backing assets, stablecoins arguably pose uncomfortably high risks for financial stability – particularly for large value and systemic settlement systems. These risks can also undermine the reliability with which they maintain their price peg, especially under times of stress, undermining their utility as monies. Indeed, many would question whether one can legitimately refer to any stablecoins as monies, even if in some respects and at some times they behave as such. Regulation of stablecoins, however, is rapidly maturing – notably with frameworks such as MiCA and the GENIUS act in the US.

Setting aside emergency liquidity infrastructure, there is also currently an absence of the sort of elaborate clearing frameworks for stablecoins that are key to traditional markets functioning efficiently (see our earlier discussions of such systems in the Eurosystem). These systems can implement netting and other services that can reduce liquidity demands. Ironically, a strength of stablecoin settlement (immediacy of gross settlement) can also be a weakness at high volumes and in some types of transaction, as it is very liquidity intensive due to pre-funding and the pre-trade sourcing of assets for delivery (see [Lee et al \(2022\)](#) for discussions of why immediate settlement can be problematic). Of course, smart contracts could perhaps ultimately implement functionality akin to what traditional clearing systems do.⁴⁶ However, these services are in their infancy.

Some prominent defi clearing systems such as [Everclear](#) do exist (see also very early work at [Paygrid](#)). There are also emerging solutions that stay closer to the centralised systems of traditional frameworks. These include [UBYX](#) and [Cleartoken](#), for example, along with the

⁴⁵ We note, however, that in recent [proposals on systemic stablecoins](#) the Bank of England has raised the possibility of a backstop lending facility.

⁴⁶ It is worth noting that while blockchains and smart contracts likely expand the scope for atomic settlement (where all elements of a transaction succeed, or all fail), atomic is not the same as *immediate*, even if they are commonly conflated (see [Lee et al \(2022\)](#) on this point). Thus, while some risks to a transaction may be alleviated by atomicity, it does not necessarily need to be at the cost of infeasible demands for immediate liquidity.

important work on digital assets being undertaken by the [DTCC, Euroclear and Clearstream](#). Developments in this area are in such flux that a full analysis is beyond the scope of this document, though in the next section we point to incipient developments in how stablecoins are being incorporated into the financial system, cooperating with traditional players and frameworks.

Incorporating stablecoins into the financial system

So far, we have described stablecoins in a somewhat stark manner, to help fix concepts and draw clear conceptual distinctions with the traditional financial system. For example, we have emphasised the decentralized peer-to-peer (P2P) manner in which they can be traded or used in payments. Relatedly, we have treated blockchain transactions as the determinant of when a broader interaction between counterparties is complete or settled. While the vast majority of stablecoin transfers do follow this pattern (or take place using crypto-native services such as centralised exchanges), important emerging use cases combine on-chain transactions with off-chain traditional systems. This hybrid model is especially significant for emerging “real world” commercial use cases for stablecoins and for regulated financial institutions.

On- and off-ramping

It is possible to obtain digital assets in various ways. One could undertake tasks that are compensated in native tokens, such as by operating a validator node in Ethereum, and then convert those assets to any number of other assets using defi protocols. Alternatively, one might provide a service, to be compensated in payments in on-chain assets, such as stablecoins. However, many people will obtain digital assets at some point by engaging with an institution, such as a [centralised exchange](#) (CEX) or some other intermediary that simultaneously holds balances in digital assets (or can source them) and is also plugged into traditional banking and payment systems. These institutions can be sent payments through the usual methods mentioned earlier and then “on-ramp” the user by crediting them with on-chain assets, perhaps sending the assets to the user’s public address (a self-custody approach) or custodialing the assets on behalf of the user, if the on-ramping is to a CEX. If it is part of a broader payment flow, the assets may in fact be sent on to another counterparty’s wallet. Reversing this process, “off-ramping” sees the debiting of a user’s digital asset balance, with a payment then being made using traditional systems, such as to the user’s bank account or to a user’s counterparty or another intermediary.

