Edited by Dirk Niepelt

Frontiers of Digital Finance

Frontiers of Digital Finance

CEPR

WITH SUPPORT OF CEPR PARIS FOUNDING PARTNERS

AXA Research Fund

BANQUE DE FRANCE
EUROSYSTÈME

MINISTÈRE DE L'ÉCONOMIE, DES FINANCES ET DE LA SOUVERAINETÉ INDUSTRIELLE ET NUMÉRIQUE
Liberté
Égalité
Fraternité
Direction générale du Trésor

MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR ET DE LA RECHERCHE
Liberté
Égalité
Fraternité

Région îledeFrance

CHOOSE PARIS REGION

SciencesPo

CEPR PRESS

Centre for Economic Policy Research
187 boulevard Saint-Germain
75007, Paris, France

2 Coldbath Square
London EC1R 5HL, UK

Tel: +44 (0)20 7183 8801
Email: cepr@cepr.org
Web: www.cepr.org

ISBN: 978-1-912179-98-5

Frontiers of Digital Finance

Edited by Dirk Niepelt

CEPR PRESS

CENTRE FOR ECONOMIC POLICY RESEARCH (CEPR)

The Centre for Economic Policy Research (CEPR) is a network of almost 1,900 research economists based mostly in European universities. The Centre's goal is twofold: to promote world-class research, and to get the policy-relevant results into the hands of key decision-makers. CEPR's guiding principle is 'Research excellence with policy relevance'. It was founded in the UK in 1983, where it is a Charity, and in November 2019 CEPR initiated the creation of an Association under French law, in order to provide a vehicle for an expansion in France. The members of the Conseil d'Administration of the Association are identical to the UK Board of Trustees.

CEPR is independent of all public and private interest groups. It takes no institutional stand on economic policy matters and its core funding comes from its Institutional Members, projects that it runs and sales of publications. Because it draws on such a large network of researchers, its output reflects a broad spectrum of individual viewpoints as well as perspectives drawn from civil society. CEPR research may include views on policy, but the Trustees/members of the Conseil d'Administration of the Association do not give prior review to its publications. The opinions expressed in this report are those of the authors and not those of CEPR.

Contents

Part III: Monetary singleness

Part IV: Tokenisation, platforms, credit, and decentralised finance

Foreword

New technologies are rapidly reshaping international finance, with the digitalisation of payment, trading, and settlement systems now challenging traditional financial institutions. Across 20 chapters, contributed by top researchers and policymakers, *The Frontiers of Digital Finance* explores the major themes of a transformation shaped by fintech innovation and government initiatives. Edited and introduced by the leader of CEPR's Fintech and Digital Currencies Research and Policy Network, Dirk Niepelt, the volume discusses diverse regional perspectives, and acts as an accessible yet detailed guide to current problems, solutions, and policy hurdles as the world shifts to digital finance. The chapters cover four main topics:

- **The implementation of digital financial systems in both developing and advanced economies**. How have different regions implemented aspects of digital finance? How do concerns about privacy impact digitalisation, especially in the euro area? How have digital innovations shaped financial inclusion in developing economies?
- **The evolution of stablecoins and the subsequent regulatory debate**. How have stablecoins become a major segment of digital finance? Do the EU MiCA Regulation and the US GENIUS Act address the risks posed by stablecoins? What about multi-issuer stablecoins?
- **Monetary cohesion**. How is monetary singleness impacted by digitalisation? What can be done to address the risks to financial stability inherent in digital finance instruments that operate outside traditional monetary systems?
- **Tokenisation, digital platforms, and decentralised finance (DeFi)**. What impact do these developments have on service bundling, credit allocation, financial inclusion, and consumer protection?

The book is an output from CEPR's Research and Policy Network on FinTech and Digital Currencies, which was established in 2018 to generate, coordinate and disseminate impactful research about the optimal policies to deal with these fast-moving changes in financial markets.

CEPR would like to thank Dirk Niepelt for his expert editorship of this eBook. Our thanks also go to Anil Shamdasani for his skilled handling of its production, and to Rhea Bhatia for her efforts in administering the network's activities.

As always, CEPR remains committed to providing a platform for balanced and expert perspectives on pressing economic issues, but itself takes no institutional positions on matters related to economic policy.

Tessa Ogden
CEO, CEPR
November 2025

Introduction

Dirk Niepelt
University of Bern and CEPR

The digitisation of payment, trading, and settlement systems is reshaping the financial architecture. New technologies are transforming how value is created, stored, transferred, and accounted for, altering the balance between public and private money, enabling the bundling of services, challenging traditional financial institutions, and prompting a wave of regulatory and institutional responses.

The global picture is uneven. Some regions are leapfrogging others, and conflicting ideologies about the proper role of the state in money give rise to fragmentation and concerns about monetary sovereignty.

This book offers an overview of major trends, as analysed by leading researchers and policymakers. It is structured in four parts. Part 1 presents regional perspectives, examining the approaches taken by India, Brazil, sub-Saharan Africa, the United States, and the euro area. For the euro area, the focus is on the digital euro and its implications for monetary sovereignty, privacy, and holding limits aimed at preserving financial stability.

Part 2 delves into stablecoins – the shooting stars in the digital financial ecosystem. Their evolution has spurred a flurry of policy debate, with the European Union's Markets in Crypto-Assets Regulation (MiCAR) and the US GENIUS Act now offering greater regulatory clarity.

Part 3 turns to the concept of monetary 'singleness' – the principle that all forms of money in a currency area should be fully interchangeable and trade at par. As new digital forms of money proliferate, the cohesion of the monetary system may be called into question.

Part 4 brings together chapters on tokenisation, digital platforms, and decentralised finance (DeFi), and their broader impact on service bundling, credit allocation, financial inclusion, and consumer protection.

REGIONAL PERSPECTIVES

In the opening chapter of Part 1, Amiyatosh Purnanandam describes how India's Unified Payments Interface (UPI), launched in 2016, has improved the efficiency of account-based payment systems by addressing the core frictions of information exchange, authentication, and final settlement. Developed under a public-private partnership, UPI enables real-time, low-cost, and interoperable digital payments between any two entities, regardless of their bank or payment service provider. India overcame challenges around identity verification and financial inclusion by implementing a

nationwide system of digital, biometric-based identification and by expanding access to bank accounts for large segments of the unbanked population. These developments, alongside digital infrastructure investments and regulatory support for private sector participation, allowed UPI to lower transaction costs and provide small businesses with digital transaction histories that improved access to credit.

Purnanandam highlights how demonetisation and the COVID-19 pandemic accelerated the adoption of UPI. The system's interoperable design allows users to choose among competing apps, reinforcing network effects and encouraging innovation. Early adoption by banks in some areas led to persistent increases in digital payment usage. Moreover, UPI has enabled streamlined welfare disbursements, with nearly 60% of subsidy payments being delivered directly into beneficiary accounts by 2024. According to Purnanandam, the UPI experience demonstrates the critical role of coordinated efforts across public and private sectors, along with a flexible and inclusive regulatory framework.

Fabio Araujo and Arnildo da Silva Correa describe the Central Bank of Brazil's comprehensive innovation strategy, Agenda BC#, fostering tokenisation and integration to enable faster, more transparent, and programmable asset transfers. The agenda is built around four interlinked pillars: (1) Pix, an instant payment system launched in 2020, which also supports a 'synthetic' retail central bank digital currency (CBDC) model; (2) Open Finance, which promotes secure data sharing and competition; (3) Drex, Brazil's central bank digital currency designed as a platform for a tokenised economy; and (4) the internationalisation of the Brazilian real, through regulatory modernisation and cross-border interoperability. Each component reinforces the others, creating a cohesive, digital financial ecosystem that enhances efficiency, security, innovation, and inclusivity.

Pix marked the foundational shift, offering a public infrastructure for instant, programmable payments that has been widely adopted across Brazil and credited with improving financial inclusion and spurring innovation. Open Finance expanded the ecosystem by allowing consumers to share financial data among institutions, unlocking more tailored services and competitive offerings. Drex builds on this by introducing distributed ledger technology, enabling advanced programmability, atomicity, and secure, tokenised deposits while incorporating privacy safeguards such as zero-knowledge proofs. Finally, internationalisation efforts are aligning domestic systems with global standards. Together, these initiatives aim to create a user-centric financial system where services are accessed through intelligent aggregators, enhanced by AI and driven by user-controlled data.

Luca Ricci and co-authors describe how digital innovations are reshaping the payment landscape across sub-Saharan Africa, facilitating financial inclusion, payment efficiency, lower remittance costs, and reduced informality. Private mobile money has been particularly impactful, with account ownership far outstripping the growth of traditional bank accounts. While central bank digital currencies, fast payment systems,

and crypto assets are debated (with Nigeria having already launched the eNaira), their broader adoption is held back by weak digital infrastructure, limited institutional capacity, low levels of financial and digital literacy, and the high costs of system deployment. Cross-border payments remain slow and costly, and fragile governance frameworks heighten concerns about consumer protection, data privacy, and financial integrity.