There are many ways in which this can be achieved. If an intermediary can execute primary market actions (minting and burning) then the tokens may be created (destroyed) at on- and off-ramps, but it could alternatively be the case that the intermediary has inventory and/or sources existing tokens as required. There is currently enormous experimentation in this area. While individuals on-ramping at a small scale may use explicit GUIs offered by popular CEXs, business uses at scale would typically involve API interfaces and more elaborate services provided by financial institutions and emerging fintech providers. It could even be that the use of stablecoins is hidden in the back-end from the end users, who simply want to make payments, without caring about implementation details.

While compliance capabilities and trust in blockchain protocols grow a significant aspect of on- and off-ramping is the implementation of KYC/AML/CTF checks and the leveraging of existing recognised distribution networks. Payments using stablecoins will often involve entities that observe Travel Rule and other compliance checks. The point of sale will also typically already be served by payment service providers who can add stablecoin rails to their back-end, capitalising on existing relationships with merchants and familiarity with users. This may be especially useful if the end users do not want to engage in the complexity of blockchains, such as challenges around digital asset custody, tax and compliance. Some solutions can obviate the need for end users, and merchants in particular, ever to handle digital assets themselves.

The stablecoin sandwich

It may ultimately be the case that most market interactions take place on DLT systems. We are nevertheless currently far from that point – if it ever transpires. As such, if real world transactions use stablecoins, it will frequently involve on- and off-ramping, with stablecoins as the “filling” of what has come to be known as the “stablecoin sandwich”. Counterparties will frequently have accounts in traditional systems, and a payment flow will typically use these systems at both ends. “Fiat” money in traditional systems constitute the “bread” of the sandwich.

While the sandwich *could* take place within a given currency area or payments jurisdiction, it has greatest utility in cross border payments, where traditional correspondent banking systems connect different countries’ payment systems.⁴⁷ In these contexts, owing to aforementioned problems with traditional systems, where stablecoins are often thought to offer the greatest promise. The process features conversion from fiat to stablecoin in the first step, a stablecoin transfer in the second step and then conversion to (likely local) fiat from stablecoin in the third and final step. It should be noted, of course, that the recipient may choose not to immediately (if at all) make the final conversion, if they are willing to hold the stablecoin for some time.

Essentially, the stablecoin transaction replaces most of the traditional intermediate steps in the chain of correspondent banks that would otherwise be used to connect the counterparties’ financial institutions. As such, one of the slowest, most opaque and costly aspects of cross-border payments can, in theory, be replaced with a system that is rapid (settling according to the speed of blockchain finalisation), transparent (inheriting the record immutability and observability of the blockchain) and cheap (depending on the chain used). Additional claimed benefits are predictability of payments, beyond simply speed and cost. There is also the scope for automation of business logic and compliance via smart contracts, if the simple *transfer* or

⁴⁷ Although the cross-border use case is especially important, benefits are available in the domestic context also. Wider use of DLT systems also offers 24/7/365 operation which – as yet – is not typical in traditional systems. This allows weekend and overnight settlement and, indirectly, reduces capital being tied up for extended periods while settlement is delayed. As discussed below, however, reform to traditional systems continues apace – for domestic, cross-border and cross currency payments, involving the Eurosystem, national central banks and international authorities such as the BIS. One would expect these schemes to make substantial improvements to cost and speed of payments, including international payments.

transferFrom functions of common stablecoins are, on their own, inadequate.⁴⁸ Where settlement is rapid and predictable, capital and collateral can be released that might traditionally be tied up to guard against settlement risks during the cross-border leg.

In practice, the fact that a single stablecoin can be used in the intermediate step means that some costly currency conversions may also be avoided, lowering costs and making them more predictable (assuming the stablecoin peg is stable). The process may also protect recipients against debasement of a local currency if they ultimately hold balances in stablecoins. Naturally, since the most prominent stablecoins for cross border transactions are dollar denominated, this raises important issues over digital dollarisation.

Frontiers of interoperability

A variety of service providers are emerging to enable on- and off-ramping, particularly to ameliorate ongoing challenges for stablecoin distribution, interoperability and compliance. The domain is in considerable flux and appears set to grow rapidly in the coming years.

Card networks derive much of their success and convenience from their international presence and networks. While they can connect customers and merchants locally, they also connect customers and merchants across borders – across currency zones and payment jurisdictions. As such, they must in some way – directly or indirectly – be able to interact with the sort of cross border solutions for settlement that we have already discussed, such as correspondent banking rails. In fact, until recently correspondent banking rails have been the principal method.

Card networks have, however, been experimenting with various stablecoin use cases, with some products now reaching production readiness. In some cases, issuers can fulfil their settlement obligations using stablecoins, on an expanding variety of blockchains (some of which feature card networks as design partners). Networks may also send stablecoins to processors/acquirers, who can then convey the coins to merchants or to some off-ramping solutions, if the merchants prefer to hold balances in fiat. Pre-funding arrangements in both stablecoins and fiat – essentially arranging on- and off-ramping in advance – are also being rolled out, so that at the point of transaction, the payment process can be speeded up.

Card networks' familiarity with compliance requirements is also an important reason for stablecoin partnerships. Credential management, consumer protection and transaction monitoring can be extended to the digital asset context, providing the sort of robust systems that regulated entities often require and where DLT-native solutions have so far struggled.

⁴⁸ On DLT systems that follow Ethereum-like protocols essentially all stablecoins will be implemented as a form of standardised [ERC-20](#) token, which must implement methods for the controller (with a private key) of an address to *transfer* an amount from their balance to that of a counterparty and for an approved agent of the controller to *transferFrom* the balance of the controller, to another counterparty. The *transferFrom* method will frequently be used by smart contracts offering richer payment functionality than *transfer* alone, when the user calls, or induces a call, to one of the smart contract's methods. Stablecoins on other chains, even if they are not formally Ethereum compatible, will typically observe ERC-20-like functionality in the abstract.

Many of the initiatives used by card networks involve partnerships with institutions who handle key steps in the on- and off-ramping. Banking institutions are emerging that handle much of the underlying infrastructure required to implement stablecoin and traditional system integration, often by providing indirect access to traditional payments systems, such as SEPA.

A notable integration of stablecoins and traditional rails can be observed in some of SWIFT's pilots, which have focused on interoperability of traditional fiat systems with on-chain payments, and on SWIFT's possible continuing role as orchestrator. SWIFT has experimented with enabling [settlement of tokenised bond transactions](#) using the [EURCV](#) stablecoin as the cash leg, connecting messages sent via SWIFT systems to on-chain logic, to effect payment and delivery. One can point to various other traditional financial players who are also now leveraging stablecoins – from [MoneyGram](#) using USDC to implement cross border remittances, to Fidelity recently announcing the issuance of their own stablecoin, the [Fidelity Digital Dollar](#) (FIDD), to various banks issuing (or considering issuing) their own stablecoin, individually or as part of a consortium (see [EUROD](#), [AllUnity](#) and [Qivalis](#), for example, as well as the aforementioned [EURCV](#)).

Despite important stablecoin explorations by banks, however, it is tokenised deposits (or deposit tokens) that seem most likely to emerge as on-chain money issued by these institutions, which we now discuss.

Tokenised deposits and deposit tokens

Two promising forms of on-chain money currently being developed are tokenised commercial bank deposits and commercial bank deposit tokens. Tokenised bank deposits are on-chain tokens that represent underlying deposits recorded in banks' traditional ledgers. Deposit tokens are themselves the native on-chain liability of the bank to its depositor – essentially the blockchain replaces the bank's traditional "internal" ledger. Notably, JP Morgan has [recently issued a deposit token](#) (JPMD) on a public blockchain, the Ethereum Layer 2, Base (though only for JP Morgan's institutional clients, at the moment). Currently, much of the debate over these monies focuses on "tokenised bank deposits". Partly this is because the terminology is in flux and usage of the term often conflates the two concepts, but also because for the short to medium term, banks will likely continue to operate their own internal "traditional" ledgers.

In terms of how the tokens can be *used*, they can loosely be thought equivalent. Both allow the user to exploit the power of smart contracts, disintermediation, and the advantages of operating on a platform where other monies such as stablecoins, and possibly CBDC or tokenised central bank money are circulating, in addition to broader classes of tokenised assets. They are distinct, however, in the mechanics of settlement. Simplifying somewhat, in the case of deposit tokens, there is less cross ledger reconciliation (between the blockchain and underlying bank ledgers). The systems may also differ in the details of how interbank ultimate settlement is achieved in central bank money once open loop systems with deposit tokens become prevalent.