To address these challenges, the authors outline four policy priorities: (1) investment in infrastructure and skills; (2) supporting private innovation within secure and competitive regulatory frameworks that enable interoperability and reinforce governance; (3) positioning public digital tools to complement – rather than compete with – private solutions, based on assessments of market gaps and resource needs; and (4) fostering regional and international coordination to ensure interoperability and resilience. Ultimately, digital payment reforms must be anchored in sound macroeconomic policies that preserve monetary sovereignty and financial stability.

Michael Lee argues that the 2025 Executive Order on digital financial technology and the GENIUS Act represent a strategic shift in the United States towards private sector-driven innovation in blockchain-based financial systems. The Executive Order rules out the development of a CBDC while endorsing a technology-neutral approach and regulatory clarity for stablecoins. The GENIUS Act establishes a federal framework for fiat-backed payment stablecoins, mandating at-par redemption, backing primarily by US dollar cash and cash equivalents, and regulatory oversight. Regarding the more than 340 stablecoins in circulation – 97% dollar-denominated and dominated by Tether and Circle – concerns remain over reserve transparency, and redemption practices vary widely.

Beyond stablecoins, Lee describes the increasing tokenisation of Treasury funds and commercial bank deposits. Tokenised US Treasury funds are largely held by long-term investors or used as on-chain reserves. Deposit tokens and tokenised deposits typically align with existing regulatory standards – including full know-your-customer (KYC)/anti-money laundering (AML) compliance and access via whitelisting – and can pay interest. In contrast, stablecoins circulate more freely (issuers functionally manage a whitelist only at the issuance stage) but are barred from offering interest directly under the GENIUS Act; however, issuers often partner with platforms to indirectly deliver yield. Together, these instruments form a spectrum, each balancing accessibility and return in different ways.

Ulrich Bindseil and Piero Cipollone argue that central bank electronic cash (CBEC) is essential to preserving monetary sovereignty, as private (often foreign) service providers increasingly dominate retail payments. This carries significant risks: rising payment costs due to oligopolistic market power, reduced financial and monetary stability, loss of seignorage income, and increased vulnerability to geopolitical risks. Bindseil and

Cipollone present CBEC not as a disruption but as a necessary evolution to ensure the continued public provision of a neutral, secure, and sovereign monetary instrument that is designed to complement rather than replace commercial bank money.

The authors emphasise that monetary sovereignty faces new threats from globalisation, the advent of new technologies such as public blockchains, and a surge of nationalism that dismisses the merits of international co-operation. CBEC helps counter these threats across five dimensions: it protects macro-financial stability by preventing dollarisation; it ensures access to payment systems without abuse of market power; it preserves seigniorage income and the financial independence of central banks; it reduces strategic dependencies on foreign actors; and it protects informational sovereignty by avoiding overreliance on foreign-owned platforms.

Maarten van Oordt argues that the accelerating shift away from cash in the euro area is driving a significant erosion of privacy in payments. Unlike cash, electronic payments generate detailed records that are monitored by payment service providers and subjected to regulatory oversight. These data are not only used for compliance but also for commercial purposes, and they can be leveraged not just to monitor but also to censor or exclude individuals. The author emphasises that common justifications for payment surveillance – such as crime prevention and tax enforcement – do not automatically warrant broad monitoring powers in a democratic society.

Van Oordt does not expect the currently proposed digital euro design, which includes both online and offline payment options, to close the growing 'privacy gap' in retail payments. Online digital euro payments would be processed centrally, offering little improvement over existing systems, and, depending on the robustness of pseudonymisation techniques, could even exacerbate privacy risks. Offline payments, while potentially more private, face challenges such as usage limits and unresolved security concerns. Without critical amendments – such as enabling remote payments through offline balances or designing online payments to emulate the anonymity of cash – the author foresees the digital euro as heightening surveillance risks. He stresses that privacy in payments is a public good and warns that failing to safeguard it in the digital age would squander a crucial opportunity to redesign the financial system in such a way that upholds individual autonomy and democratic values.

Katrin Assenmacher and Oscar Soons explain that the European Commission's June 2023 legislative proposal tasks the European Central Bank (ECB) with developing instruments to limit the use of the digital euro as a store of value, including the introduction of individual holding limits. These limits are intended to balance three objectives: enabling convenient payments; ensuring smooth monetary policy transmission; and safeguarding financial stability. The authors describe the ECB's methodology for calibrating these limits so they are high enough for payment use but low enough to prevent significant bank deposit outflows that could destabilise funding structures.

To assess the appropriate holding limits, the ECB considers both a business-as-usual scenario – where the digital euro is mainly used for payments – and a flight-to-safety scenario, which involves mass withdrawals from banks during crises. Surveys and econometric analyses yield a broad range of estimates for digital euro demand. However, even under conservative assumptions, research indicates that large deposit outflows would likely only arise if individual holding limits exceeded €5,000, at which point banks would need to rely more heavily on central bank or market-based funding to manage liquidity pressures.

STABLECOINS

In the first chapter of Part 2, Hans Gersbach, Hugo van Buggenum, and Sebastian Zelzner discuss how stablecoins – digital assets pegged to fiat currencies – have rapidly evolved from niche instruments into a major segment of digital finance. While fiat-backed stablecoins promise to combine the technological advantages of crypto with the stability of traditional money, depegging episodes underscore their vulnerability to run risks due to illiquid reserves, limited issuer commitment, and noisy market signals. Trading on active secondary markets can mitigate run incentives by giving holders alternative exit options when redemptions are restricted.

The authors discuss how the EU MiCA Regulation and the US GENIUS Act address systemic risks posed by stablecoins, focusing on reserve quality, redemption rights, and transparency. They suggest that well-designed redemption restrictions – such as gates or fees – should be permitted to prevent destabilising runs. They also caution against the remuneration of stablecoins, as interest payments could trigger destabilising competitive dynamics and coordination failures across issuers, and examine potential effects on banks, monetary policy transmission, and overall financial stability.

Rodney Garratt highlights the dramatic growth of the US dollar-denominated stablecoin market and the fundamental regulatory shift that now encourages institutional participation, including by commercial banks. The author expects the entry of traditional financial institutions to reshape the competitive landscape, with banks serving their regulated clients via public blockchain-based payment rails, while existing issuers continue to operate within the crypto ecosystem.

Garratt likens stablecoins to digital travellers' cheques – clearing instruments redeemable at par but not tied to individual account holders. As banks enter the space, redemption frictions and interoperability challenges echo historical issues from the pre-clearinghouse era of cheque processing. He argues that a universal stablecoin clearing system will be crucial for broader adoption, ensuring fungibility and monetary singleness across issuers. While stablecoins may not offer clear advantages in many domestic use cases – given the rise of real-time payment systems – he sees potential in global, programmable transactions, particularly for corporate users needing low-cost,

high-speed, cross-border payments. Garratt predicts bank-issued stablecoins will have short lifecycles, acting as temporary payment instruments rather than long-term stores of value.

Steve Cecchetti and Kermit Schoenholtz compare stablecoins and tokenised deposits within the context of the new US regulatory framework. They note that although the GENIUS Act prohibits interest payments to holders, limits eligible reserve assets, and enforces compliance with KYC, AML, and anti-terrorist financing (ATF) standards, it still contains significant regulatory gaps. Platforms can circumvent the interest ban by offering yield-like 'rewards'; reserve requirements permit exposure to run-prone assets like prime money market funds and uninsured bank deposits; and enforcing illicit-use restrictions is particularly challenging for users of noncustodial wallets. Most notably, the absence of capital requirements raises doubts about the ability of stablecoins to serve as safe, information-insensitive assets under stress.

According to the authors, tokenised bank deposits offer a more stable and robust alternative, combining the legal protections of traditional bank deposits with features such as programmable settlement, real-time clearing, and blockchain interoperability. Because they are issued by regulated, FDIC-insured banks with central bank access, tokenised deposits are shielded from many of the structural vulnerabilities that afflict stablecoins. Moreover, they offer stronger privacy protections, reduce cross-border redemption risks, and more easily support multiple currencies – mitigating concerns around dollar dominance.

David Andolfatto explores the role of Tether (USDT) in the evolving landscape of private digital money, highlighting both its utility and its vulnerabilities. Pegged to the US dollar while operating outside the traditional banking system, Tether fills critical roles in blockchain-based asset trading, cross-border payments, and as a dollar substitute in emerging markets. While verified institutional users are entitled to par redemption, retail users depend on secondary market liquidity. This two-tier structure and the absence of regulatory oversight raise financial stability concerns.

Despite claims of full reserve backing, primarily in short-term US Treasuries, Tether's transparency is limited to attestations, and it is legally structured to avoid US regulation. But Andolfatto argues that Tether's reliance on Cantor Fitzgerald, a US-regulated primary dealer, presents a policy window for oversight and systemic risk mitigation. In particular, US policymakers could require Cantor to act as a fiduciary, using its Federal Reserve master account to tighten reserve management, and applying existing AML/KYC standards.

Richard Portes argues that the multi-issuer stablecoin model (MISC), where a stablecoin is issued jointly by EU-regulated institutions and third-country entities, presents serious financial stability risks and regulatory challenges. This arrangement, not explicitly foreseen under the MiCA regulation, creates loopholes for regulatory arbitrage, fragmented reserve management, and accountability confusion, particularly

during redemption runs or crises. The fungibility of tokens across jurisdictions allows issuers and holders to treat them as interchangeable, even though only part of the system is subject to EU rules, reserves may be ringfenced abroad during stress, and redemptions could be unequally honoured.

Portes sees several policy options, including banning MISCs outright, amending MiCA to explicitly regulate cross-jurisdiction co-issuance, or developing global regulatory standards. He notes that some EU policymakers have voiced strong opposition to MISCs, and warns that regardless of the legislative path chosen, urgent supervisory and legal adaptations are needed to preserve financial stability, close regulatory gaps, and uphold MiCA's credibility in a globalised crypto-financial system.

Harald Uhlig compares European plans for a CBDC and the US strategy to promote privately issued stablecoins. While the ECB sees CBDC as a way to modernise cash, preserve monetary sovereignty, and reduce dependence on foreign payment providers, the US approach possibly reflects stronger trust in markets and concerns about government overreach and privacy. Despite these different strategies, the author notes a fundamental convergence: both digital currencies must avoid paying interest and may ultimately rely on central bank backing to ensure safety and stability.

Uhlig is critical of the US regulatory framework that prevents stablecoins from becoming robust and competitive – particularly the denial of Federal Reserve master accounts and interest payments, which would allow them to operate like fully reserved narrow banks. He warns that this creates stablecoins that are 'fragile by design', as illustrated by recent depegging events. He also highlights the inconsistency of paying interest on bank reserves but not on digital cash held by the public, viewing it as a concession to the traditional banking sector. While stablecoins may offer innovative features like smart contracts and programmable payments, their growth could generate international tensions. Ultimately, Uhlig sees stablecoins and CBDCs as part of ongoing creative destruction in finance – technological progress that doesn't eliminate but instead relocates deeper structural tensions like liquidity risk and maturity mismatches.

MONETARY SINGLENESS

In the first chapter of Part 3, Rhys Bidder explores the principle of singleness of money – the idea that all forms of money within a currency area, including bank deposits and digital tokens, should trade at par with the central bank's unit of account. In the traditional two-tier banking system, singleness is maintained through central bank infrastructure and liquidity support, ensuring trust and stability. In contrast, stablecoins and DeFi instruments operate outside these systems, making minor deviations from par common.

Bidder argues that these small fluctuations are not inherently problematic and may fade as technology, transparency, and market infrastructure improve. The real concern lies in large depegs during periods of stress, such as during the 2023 US banking crisis,

which exposed the fragility of stablecoins under liquidity pressure. To address this, he proposes that stablecoins backed by high-quality assets be granted conditional access to emergency liquidity facilities. Rather than fixating on minor price noise, the policy debate should focus on preventing systemic instability during times of stress.

Jonathan Chiu and Cyril Monnet similarly examine the concept of monetary singleness. Their starting point is the common concern among central banks that programmable digital currencies – whose use can be restricted through embedded rules – could undermine singleness by creating distinctions among tokens of equal face value. This concern has led central banks to dismiss digital currencies incorporating programmability. In contrast, the authors argue that programmability can enhance economic efficiency and that the loss of singleness may be an acceptable – or even desirable – feature in certain contexts.

Chiu and Monnet observe that, under perfect information, token prices would adjust to reflect differences in restrictions, enabling efficient allocations despite the loss of singleness. In such cases, prohibiting programmability would reduce welfare. However, under imperfect information, adverse selection may arise, with unrestricted tokens effectively subsidising restricted ones. As these distortions grow, the welfare gains from programmability diminish. The authors challenge the conventional view – often informed by the US free banking era – that non-uniform money necessarily leads to inefficiency. Instead, they advocate for a nuanced regulatory approach, such as Pigouvian taxes on excessive programmability or incentives to enhance token transparency.

TOKENISATION, PLATFORMS, CREDIT, AND DECENTRALISED FINANCE

In the first chapter of Part 4, Jon Frost, Leonardo Gambacorta, Anneke Kosse, and Peter Wierts argue that tokenisation – the digital representation of assets on programmable platforms – has the potential to improve the efficiency and functionality of the financial system. The tokenisation of money, including central bank money and commercial bank deposits, could be a first step, while stablecoins fall short in the authors' eyes on stability, liquidity, and regulatory compliance. They suggest building on the existing two-tier monetary system and integrating tokenisation with central bank money to ensure trust and safety.

The authors also see potential for tokenisation to enhance capital markets – particularly in bond issuance – by reducing costs and improving liquidity. However, they also point to risks stemming from legal uncertainty, operational vulnerabilities, and the concentration of multiple functions on single platforms. Governance challenges and poor interoperability with legacy systems further complicate adoption. In the authors' view, both public and private sectors have roles to play in managing these risks and enabling tokenisation to contribute meaningfully to financial safety and efficiency.

Emre Ozdenoren and Kathy Yuan explore how tokenised money – digital currencies issued or guaranteed by central banks or private platforms – can transform financial systems by automating transactions, reducing information frictions, and enhancing liquidity. Unlike traditional digital payment instruments, tokenised money incorporates smart contracts, enabling automatic enforcement of contractual terms without intermediaries. It serves a dual function as both a payment method and a collateral asset for financial contracts, offering greater efficiency, security, and traceability. Its programmability reduces human error, minimises fraud, and lowers custodial and settlement costs, particularly in complex financial transactions involving future obligations.

Ozdenoren and Yuan describe how tokenised money acts as a collateral multiplier, expanding the supply of secure and transparent assets while reducing reliance on sovereign bonds – thereby mitigating systemic risks such as the 'dash for cash' or the sovereign-financial doom loop. Tokenisation also enables the creation of secondary markets, closely integrating funding and market liquidity. While it introduces new risks, including cybersecurity threats and novel financial vulnerabilities, its potential benefits – and seigniorage opportunities for issuers – position tokenised money as a foundational element of future financial infrastructure.

Markus Brunnermeier and Jonathan Payne similarly stress the role of digital payment ledgers in offering a powerful new mechanism to expand access to credit by embedding repayment directly into digital transaction systems. Turning future revenues into 'digital collateral', these systems promise to relax borrowing constraints, but their potential is shaped less by technology than by institutional design and confronts a trilemma: no arrangement can simultaneously ensure strong enforcement, limit private rent extraction, and preserve user privacy. According to the authors, this trilemma lies at the heart of the evolving financial architecture.

Brunnermeier and Payne compare three institutional approaches. The first is BigTech platforms, which can enforce repayment by controlling trade and payment flows, using proprietary tokens and internal ledgers, but create risks of monopoly power and privacy loss. The second is public options – from basic infrastructure like FedNow to full programmable CBDCs – that can serve as inclusive, transparent alternatives, but may weaken enforcement or require trade-offs on privacy. The third approach is regulatory 'co-opetition' between platforms, which encourages enforcement through shared data and coordinated default tracking, while using competition to suppress rents. All these models face technical and governance complexities, particularly in enforcing privacy and limiting systemic risk. The authors conclude that, ultimately, expanding access to credit through digital payment systems demands a nuanced balance across enforcement, rent extraction, and privacy.

Wenqian Huang describes how DeFi is transforming financial infrastructure by enabling trading and lending without traditional intermediaries. At the core of this system are decentralised exchanges and lending protocols that use smart contracts to

automate market functions. Decentralised exchanges replace order books with pooled liquidity and algorithmic pricing, enabling large trades with minimal price dislocation for near-par instruments like stablecoins. DeFi lending protocols mimic collateralised finance by letting users borrow against tokenised assets, with automatic margin calls enforced by code. These innovations are now expanding into real-world asset markets, such as tokenised real estate.

Huang argues that the integration of DeFi mechanisms into tokenised real-world asset markets offers efficiency gains but also introduces risks. As DeFi becomes increasingly intertwined with fiat systems and real assets, the challenge for regulators is to craft oversight that acknowledges decentralisation while mitigating systemic risk. Ultimately, DeFi's contribution may not lie in replacing existing institutions but in reshaping our understanding of resilient and efficient market design.

Claudio Tebaldi argues that digital adoption, rising incomes, and growing global interest have brought a younger, more diverse cohort of retail investors into financial markets. While these investors now access a broad range of complex financial products, their financial literacy is often low and their understanding of product risks inadequate. De facto, digital innovation brings with it a form of technology-driven deregulation, and finding the right balance between fostering innovation and protecting retail investors is difficult. While some regulatory environments, such as that of the European Union, emphasise consumer protection through rules and oversight, they often limit scalability and participation, raising concerns about accessibility and innovation. In some cases, platform design – rather than regulation – bears the burden of educating and guiding users.

Tebaldi proposes a regulatory framework that balances the goals of consumer protection, large-scale participation, and inclusive stakeholder governance. He argues that AI-powered robo-advisory tools offer promise in bridging the education gap at scale. To improve governance, token issuers should meet governance standards comparable to those common in traditional finance.