The [Partior](#) system is one example, ostensibly, of an open-loop deposit token or tokenised deposit system that is designed to be interoperable with central bank money. See also the

[Regulated Liability Network](#) for another example of a system incorporating tokenised private monies that are interoperable with central bank money.

The precise details of ultimate settlement for tokenised deposit and deposit token transactions are somewhat ambiguous, but the key point to note is that *ultimate settlement still occurs in central bank money*. In one model, in the presence of a CBDC on the same ledger, for example, a transaction in tokenised deposits (or deposit tokens) may be paired with a transfer of central bank money on the same ledger (see [Garratt and Shin \(2023\)](#) for a clear discussion of such a model). If there is no central bank money on chain, or if there is only a token *representing* underlying central bank reserves, then there would need to be more administrative steps, to bridge the ledger where the tokenised deposits (or deposit tokens) and tokenised central bank money are circulating, to the “traditional” ledger recording central bank reserve accounts. In the case of tokenised deposits, there would also need to be some sort of reconciliation approach to ensure that the trades in tokenised deposits are reflected in banks’ underlying traditional deposit ledgers.⁴⁹

In an important sense, tokenised deposits and deposit tokens are simply “deposits”. As noted, ultimate settlement continues to occur in central bank money, in one way or another (unlike in the case of stablecoins). Furthermore, they inherit the KYC and regulatory frameworks of traditional deposits – perhaps adapted for technical/operational differences, but conceptually almost unchanged. Notably, they apparently can deliver exact singleness of money in a way that stablecoins alone cannot. Again, deposit token (or tokenised deposit) transactions between people at different banks will see their respective balances in their two banks’ monies adjusted, with ultimate settlement being reached through reconciliation between banks in some form of central bank money, much as in the traditional system, despite new technologies being used.

Public infrastructure for ‘two-tier on chain’

Reflecting interest in tokenised deposits, deposit tokens and CBDC, there is ongoing work by various central banks and regulatory authorities to modernise the two-tier payments structure to exploit DLT technology. Given the longstanding desire to improve cross-border settlement, this work also comprises schemes to reform correspondent banking.

The BIS’ [Project Agora](#) explores the interaction of RTGS payments systems, tokenised asset ledgers, and tokenised deposits. Improving correspondent banking is a core element of this scheme which, broadly speaking, falls under the BIS’ [finternet](#) or [unified ledger](#) strategy.⁵⁰ The power of the approach seems to rest in the ability to standardize frameworks, contract the number of intermediaries needed, and automate a larger fraction of logic within smart

⁴⁹ In this case, there is an operational question of how the central bank’s ledger is updated – would the tokenised deposits transaction on chain be used as the messaging service to trigger interbank reserves settlements (presumably yes if reserves or some form of CBDC are themselves on-chain), or would traditional messaging methods continue to be used to ensure that the updates to underlying traditional bank deposit ledgers are reflected in appropriate reserves transactions?

⁵⁰ It is important to note that the unified ledger strategy does not literally imply a single-ledger. Instead, it is envisaged that multiple ledgers co-exist and be interoperable.

contracts. The presence of an on-chain central bank money provides the safest (presuming the tokenisation of reserves is done securely) settlement asset. In related work (in [Project Mandala](#)) there is a more explicit focus on automation of compliance via smart contracts, which presumably will be combined with the Agora framework at some point. Instant payment systems are also being connected internationally, such as in important pilots like the BIS' [Project Nexus](#), involving the central banks of India, Malaysia, the Philippines, Singapore and Thailand.

Within the Eurosystem, early work from the [Bundesbank](#), [Banca d'Italia](#) and the [Banque de France](#), has led to an ambitious [two-track plan](#) for incorporation of DLT solutions into TARGET. The two tracks entail, first, developing interoperability solutions with relatively little change to underlying TARGET services (see existing workstreams [here](#)), before, second, designing a more integrated DLT solution. The two stages have been given the monikers "Pontes" and "Appia" ([Vlassopoulos \(2025\)](#))

In the, UK pilots such as [Project Meridian](#) and [Project Meridian FX](#) have explored how to connect the Bank of England-run payments systems to external ledgers – achieving "synchronised" settlement. The broader [update to the UK RTGS systems](#) has emphasised interoperability, at least partly with a view to preserving the role of central bank money in a wholesale finance and payments system that seems increasingly likely to feature various distributed ledgers. Indeed, ongoing [collaboration](#) between the Bank of England and BIS is exploring experimental methods for using wholesale central bank money on external programmable ledgers.