PART I
REGIONAL PERSPECTIVES

CHAPTER 1

Cashless payments in India: The UPI story

Amiyatosh Purnanandam
University of Texas, Austin

Payment systems solve two fundamental economic frictions: (1) a mismatch in the timing of the exchange of goods and services across agents; and (2) limited enforceability of contracts (Kahn and Roberds 2009). Account-based systems do so by reliably transmitting information to various parties involved in an economic exchange, authenticating the identity of the payer and payee, and ultimately settling the transactions in their accounts. An alternative to an account-based system is a value-based system, such as fiat money, in which the need for authentication and settlement is replaced by trust in the value of cash or equivalent. With technological advancements of the past few decades, economies around the world are moving towards more efficient account-based systems for both retail and wholesale payments. Mechanisms that can minimise the verification, authentication, and settlement costs of such account-based systems can bring improvements in economic welfare that go well beyond their role as simply a medium of exchange. They can lower information frictions, improve contract enforceability, and allow for more efficient consumption and trading. All of this, in turn, can lead to better economic outcomes through improved credit contracts and reduction in transaction costs, as in the case of India's Unified Payment Interface (UPI) (Dubey and Purnanandam 2023).

UPI provides a useful template for designing a payment system that can tackle fundamental payment frictions using technological tools and regulatory reforms. Launched in 2016, it soon became one of the most widely adopted payment systems in the world, with almost 19-20 billion monthly transactions in July 2025, covering close to $300 billion in payment volume.[1] What led to the successful launch and adoption of UPI? What financial and economic impact did it have on the Indian economy? And what lessons can be drawn from the experience for other economies as well as theoretical models of payment economics? This chapter provides a brief overview of UPI through the lens of these three questions.

UPI, a public payments utility, was launched by the National Payment Corporation of India (NPCI) under a public–private partnership to provide an instant payment and settlement platform between any two entities with unique identity in an interoperable

1 See the NPCI statistics on number of transactions and payment volume at https://www.npci.org.in/what- we-do/upi/product-statistics.

manner, i.e. without requiring the payer and payee to use the same payment provider (Acharya 2023). As mentioned above, authentication of the payer and payee is a key impediment in designing an account-based payment system. The friction was especially high in the Indian market due to limited financial inclusion and lack of a consistent system to verify the identity of an individual. Unsurprisingly, the country mainly relied on a cash-based system for payments before 2016.

India solved the verification problem by providing a unique identification card, called the Aadhaar Card, to every Indian citizen through a nationwide initiative that started in 2010. The digital and biometric-based Aadhaar card made the verification of a banking transaction instant and secure. The NPCI also developed a payment rail that allowed real-time gross settlement of transactions between the payer and the payee without any need for them to enter their bank account details for every transaction. The NPCI not only played a pivotal role in solving the technical aspect of real time settlement, but it also facilitated – primarily due to its public–private ownership structure – the development of a truly interoperable system where any bank or fintech company can participate in the flow of payments in a seamless manner. Finally, the regulation allowed payment service providers (PSPs) to act as interfaces between users and their financial institutions, greatly improving the information exchange and user experience. The net result was the development of a system that could tackle all three payment frictions – information exchange, authentication, and final settlement – in a seamless manner.

However, the availability of a robust system does no guarantee its adoption at large scale. Several inherent features of UPI, in combination with policy initiatives and economic shocks, helped in its widespread adoption over time. As a starting point, a user needs a bank account to send or receive money through the UPI system. In a typical transaction flow, the payer initiates a UPI transaction using her UPI app provided by either her bank or an independent PSP, such as PhonePe, Paytm, or Google Pay. The PSP contacts the NPCI, which in turn transmits the information to both the payee's bank and the payer's bank. The payer's bank account gets debited, the payee's account credited, and the payee receives the money in real time through her own PSP. There are therefore three critical elements to participation in this system: access to a bank account, access to a PSP app, and access to a mobile phone.

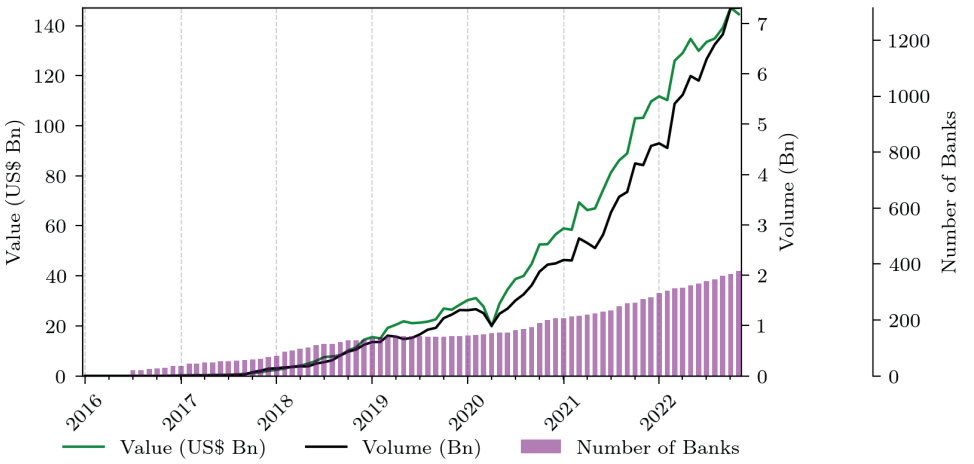
In 2014, the central government of India launched a scheme, called the Pradhan Mantri JanDhan Yojna (JDY), to open bank accounts for the unbanked population (Agarwal et al.2017), bringing practically every household under the coverage of the formal banking system. More than half a billion accounts were opened under this scheme by August 2024, with about two-thirds of the accounts in rural or semi-urban areas of the country.[2] The country also invested significant resources in developing the digital infrastructure, including reliable internet connection and mobile phone access. Reliance Jio, a private corporation, disrupted the Indian telecommunication market by entering

2 See the Government of India press release at https://www.pib.gov.in/PressReleasePage.aspx?PRID=2049231

into partnerships with smartphone manufacturers and making 4G-enabled devices available to the masses at very affordable prices. Finally, the government regulation allowed the entry of private players, those under foreign ownership, to enter the PSP market, which significantly improved user experience through healthy competition and state-of-the-art technologies. For example, the top three app providers are PhonePe, Paytm, and Google Pay, backed by Walmart, Alibaba, and Alphabet, respectively.[3]

While access to bank accounts, PSPs, and mobile phones set the stage for a widespread use of the newly developed payment system, the demonetisation of high-denomination currency notes in the country in November 2016 and the COVID-19 pandemic shock gave further impetus to the adoption of cashless payments. Figure 1, taken from Dubey and Purnanandam (2023), plots the evolution of UPI payments over time, based on NPCI statistics. Both the value and volume of transactions increased considerably over time, with a sharp upward trend after the pandemic. The number of banks that participated in the network increased steadily too, with almost the entire banking sector on the UPI by now. Cornelli et al. (2024) provide further details on the evolution of UPI in India.

FIGURE 1 GROWTH IN DIGITAL TRANSACTIONS ON THE UPI PLATFORM



Source: National Payments Council of India (NPCI); Dubey and Purnanandam (2023).

The evolution of UPI provides several insights into the supply- and demand-side factors that shape the adoption of instant payment systems, and financial technology in general (Crouzet et al. 2023, Chodorow-Reich et al. 2020, Dubey and Purnanandam 2023, Aggarwal et al. 2023). Crouzet et al. (2023) provide evidence of significant network externalities and persistence in the use of these technologies. Dubey and Purnanandam (2023) show that areas where banks were early adopters of the UPI had considerably higher usage of digital payments, which persisted for a long time. Copestake et al.

3 Alibaba has recently exited from its investment in Paytm.

(2025) show that the interoperable nature of UPI helped achieve higher usage levels, as it allowed users to shop around for apps that best matched their preferences. Interoperability also incentivises PSPs to innovate through competition for market share. Together, these studies highlight the importance of strong network externalities, benefits of interoperability, and the pivotal role of local banks in the adoption of new financial technology in an economy.

Another key feature of the UPI system is that it provides the merchants with the ability to collect payments, typically using a QR code, without the installation of the costly infrastructure needed for card-based systems. In addition, small-denomination transfers have remained free of charge for retail users, making this payment mechanism attractive both to merchants and to consumers.

What impact did UPI have on economic growth? The system lowered the transaction costs of payments to both consumers and businesses; it allowed small entrepreneurs to have a digital record of their business transactions; and it facilitated the entry of a new set of financial service providers, such as new fintech lenders that expand the scale and scope of credit and saving products. These changes can be especially beneficial for cashflow-based lending for small businesses, which typically lack collateral for traditional lending products. Collectively, reductions in transaction costs and the availability of cashflow-based lending can spur economic growth. Dubey and Purnanandam (2023) show that districts where banks were early adopters of the UPI – specifically, districts where banks were present on the UPI platform before the demonetisation shock of November 2016 – adopted cashless payments at a much higher intensity than districts that were late adopters. Using this source of variation as an exogenous shock to the adoption of cashless payments, the authors study the impact of UPI on economic growth. In a difference-in-differences setting, they show that households residing in districts with early adoption of cashless payments saw an increase in business ownership and income, compared to households residing in other comparable districts where the main banks were late adopters of UPI. The effect was especially strong for marginal entrepreneurs such as road-side hawkers, who lacked access to collateral-based credit.

Ghosh et al. (2021) show that cashless payments led to an increase in lending by fintech firms. Alok et al. (2024) provide a comprehensive study of how UPI, and its open banking nature, led to the creation of credit through both traditional and innovative means. Collectively, these papers establish two key insights: digital payments can create digital footprints (Berg et al. 2020) that can help with cashflow-based underwriting, which in turn can help with economic growth, especially for small and marginal businesses.

In addition to these benefits to households and businesses, NPCI's infrastructure has also allowed the government to seamlessly transfer welfare and subsidy benefits to recipients. Delivering government schemes through this channel has led to savings both

in terms of cost of transfer as well as prevention of fraud and abuse. Since 2014, close to 60% of the entire welfare and subsidy budget of the Government of India has been disbursed through direct payments to the bank accounts of beneficiaries.[4]

The success of UPI has not come without its challenges. First, there are the operational and maintenance costs of running the system, which the government is currently subsidising. Banks and some payment aggregators are absorbing a small portion of the cost, but the economics of cost sharing is still evolving, and policymakers are considering various options for covering the costs as the scale and scope of UPI continues to grow. Consumer protection and fraud prevention is yet another important area of concern, especially with the increasing use of artificial intelligence tools. Any direct and indirect cost of running the system must be evaluated against the savings that come from lower costs of printing cash, the benefits that financial players obtain from cross-selling products on their platform, and the overall economic benefits of cashless payments.

What are some broad lessons we can learn from the UPI experience for other economies? A key message that emerges is that the successful implementation of a digital payment system requires active coordination across technological solution providers, incumbent banks, regulators, and new market participants such as PSPs. Private–public cooperation, and the resulting ownership structure of the NPCI, has been instrumental in the development of an interoperable system that can be accessed by anyone in the economy. At the same time, the willingness of regulators to allow private non-bank players to connect to the payment rail has led to a considerably better user experience and product innovation, and therefore wider adoption. The UPI experience also shows that traditional banks play a central role in the adoption and usage of cashless payments: they act as enablers of, rather than a substitute for, digital payments. Finally, the benefits of instant payment systems go far beyond their role as a medium of exchange: they can improve access to credit, help in business creation, reduce costs of managing government welfare schemes, and improve financial inclusion.

REFERENCES

Acharya, V V (2023), "India at 75: Replete with contradictions, brimming with opportunities, saddled with challenges", *Brookings Papers on Economic Activity*, Spring, 185–288.

Agarwal, S, S Alok, P Ghosh, S Ghosh, T Piskorski, and A Seru (2017), "Banking the unbanked: What do 255 million new bank accounts reveal about financial access?", Columbia Business School Research Paper .

4 See https://www.nic.gov.in/blog/direct-benefit-transfer-a-blessing-during-the-time-of-pandemic/

Aggarwal, B, N Kulkarni, and S K Ritadhi (2023), "Cash is king: The role of financial infrastructure in digital adoption", *The Review of Corporate Finance Studies* 12: 867–905.

Alok, S, P Ghosh, N Kulkarni, and M Puri (2024), "Open banking and digital payments: Implications for credit access", NBER Working Paper.

Berg, T, V Burg, A Gombovic, and M Puri (2020), "On the rise of fintechs: Credit scoring using digital footprints", *The Review of Financial Studies* 33: 2845–2897.

Chodorow-Reich, G, G Gopinath, P Mishra, and A Narayanan (2020), "Cash and the economy: Evidence from India's demonetization", *The Quarterly Journal of Economics* 135: 57–103.

Copestake, A, D Kirti, M S Martinez Peria, and Y Zeng (2025), "Integrating fragmented networks: The value of interoperability in money and payments", IMF Working Paper.

Cornelli, G, J Frost, L Gambacorta, S Sinha, and R M Townsend (2024), "The organisation of digital payments in India–lessons from the Unified Payments Interface (UPI)", in SUERF Policy Note No. 355.

Crouzet, N, A Gupta, and F Mezzanotti (2023), "Shocks and technology adoption: Evidence from electronic payment systems", *Journal of Political Economy* 131: 3003–3065.

Dubey, T S, and A Purnanandam (2023), "Can cashless payments spur economic growth?", available at SSRN 4373602.

Ghosh, P, B Vallee, and Y Zeng (2021), "Fintech lending and cashless payments", Working Paper.

Kahn, C M and W Roberds (2009), "Why pay? an introduction to payments economics", *Journal of Financial Intermediation* 18: 1–23.

ABOUT THE AUTHOR

Amiyatosh Purnanandam is the Denise and Ray Nixon Professor of Finance at McCombs School of Business at the University of Texas, Austin. Previously, he was the Michael Stark Professor of Finance at the Ross School of Business, University of Michigan, Ann Arbor. Purnanandam's research focuses on bank funding, digital payments, and risk-management. He has served on editorial boards of several leading finance journals, including *Journal of Finance*, *Review of Financial Studies*, and *Review of Finance*. His research has shaped policy decisions on banking sector reforms, credit rating regulations, consumer financial protection, and securitization by policymakers across the world. He received his PhD from Cornell University.

CHAPTER 2

The future financial system: Brazil's experience

Fabio Araujo and Arnildo da Silva Correa
Central Bank of Brazil

1 INTRODUCTION: A VISION FOR THE FUTURE

Contemporary financial systems are undergoing an unprecedented transformation, driven by the accelerating pace of technological change. The exponential decrease in the cost of data production, storage, and processing has reshaped the architecture of financial services, turning the sector into an information-intensive and technology-driven industry. Among the most visible aspects of this revolution are the innovations in payment systems, which have rapidly evolved towards fully digital solutions, radically altering how individuals and institutions interact with money.

At the heart of this transformation is the ongoing shift to a tokenised economy. Tokenisation represents a fundamental change in how value is stored, transferred, and utilised. By encrypting assets and placing them on distributed ledger technologies (DLT), tokenisation enables, for instance, more efficient trading, registration, contracting, and collateral management. It introduces key advantages: increased speed and transparency, lower transaction costs, enhanced openness, and the programmability of asset transfers. Moreover, it fosters composability — the ability to in tegrate and automate operations across multiple financial layers — thus paving the way for novel functionalities and more complex financial arrangements (Schär 2021).

The main challenge of this tokenised economy lies in its implementation. The potential efficiency gains from tokenisation depend not merely on the existence of individual components but on their integration. Financial innovation must overcome the fragmented approach that treats systems as isolated blocks. Instead, a convergent and integrated ecosystem is required (Carstens and Nilekani 2024, Brunnermeier and Payne 2023, BIS 2023).

In this context, Banco Central do Brasil (BCB) has adopted a proactive stance through its innovation agenda, known as *Agenda BC#*. Over the past years, the BCB has launched a series of initiatives aimed at building the financial system of the future (Campos Neto 2023). This chapter presents the key components of that agenda, their progressive integration, and the transformative impact already being realised in Brazil.

2 AN INTEGRATED AGENDA: THE FOUR FUNDAMENTAL BLOCKS

In recent years, the BCB has advanced a strategic innovation agenda designed to enact structural transformations in the national financial system. This agenda is structured around four interrelated building blocks: (1) Pix, the instant payments system; (2) the Open Finance initiative; (3) the development of Drex, Brazil's central bank digital currency (CBDC); and (4) the internationalisation of the currency.

From the outset, the BCB recognised that achieving meaningful impact would require engaging the population directly in this innovation journey. To that end, the first building block was the implementation of a user-friendly instant payment system that could deliver immediate and tangible benefits to the general public. The goal was not only to facilitate digital transactions but also to enable programmability from the start, allowing for future enhancements and integration with other systems.

The second component involved the construction of an open financial scheme to enable the secure sharing of user data between regulated entities. This initiative, known as Open Finance, was designed to foster portability, comparability, and improved service offerings, while also promoting competition and innovation.

The third building block introduces the concept of tokenisation into the financial system, primarily through the Drex project, with the aim of transitioning toward a more open, programmable, and efficient digital economy.

Finally, the agenda envisioned the connection of this domestic financial ecosystem with international payment systems, a step that required both regulatory modernisation and the establishment of minimum standards of cross-border governance.

These four components, initially pursued as distinct initiatives, have become increasingly interconnected, forming the foundation for a modern and integrated financial ecosystem.

2.1 Pix

Within the strategic vision outlined by the BCB, Pix was the initial and foundational step towards building a digital financial ecosystem. Launched in November 2020, Pix was designed as a public infrastructure for instant payments, with the express purpose of delivering immediate, secure, and cost-effective transfers to the population. It rapidly became the gateway for millions of Brazilians to access digital financial services.