All these schemes fundamentally maintain the traditional two-tier system of relying on central bank money for ultimate settlement – but they aim to bring the methods up to date, to enable innovation in payments and/or tokenisation.

7. Conclusions

Money and payments are in a state of flux – in theory and in practice. While it can be disorienting trying to keep track of the voluminous flow of new monies and new technologies, it is much easier to do so if they can be mapped to a coherent underlying framework for understanding – and a framework that also encompasses traditional systems. This note attempts to provide such a framework. Monies should not only be distinguished by who issues them or by what (if any) assets back them. They must also be distinguished by their mode of settlement. This is key in understanding the difference between stablecoins and deposit tokens of a narrow bank which, in many respects, otherwise appear very similar. As such, some awareness of the underlying settlement infrastructure is useful.

For the Eurosystem, we provide some introductory descriptions of the *current* system and briefly noted important reforms in wholesale payments – notably under the Pontes and Appia workstreams on wholesale DLT settlement. Of course, there is also the [digital euro](#) project, which is in the advanced stages of technical design and is also [progressing](#) in terms of the legislative framework for its issuance.

While stablecoins are already operational for programmable and cross-border payments, they face various challenges before they scale sustainably and safely. They also raise difficult issues over monetary sovereignty. While these challenges and issues are solved or mitigated, rapid enhancements of the traditional two-tier system, anchored in central bank money, seem set to continue. Ultimately, various monies and payment options are likely to co-exist, with user demand and freedom of choice primarily determining which rails are best suited to particular use cases.

Abbreviations

Acronym	Full Form
A2A	Account-to-account
ACH	Automated Clearing House
ASTA	Ancillary Service Technical Account
AML	Anti-Money Laundering
AMM	Automated Market Maker
ART	Asset-Referenced Token
BIC	Bank Identifier Code
BIS	Bank for International Settlements
CBDC	Central Bank Digital Currency
CEX	Centralised Exchange
CTF	Counter-Terrorism Financing
DAO	Decentralised Autonomous Organisation
DCA	Dedicated Cash Account in TARGET systems
DeFi	Decentralised Finance
DEX	Decentralised Exchange
DLT	Distributed Ledger Technology
DTCC	Depository Trust & Clearing Corporation
EBA	European Banking Authority
ECB	European Central Bank
EMI	Electronic Money Institution
EMT	Electronic Money Token
EPC	European Payments Council
EPI	European Payments Initiative
ERC-20	Ethereum Request for Comments 20 (token standard)
ESMIG	Eurosystem Single Market Infrastructure Gateway
EURC	Euro Coin (Circle's euro-pegged stablecoin)
EURS	Stasis Euro (euro-pegged stablecoin)
FMI	Financial Market Infrastructure
FX	Foreign Exchange
GFC	Global Financial Crisis
GUI	Graphical User Interface
HQLA	High Quality Liquid Assets
IBAN	International Bank Account Number
ISO 20022	International Organisation for Standardisation – Financial messaging standard
KYC	Know Your Customer
LDI	Liquidity Driven Investment
MCA	Main Cash Account in TARGET systems
MiCA	Markets in Crypto-Assets Regulation
P2P	Peer-to-Peer
PoS	Point of Sale
PSP	Payment Service Provider
RTGS	Real-Time Gross Settlement
SCT	SEPA Credit Transfer
SCT Inst	SEPA Instant Credit Transfer
SDD	SEPA Direct Debit
SEPA	Single Euro Payments Area
SIPS	Systemically Important Payment System
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TARGET	Trans-European Automated Real-time Gross settlement Express Transfer
TIPS	TARGET Instant Payment Settlement
T2	TARGET2 (RTGS component of TARGET)
T2S	TARGET2-Securities
USDC	USD Coin (Circle's dollar-pegged stablecoin)
USDT	USD Tether (Tether's dollar-pegged stablecoin)

Glossary of Key Terms

Short definitions are provided for beginner and intermediate readers. Terms are listed alphabetically.