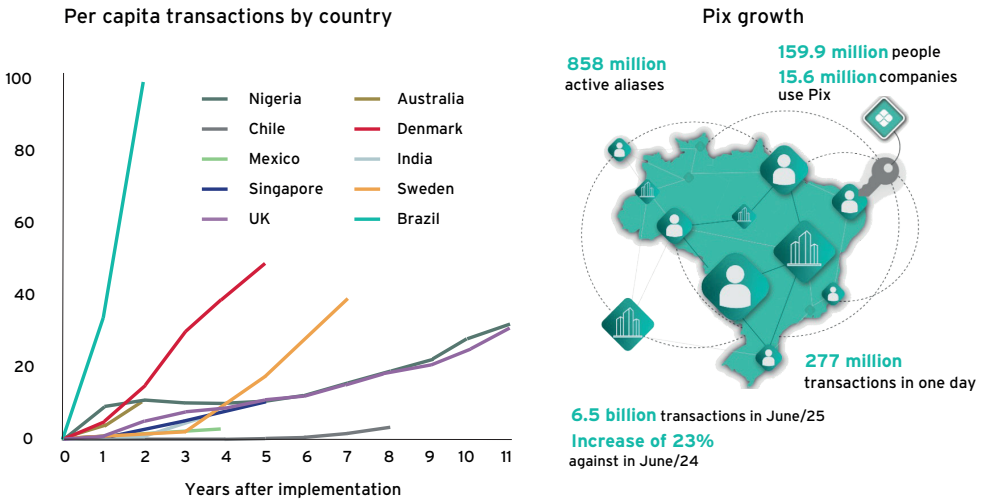
From its inception, the BCB envisioned Pix not merely as a payment tool, but as a programmable platform that could support a wide range of functionalities over time. This flexibility has allowed the system to evolve and incorporate new features, including Pix Agendado (scheduled payments), Pix Cobrança (future billing), Pix Saque and Pix Troco (cash withdrawals and change), Pix Automático (recurring payments), and Pix por Aproximação (contactless payments).

The adoption of Pix has far exceeded expectations. As shown in Figure 1, as of 2025, the system accounts for nearly 160 million individual users, 16 million corporate users, and over 858 million active Pix keys, in a country with a population of 212 million. On its highest recorded day, Pix processed 277 million transactions — more than one per capita.

Crucially, Pix has had a profound impact on financial inclusion, bringing 72 million new users into the realm of electronic payments. Rather than displacing other payment instruments, the overall volume of transactions using alternative means, such as credit and debit cards, has also increased. This expansion of digital activity has generated rich digital footprints, enabling financial institutions to offer more customised and data-driven services.

Beyond its scale and efficiency, Pix has catalysed competition, innovation, and the emergence of new business models. The system remains subject to an evolving agenda, with ongoing enhancements that will further consolidate its role in Brazil's digital financial infrastructure.

FIGURE 1 PIX ADOPTION



Source: BCB, BIS.

2.2. Open Finance

The Brazilian Open Finance initiative is built on the principle of data sharing among regulated entities – such as banks, payment institutions, and other participants – at the customer's discretion. Launched in 2021, the project aims to enhance competition, foster innovation, improve efficiency, and promote financial citizenship.

Open Finance enables users to share their data voluntarily across a broad range of financial services. The scope of shared information is expansive, encompassing bank account data (credit, card and credit operations), exchange rates, investment services,

insurance, pension funds, and capitalisation products. With around 800 participating institutions, the Brazilian model has become an international benchmark, notable for both its scale and its comprehensiveness.

One of the most immediate benefits of this system lies in its ability to transform the vast quantity of data generated in the digital environment into more personalised, accessible, and efficient financial services. Through real-time portability and comparability, Open Finance facilitates better-informed decision-making and encourages the delivery of more competitive offerings to consumers.

As of late 2024, the ecosystem registered over 62 million accounts with data-sharing consent, representing approximately 41 million unique clients – a 49% increase in one year. According to a study conducted by the BCB, participants developed 139 use cases derived from Open Finance implementations in the second half of 2024 alone. In fact, several Pix functionalities are now enabled through Open Finance connectivity.

The initiative is now in a mature implementation phase, supported by ongoing regulatory refinements and institutional strengthening through the newly created Open Finance Association, which provides a robust foundation for its continued evolution.

2.3 Drex

Another central pillar of the BCB's innovation agenda is Drex, Brazil's central bank digital currency (CBDC) project. The benefits associated with CBDCs go beyond improvements in payments. In fact, Brazil already operates a 'synthetic' retail CBDC model, composed of Pix, electronic money issued by non-bank payment service providers (PSPs), and a simplified access policy. With these functionalities available for the population, any individual can maintain a 24/7 payment account in electronic money fully backed by reserves at the BCB. Therefore, Drex is not aimed at replicating these functions, but to serve as a technological platform for a tokenised economy, enabling new business models and expanding the reach of digital financial services.

The traditional financial infrastructure, although functional, presents limitations in programmability and interoperability. Open Finance attempts to overcome these challenges via application programming interfaces (APIs), which, while flexible and standardisable, are constrained by gatekeeper-controlled data structures. In such environments, operations that depend on multiple service providers cannot ensure mutual conditionality or atomicity, increasing risks and limiting innovation.

In contrast, DLT, as adopted in the Drex architecture, offers native programmability, interoperability, and atomicity, allowing different services to interact efficiently within the same environment. This structure supports the execution of complex financial operations with greater security and automation. Nonetheless, it raises new challenges, particularly regarding privacy, since the openness inherent to DLT requires the use of privacy-enhancing mechanisms. The project is being developed in full compliance with

the Brazilian General Data Protection Law (LGPD), and zero-knowledge proof (ZKP) technologies have been explored as possible solutions to the privacy–composability–decentralisation trilemma faced by Drex.

The initiative proposes a model of tokenised deposits, issued by banks and convertible at parity with reserves held at the BCB. This model maintains the same regulatory principles as traditional deposits, thus avoiding disintermediation problems while enabling the emergence of programmable, DeFi-inspired services (Schüler et al. 2024, Garratt and Shin 2023). The architecture draws on models such as Schär (2021), combining innovation with regulatory compliance.

The project has evolved through structured phases. After initial experimentation in the LIFT Challenge, Phase 1 of the pilot (March 2023 to August 2024) focused on evaluating the technical and operational viability of the platform, with BCB responsible for the development and participants conducting controlled testing. Phase 2 (September 2024 to June 2025) emphasised market-led development. Participants designed business models, authored smart contracts, and implemented privacy solutions across 13 complex use cases, including receivables, credit backed by public and private securities, trade finance, foreign exchange, agribusiness assets, carbon credits and green bonds, vehicles, and real estate.

An important element in Phase 2 was privacy, with participants testing ZKP solutions. While still evolving, ZKP-based approaches are maturing rapidly and demonstrated significant progress in recent testing phases. The BCB maintained coordination of the process to ensure alignment with the project's scope, and conducted a study on governance of the network, including technological aspects of embedded compliance (Auer 2019, Zetzsche et al. 2020.[1]

2.4 Connecting with international systems

The fourth component of the BCB's innovation agenda involves the connection of Brazil's financial infrastructure with international payment systems. This effort rests on two main pillars: the modernisation of Brazil's foreign exchange (FX) regulatory framework, and the development of a minimum standard of cross-border governance.

The first step was legislative, followed by infra-legal work by the BCB. In late 2021, the Brazilian Congress approved a new foreign exchange law and the BCB subsequently enacted regulation, replacing a fragmented and outdated regulatory structure dating back over four decades. This modernisation process has simplified and harmonised rules governing FX transactions, enhancing the efficiency, transparency, and legal certainty of cross-border operations.

1 The Phase 2 reports of the Drex Pilot will be released soon and will contain all the results.

The second step addresses the complexity of connecting domestic payment systems with those of other countries. Cross-border transactions are governed by distinct national rules related, for example, to taxation, transaction identification, AML/CFT procedures, and other compliance requirements. As such, interoperability cannot be achieved solely through technological means – it requires a shared governance model that balances efficiency with regulatory sovereignty.

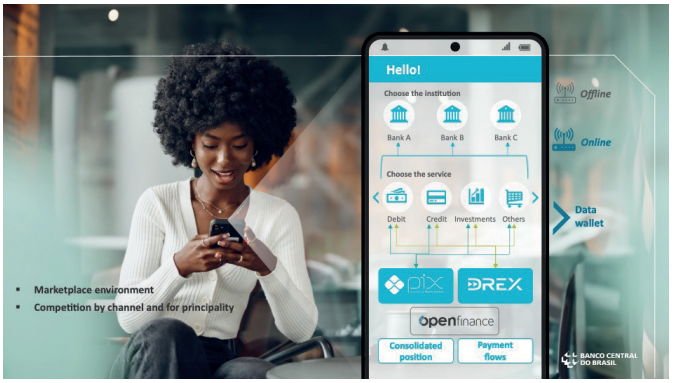
During Brazil's presidency of the G20 in 2024, the BCB – in collaboration with other central banks and under the leadership of Banca d'Italia within the Committee on Payments and Market Infrastructures (CPMI) – launched a multilateral effort to promote minimum governance standards for cross-border instant payments. This initiative reflects a broader commitment to fostering international financial integration while preserving legal and institutional autonomy.

3 INTEGRATION OF FUNDAMENTAL BLOCKS

Although originally developed as separate initiatives, the four fundamental blocks of Brazil's innovation agenda – Pix, Open Finance, Drex, and currency internationalisation – have evolved towards increasing integration and strategic convergence. This integration process is not incidental; it reflects a deliberate architectural vision aimed at fostering efficiency, competition, and innovation.

The convergence of these components is paving the way for the development of a new interoperable system, in which financial information, services, and transactions are seamlessly connected. In this emerging environment, users will be able to access a wide array of financial products – including payments, transfers, investments, asset purchases, cash management, and credit – through a unified interface provided by the private sector, as illustrated in Figure 2. These interfaces of financial aggregators will serve as intelligent hubs, allowing clients to interact with multiple financial institutions via a single access point.