Atomic Settlement

A settlement mechanism in which all legs of a transaction succeed or all fail together – often enabled by smart contracts on DLT systems – eliminating the risk that one party pays but the other does not deliver.

Bearer Instrument

A financial asset (such as cash or many crypto tokens) whose ownership is determined by possession, meaning whoever holds the instrument can exercise the associated rights.

Central Bank Reserves

Deposits held by commercial banks in accounts at the central bank; the safest and most liquid form of money, used as the ultimate settlement asset in interbank transactions.

Clearing

The process of transmitting, reconciling, and in some cases netting the information about financial transactions between counterparties before final settlement takes place.

Collateral

Collateral is an asset or property offered by a borrower to a lender as security for a loan/liability, which the lender can seize and sell to recover their losses if the borrower fails to make good on the loan/liability.

Correspondent Banking

An arrangement whereby one bank (the correspondent) holds accounts and provides services on behalf of another bank (the respondent) in a different country or currency area, enabling cross-border payments.

Deferred Net Settlement (DNS)

A settlement model in which multiple transactions between parties are accumulated over a period and then netted, with only the net positions settled at a specified time – contrasted with RTGS.

Deposit Token

A blockchain-native liability of a commercial bank to its depositor, where the blockchain itself serves as the bank's ledger rather than records on the bank's own systems.

Depeg

A breakdown in the 1:1 exchange rate between a stablecoin and its reference asset (e.g., the euro), which can be temporary or persistent and may signal stress in a stablecoin's backing or governance.

Distributed Ledger Technology (DLT)

A class of technologies in which records are maintained and updated simultaneously across multiple nodes or participants, with no single central administrator – blockchains are a prominent example.

E-Money

Electronically stored monetary value that represents a claim on the issuer, issued on receipt of funds; regulated in the EU under the Electronic Money Directive and distinct from bank deposits.

Finternet / Unified Ledger

A BIS concept for a future financial system built on interoperable tokenised ledgers where central bank money, commercial bank deposits, and other assets can be exchanged programmatically under a common set of rules.

Haircut

A risk-management discount applied to the face value of collateral pledged to a central bank or counterparty, reflecting the asset's liquidity and price-volatility risk.

Legal Finality

The point at which a payment or transfer is irrevocable and binding under law, regardless of the circumstances of either party; distinct from technical finality, which reflects only the update of a system's records.

Liquidity Savings Mechanism (LSM)

A feature of some RTGS systems that temporarily queues payments and offsets them against incoming payments, reducing the total amount of reserves needed to settle a given set of transactions.

Narrow Bank

A financial institution that backs all customer deposits with high-quality liquid assets (typically central bank reserves), rather than backing them with assets such as loans, with greater credit and liquidity risks; often proposed as a structural analogue to reserve-backed stablecoin issuers.

Netting

The aggregation and offsetting of multiple payment obligations between counterparties so that only the net amount needs to be transferred, reducing total liquidity demands.

Off-Ramping

The process of converting on-chain digital assets (e.g., a stablecoin) into fiat money held in a traditional bank account, typically via a centralised exchange or payment intermediary.

On-Ramping

The process of converting fiat money into on-chain digital assets (e.g., stablecoins), enabling participation in blockchain-based payment or financial systems.

Oracle

A trusted service that provides real-world data (such as asset prices or exchange rates) to a smart contract on a blockchain, allowing the contract to reference off-chain information in its logic.

Programmable Money / Smart Contract

Code stored and executed on a blockchain that automatically enforces the terms of an agreement – such as releasing payment when a delivery condition is met – without requiring a trusted intermediary.

Public Key / Private Key

A cryptographic pair central to blockchain security where the public key implies a shareable address to identify and receive assets, while the related private key acts

as a digital signature that must remain secret to authorize and broadcast outgoing transactions on behalf of the public address.

Real-Time Gross Settlement (RTGS)

A payment system in which transactions are settled individually and immediately in central bank money as they occur, rather than being netted or deferred.