FIGURE 2 FINANCIAL SERVICES AGGREGATOR



This marketplace architecture introduces a new paradigm in the delivery of financial services. As services become increasingly commoditised, the competitive dynamic shifts towards the aggregation layer, where providers compete for 'principality' – that is, to become the user's primary gateway to financial services. In this context, the BCB's role is to provide the enabling infrastructure, both regulatory and technological, setting the conditions for market-led innovation to flourish.

Moreover, this integrated ecosystem opens space for two additional transformative elements. The first is the application of artificial intelligence to enhance the efficiency and customisation of financial services. The second is the monetisation of personal financial data, grounded in the principle that users are the rightful owners of their data. In this regard, the envisioned financial aggregator may also function as a data wallet, empowering users to manage, store, and monetise their data as they see fit.

Together, these developments reinforce a systemic shift toward a more intelligent, decentralised, and user-centric financial system, where integration, data, and digital infrastructure are key enablers of value creation.

4 CONCLUSIONS

Technology has become one of the most powerful instruments in shaping the financial system of the future. In Brazil, the BCB has made technological evolution a central pillar of its strategy to promote efficiency, digital transformation, and financial inclusion.

The innovation agenda pursued by the BCB reflects a commitment to building a tokenised, programmable, and interoperable economy, based on the integration of Pix, Open Finance, Drex, and international connectivity. These initiatives are not ends in themselves, but foundational elements of a convergent and evolving ecosystem.

Brazil's experience shows that a future-oriented financial architecture is possible – one that is more open, more intelligent, and more aligned with the needs of a digital society. A lot has already been accomplished, but much more can be done to increase financial inclusion and provision of financial services in Brazil.

REFERENCES

Auer, R (2019), "Embedded supervision: how to build regulation into decentralised finance", BIS Working Papers No. 811.

Bank for International Settlements (2023), "Blueprint for the future monetary system: improving the old, enabling the new", Chapter 3 in *Annual Economic Report 2023*.

Brunnermeier, M and J Payne (2023), "Platform, ledgers, and interoperability", Princeton Working Paper.

Campos Neto, R (2023), "The BIS and Banco Central do Brasil relationship: lessons learned and challenges ahead", in *Central banking in the Americas: lessons from two decades*, pp. 41–54.

Carstens, A and N Nilekani (2024), "Finternet: the financial system for the future", BIS Working Paper No. 1178.

Garratt, R and H S Shin (2023), "Stablecoins versus tokenised deposits: implications for the singleness of money", BIS Bulletin 73.

Schär, F (2021), "Decentralized finance: on blockchain- and smart contract-based financial markets", *Federal Reserve Bank of St. Louis Review* 103(2): 153–174.

Schüler, K, A-S Cloots and F Schär (2024), "On DeFi and On-Chain CeFi: How (not) to regulate Decentralized Finance", J*ournal of Financial Regulation* 10(2): 213–242.

Zetzsche, D, D Arner and R Buckley (2020), "Decentralized Finance", *Journal of Financial Regulation* 6(2): 172–203.

ABOUT THE AUTHORS

Fabio Araujo is a telecommunications engineer, a PhD in Economics and has been working at Banco Central do Brasil (BCB) since 1998. At the beginning of his career at the BCB he took part in the implementation of the inflation targeting regime in Brazil, and afterwards dedicated himself to advising the conduct of the monetary policy. More recently, Fabio was the Head of the Governor's Office of Economic Advisory and currently coordinates the work for the future implementation of Drex - the digital version of the Brazilian real.

Arnildo Correa is an economist with a PhD from the Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil. He has been a member of the Banco Central do Brasil (BCB) since 2002, holding various positions across the organisation. For over a decade, he worked in the Research Department, specialising in macroeconomics and monetary policy. From 2020 to 2024, he served as Head of the Governor's Office of Economic Advisory. Currently, he is working on Drex, the BCB's project for the future implementation of the Brazilian digital real.

CHAPTER 3

Strengthening digital payments in sub-Saharan Africa: An overview

Luca Antonio Ricci, Calixte Ahokpossi, Saad Quayyum, Rima Turk, Anna Belianska, Mehmet Cangul, Habtamu Fuje, Sunwoo Lee, Grace Li, Yibin Mu, Nkunde Mwase, Jack Joo Ree, Haiyan Shi, and Vitaliy Kramarenko[1]
International Monetary Fund

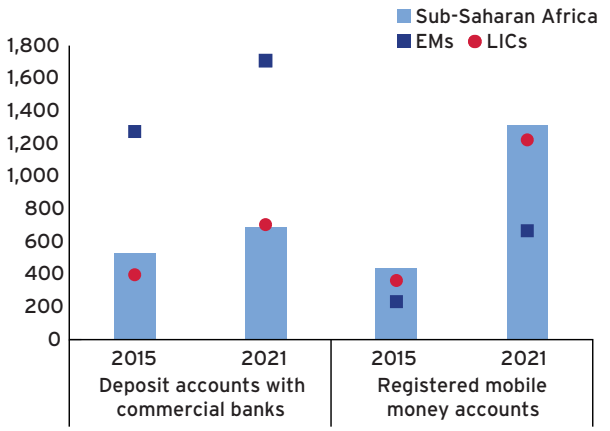
Digital innovations are rapidly changing the payment and financial landscape in sub-Saharan Africa (SSA), offering opportunities to expand financial inclusion, enhance the efficiency of payments systems, lower the cost of remittances, and reduce informality. Innovations in payments and money, such as private mobile money, central bank digital currencies (CBDCs), fast payment systems, and crypto assets are now central to the policy debate in SSA. Private mobile money, in particular, is revolutionising access to financial services for unbanked populations (IMF 2021a), with mobile money accounts per adult tripling between 2015 and 2021 and far exceeding the growth of bank accounts (Figure 1). CBDCs and crypto-assets also hold further potential through functionalities such as smart contracts, tokenisation, and fractionalization (BIS 2024). About 75% of SSA central banks are actively exploring a CBDC to boost financial inclusion and improve the efficiency of domestic payments (Figure 2) and Nigeria has already issued its eNaira in 2021. Crypto-assets are currently less widely used, concentrated in countries such as Kenya, Ghana, Nigeria, Seychelles, South Africa, though interest continues to grow.

Why a special focus on Africa? SSA is home to one of the world's largest unbanked populations, with nearly half of adults lacking access to formal financial services. This financial exclusion limits people's ability to save safely, access credit, and participate in modern economic systems. With more people holding phones than bank accounts, digital payment platforms – such as mobile money and fintech wallets – offer a powerful solution to bridge the financial inclusion gap, as they eliminate the need for traditional bank accounts or physical infrastructure. Cash-based economies are also costly and inefficient. Digital payments can help reduce the transaction costs for consumers, businesses, and governments. In addition, digital payments make it easier for small enterprises to receive payments, pay suppliers, and manage cashflows, which enhances productivity and supports formalisation of the informal sector – a key structural challenge in SSA. Promoting digital payments in SSA is therefore both a developmental imperative and a strategic economic policy.

1 This chapter is based on Ricci et al. (2025). The views expressed herein are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

FIGURE 1 MOBILE MONEY IS BOOSTING FINANCIAL INCLUSION

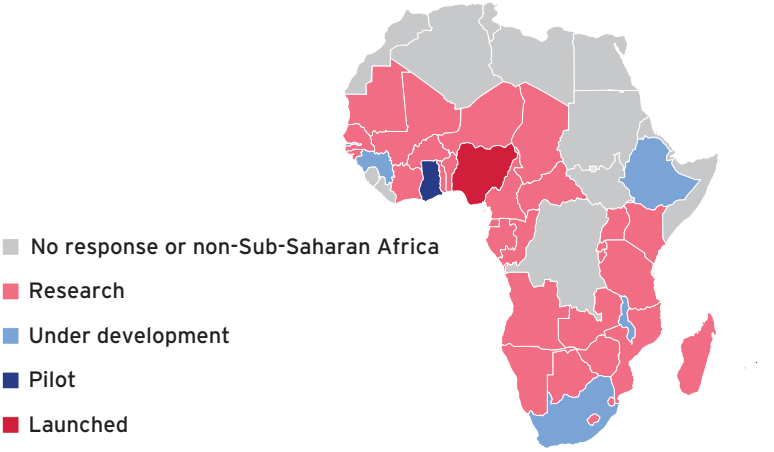
Deposit accounts and registered mobile money accounts per 1000 adults



Note: Data availability covers a sample of 29 and 21 sub-Saharan countries in 2015 and 2021, respectively for deposit accounts; and 30 and 21 countries in the same years for mobile money accounts. EMs = emerging m arkets; LICs = low-income country.

Source: Financial Access Survey and IMF staff calculations.

FIGURE 2 CBDC EXPLORATION IN SUB-SAHARAN AFRICA



Source: Ricci et al. (2024)

Despite the transformative potential, digitisation of payments in SSA will require a coordinated and sustained effort amongst governments, central banks, financial institutions, telecom operators, and development partners. This is because the region faces structural challenges that are both deep-rooted and widespread, and could hinder broad-based adoption and impact. The region continues to grapple with weak digital infrastructure (intermittent mobile and internet connectivity) paired with unreliable electricity supply, substantial gaps in IT skills, inadequate resources, and pervasive low levels of financial and digital literacy. Public administration capacity is often stretched thin with limited capacity and resources, while the costs of deploying new payment technologies – both in human capital and physical infrastructure – remain

steep. Compounding these challenges are factors such as the high degree of economic informality (reflected also in low tax revenue relative to GDP), poor financial inclusion, weak governance, and inadequate data privacy safeguards. Slow and costly cross-border payment systems exacerbate transaction costs of remittances, which are a vital source of both household income and external financing (World Bank 2023).