Singleness of Money

The principle that different forms of a currency (cash, bank deposits, reserves) transact at par with one another, maintaining a unified unit of account; violations occur when a stablecoin trades below or above its pegged value.

Stablecoin

A crypto-asset designed to maintain a stable value relative to a reference asset (commonly a fiat currency such as the US dollar or euro), typically backed by fiat reserves, other crypto-assets, or algorithmic mechanisms.

Stablecoin Sandwich

An informal term for a cross-border payment architecture in which fiat money is on-ramped to a stablecoin (the 'filling'), transferred on-chain, and then off-ramped back to fiat at the destination – typically replacing the correspondent banking leg(s).

Settlement Asset

The money or instrument used to extinguish a payment obligation between parties; central bank reserves are the conventional benchmark settlement asset in modern economies.

Tokenised Deposit

A blockchain-based token that represents a claim on an underlying deposit recorded in a commercial bank's traditional ledger, distinct from a deposit token where the blockchain hosts the ledger.

Travel Rule (FATF)

A Financial Action Task Force requirement that obligates payment service providers and virtual asset service providers to pass on identifying information about the originator and beneficiary of transactions above certain thresholds.

Two-Tier Monetary System

The structure in modern economies where central banks issue base money (reserves and cash) and commercial banks create deposit money by extending credit.

Wallet (Crypto)

Software or hardware that stores a user's private keys and interacts with a blockchain to send, receive, and manage digital assets; may follow a self-custody model (user controls keys) or the wallet may be controlled by an exchange or other institution on the user's behalf

References

- Ahmed, R. and Aldasoro, I. 2025. "[Stablecoins and safe asset prices.](#)" BIS Working Paper No. 1270.
- Andolfatto, D. 2015. "[Fedcoin: On the desirability of a government cryptocurrency.](#)" Blog post.
- Aramonte, S., Huang, W. and Schrimpf, A. 2021. "[Trading in the DeFi era: automated market-maker.](#)" BIS Quarterly Review, December 2021.
- Arseneau, D. et al. 2025. "[Central Bank Liquidity Facilities Around the World.](#)" FEDS Notes, Federal Reserve Board.
- Barbon, A. and Ranaldo, A. 2024. "[On the quality of cryptocurrency markets: Centralized versus decentralized exchanges](#)". SSRN Working Paper.
- Bidder, R. 2025a. "[Taking the Next Step: What is the Future of Stablecoins, and How do We Get There?](#)". SSRN Working Paper.
- Bidder, R. 2025b. "Singleness of money: Towards a nuanced debate". Chapter in CEPR Press book, "[Frontiers of Digital Finance](#)", edited by Dirk Niepelt
- Bindseil, U. and Malekan, O. 2025. "[Public crypto networks as financial market infrastructures.](#)" SSRN Working Paper.
- Bank for International Settlements. 2022. "[SWIFT gpi data indicate drivers of fast cross-border payments.](#)" BIS CPMI.
- Bank for International Settlements. 2024. "[Next generation correspondent banking.](#)" BIS Bulletin No. 87.
- Bank of England. 2014. "[Money creation in the modern economy.](#)" Bank of England Quarterly Bulletin, Q1 2014.
- Bank of England -MIT Digital Currency Initiative. 2025. "[Enhancing the Privacy of a Digital Pound](#)". Bank of England / MIT.
- Briola, A. et al. 2023. "[Anatomy of a Stablecoin's failure: The Terra-Luna case.](#)" Finance Research Letters
- Cipollone, P. 2025. "[Harnessing the digital future of payments: Europe's path to sovereignty and innovation](#)". BIS Review.
- Committee on Payment and Settlement Systems. 2003. "[The role of central bank money in payment systems.](#)" Bank for International Settlements.
- Cyfrin. 2024. "[What Is Blockchain Interoperability: A Complete Guide](#)". Cyfrin Blog.

- Drechsler, I. 2022. "[Blockchain Basics: A Non-Technical Introduction in 25 Steps.](#)" Apress (ISBN-13: 978-1484226032)
- European Central Bank. 2024a. "[Collateral management in Eurosystem credit operations](#)". European Central Bank.
- European Central Bank. 2024b. "[ECB takes steps to improve efficiency of retail payments market by giving non-bank payment service providers access to its TARGET Services](#)". European Central Bank Press Release.
- European Central Bank. 2025. "[The Eurosystem's instruments](#)". European Central Bank webpages.
- Everington, J. 2023. "[Solving correspondent banking's woes](#)". The Banker.
- Fisher, P. 2012. "[Liquidity support from the Bank of England – the Discount Window Facility](#)." Bank for International Settlements Review.
- Garratt, R., Lee, M.J., Malone, B. and Martin, A. 2020. "[Token- or Account-Based? A Digital Currency Can Be Both.](#)" Liberty Street Economics, Federal Reserve Bank of New York.
- Garratt, R. and Shin, H.S. 2023. "[Stablecoins versus tokenised deposits: implications for the singleness of money.](#)" Bank for International Settlements Bulletin No. 73.
- Goel, T. 2024. "[The search for tokenised money: how about reserve-backed tokens?](#)" SUERF Policy Note.
- Herbst-Murphy, S. 2013. "[Clearing and Settlement of Interbank Card Transactions: A MasterCard Tutorial for Federal Reserve Payments Analysts.](#)" Federal Reserve Bank of Philadelphia Discussion Paper.
- International Monetary Fund. 2025. "[Blockchain Consensus Mechanisms: A Primer for Supervisors \(2025 Update\).](#)" IMF Working Paper.
- JP Morgan. 2024. "[Project EPIC: Fueling Tokenized Finance with On-Chain Enterprise Privacy, Identity, and Composability.](#)" JP Morgan Kinexys.
- Kosse, A. et al. 2023. "[Will the real stablecoin please stand up?](#)" Bank for International Settlements CPMI Papers No. 141.
- Lee, M.J., Martin, A. and Thampuran, P. 2022. "[What Is Atomic Settlement?](#)" Liberty Street Economics, Federal Reserve Bank of New York.
- Lipton, A. and Treccani, A. 2021. "[Blockchain and Distributed Ledgers: Mathematics, Technology and Economics](#)", World Scientific (ISBN-13: 978-9811221521).

- Ma, Y., Zeng, Y. and Zhang, A. 2025. "[Stablecoin Runs and the Centralization of Arbitrage.](#)" NBER Working Paper No. 33882.
- Panetta, F. 2025. "[Invisible yet essential: the contribution of cross-border payments to a better world and a safer financial system.](#)" Bank for International Settlements Review.
- Rice, T., von Peter, G. and Boar, C. 2020. "[On the global retreat of correspondent banks.](#)" Bank for International Settlements Quarterly Review, March 2020.
- Schär, F. 2024. "[Enhancing financial services with permissionless blockchains.](#)" Publications Office of the European Union.
- Statista. 2025. "[Payment card scheme market share in Europe by country.](#)" Statista.
- SWIFT. 2019. "[ISO 20022: Better data means better payments - Why correspondent banking needs ISO 20022 now.](#)" SWIFT White Paper.
- SWIFT. 2024. "[SWIFT cross-border payment processing speed stretches further ahead of G20 target.](#)" SWIFT Press Release.
- van Hee, C., Mehrotra, A. and Tham, T. 2025. "[Let's speak the same language: a formally defined model to describe and compare payment system architectures.](#)" BIS Working Paper No. 1259.
- Visa. 2024. "[Visa USA Interchange Reimbursement Fees.](#)" Visa.
- Vlassopoulos, T. 2025. "[Making wholesale central bank money fit for the digital age.](#)" Keynote address, European Central Bank.
- World Economic Forum. 2020. "[Inclusive Deployment of Blockchain for Supply Chains: Part 6 – A Framework for Blockchain Interoperability.](#)" World Economic Forum.
- Wise. 2016. "[TransferWise the first tech company with direct access to UK Faster Payments Service.](#)" Wise Blog.
- Wise. 2024. "[Wise vs international bank transfers.](#)" Wise Blog.
- Wise. 2025. "[Modernising cross-border payments.](#)" Wise Blog.
- World Bank. 2021. "[Blockchain Interoperability.](#)" World Bank Report.

T: +353 (0)1 224 5800
E: enquiries@centralbank.ie
www.centralbank.ie



Banc Ceannais na hÉireann
Central Bank of Ireland

Eurosystem