Further, while digitisation of payments can enhance efficiency and inclusion, it also introduces new financial integrity and stability challenges that governments in SSA will need to manage carefully. The rapid expansion of digital financial services, often through nonbanks that are not subject to the same supervisory oversight like banks, can increase exposure to money laundering (ML), terrorism financing (TF), fraud, and cyber risks. Customer due diligence (CDD) and anti-money laundering/countering the financing of terrorism (AML/CFT) frameworks may be challenging to implement where there is a prevalence use of mobile wallets, agent networks, and crypto assets. Moreover, data privacy regimes, consumer protection, and cyber security infrastructures remain underdeveloped in many jurisdictions heightening vulnerabilities. Without adequate safeguards, banking disintermediation, weaker monetary policy transmission, currency substitution, capital account volatility, and fragile cross-border linkages can become even greater risks when new instruments, including CBDCs or crypto-assets, are introduced (IMF 2021b).

In this chapter, we highlight the main policy conclusions from a recent detailed paper that extensively discusses policy issues related to digital payments in SSA (Ricci et al. 2025).

POLICY PRIORITIES TO STRENGTHEN THE DIGITAL PAYMENT LANDSCAPE

Priority set 1: Tackling fundamental bottlenecks and mitigating risks

Strengthening the foundation for digital payment innovation begins with investment in infrastructure – ensuring reliable electricity supply, improving coverage and affordability of mobile and internet networks, and supporting resilient connectivity. Short-term technological solutions, including offline digital payment systems, may help in lower-connectivity areas. Expanding coverage of national and digital identity systems is equally essential, enabling access to accounts while supporting regulators in addressing financial integrity risks and mitigating fraud. Prioritising greater investments in human capital, particularly in digital and financial domains, would also promote new skills to develop digital payments, while promoting financial and digital literacy would not only advance financial inclusion, efficiency, and fairness, but also enhance consumer protection and reduce risks of consumer fraud.

Governments will need to strike a careful balance in promoting innovation, financial inclusion, while safeguarding financial integrity through enhanced regulation, public-private sector coordination, investment in supervisory technology, and regional cooperation on cross-border risk management. Cash will need to coexist with digital

instruments in order to mitigate the risk of financial exclusion, given that parts of the SSA population – including the elderly, rural communities, and low-income people – still lack access to affordable and reliable internet and mobile phones. Strengthening regulation and supervision of crypto-assets is crucial, with clear differentiation between stablecoins and unbacked cryptos, supported by strong AML/CFT, transparency, and consumer protection frameworks. Policymakers must manage risks of financial disintermediation, preserve the efficiency of monetary policy transmission, and safeguard financial stability amid digitalisation. Investment in resilient and interoperable infrastructure and adherence to global standards are essential to counter network and cybersecurity risks. Effective design, clear rules, and private sector participation are key to building trust and encouraging broad adoption.

Priority set 2: Supporting private innovation within secure and competitive frameworks

Governments can promote digital payment innovations by creating an enabling regulatory, operational, and supervisory environment. Priorities include developing interoperable digital payment platforms domestically and regionally, alongside stronger governance and data privacy frameworks. These measures level the playing field, improve service portability, encourage competition, and reduce risks like arbitrage and disintermediation. They also help limit threats to users and curb money laundering and financing of terrorism.

Building a robust fast payment system and a competitive mobile money sector is essential for efficient and inclusive digital payments. Private digital service providers should be subject to similar regulation and prudential rules for comparable activities (if any) offered by traditional financial institutions. It would be essential for e-money issuers (Dobler et al. 2021) to meet licensing requirements, be well-capitalised to cover startup costs and infrastructure, and invest customer funds in safe assets to protect users and maintain trust. Since many in SSA remain outside the formal financial system, preserving cash availability and the obligation to accept it as a form of payment is vital to avoid exacerbating financial exclusion as the use of digital payments expands. Crypto-assets need regulation and supervision to manage risks (IMF 2023). Given weak institutional capacity, priority should be on consumer protection, AML/CTF controls, and strengthening legal frameworks, especially in fragile and conflict-affected states. Managing capital flow volatility and improving financial literacy, particularly for older or vulnerable groups, is crucial.

Policymakers should prepare for unintended effects on monetary transmission and financial stability. Mobile money balances may react faster to policy changes, causing quicker liquidity shifts between banks and payment providers. The growth of mobile money operators could create large systemic depositors, complicating monetary policy. And the promotion of digital monies should be balanced against the risk of potential bank disintermediation.

Investing in infrastructure and encouraging the development of a system involving multiple actors could reduce risks from network failures, disruptions, or cyberattacks. Collaborating with other central banks is critical for managing rapid technological change and ensuring interoperability. Strong design and private sector engagement can build trust, reduce reputational risks, and support wider adoption of digital payments.

Priority set 3: Positioning public digital innovations – including CBDC – as complements to private sector solutions

A key priority of the public sector is to provide a conducive environment for a flourishing digital financial sector, by developing a robust fast payment system and promoting competitive private digital payment solutions. Before developing a CBDC, it is important to assess whether market failures persist in private digital solutions (such as insufficient transaction costs reduction or limited population reach), or if other justifications for a CBDC exist. These may encompass the need to mitigate the risks of failure of private digital payment solutions, lowering costs of cash, introducing programmable public money, and interacting more efficiently with well-advanced digital markets, including tokenised markets.

Wholesale CBDCs could enhance resilience and reduce fragmentation by serving as a settlement asset on private or hybrid infrastructures. Retail CBDCs could similarly complement fast payment systems by providing a public, risk-free digital instrument that promotes interoperability, competition, and stability across the retail payment landscape. Many of the potential benefits attributed to retail CBDCs – such as greater financial inclusion and improved payment efficiency – can also be achieved through well-functioning fast payment systems and private mobile money schemes that are backed by central bank reserves. However, developing and maintaining a CBDC requires significant human and financial resources, and central banks need to carefully weigh this commitment, especially in the absence of international CBDC standards for CBDC design and interoperability.

Strengthening central bank digital technology capacity is critical to ensure operational efficiency, keep pace with technological advances, and reduce risks from obsolescence and cyberattacks (BIS 2023). Central banks with limited resources can benefit from peer learning and collaboration with those managing more advanced digital payment systems.

Digitalising public finance could promote regular use of private mobile money or CBDCs for public transfers or paying taxes (World Bank 2022). This transition can expand the digital network, reduce waste and leakages in public spending by reaching individuals directly, improve targeting of vulnerable people, enhance fiscal transparency, and curb informality while boosting tax compliance. While reduced informality might initially discourage some from adopting these digital solutions, the resulting efficiency gains and network effects can incentivise private sector participation in digitalised public transactions.

Government borrowing can be fractionalised through digital investment and payment platforms that enable small-value transactions, allowing individuals to purchase micro-denominated government securities. This approach broadens savings opportunities, particularly for lower-income people, and could integrate digital credit and investment ecosystems to further expand access to digital finance.

Artificial intelligence (AI) is increasingly shaping opportunities and risks in digital finance. On one hand, AI can significantly strengthen fraud detection, anti-money laundering, and cyber security by analysing large volumes of data in real time to identify unusual patterns and prevent illicit activities. AI can also help enable smart digital contracts and expand financing opportunities. However, AI introduces new and sophisticated risks. Generative AI can be exploited to create deep fakes, synthetic identities, and convincing phishing schemes that can deceive both consumers and financial institutions, thus undermining trust in digital systems. Traditional authentication methods such as passwords or simple biometric checks maybe insufficient. In this context, SSA countries should adopt a balanced approach leveraging AI to enhance financial integrity and consumer as well as data protection while investing in AI governance frameworks and digital literacy to mitigate emerging risks. Central banks and payment regulators should also promote responsible AI in financial services and support innovation sandboxes to test AI driven solutions in controlled environments.

Priority set 4: Fostering cross-border collaboration and interoperability

Engaging in regional or global consultations early on can promote interoperability by ensuring that digital developments rely on consistent cross-border legal, regulatory, and technological frameworks. This collaboration helps prevent the emergence of incompatible systems.

Such collaborations would promote regional cross-border flows, reduce regulatory arbitrage, and potentially enhance trade integration, especially if an interoperable, fast, and efficient regional payment system is established. Connecting these systems with domestic records of credit history would reduce the asymmetric information problem inherent in lending and hence further support cross-border flows and foster international financial integration.

Concerns about the volatility of capital flows and sudden stops would need to continue to be addressed through appropriate macroeconomic policies, capital flow management measures, and effective regulation of new digital financial instruments. International collaboration will be crucial not only to maintain interoperability but also to address the rapid obsolescence of technology platforms.

CONCLUSIONS: RECOMMENDATIONS TAILORED TO DIFFERENT DIGITAL PAYMENT INNOVATIONS

First, harnessing digital payments is both a developmental necessity and a strategic economic priority for SSA. With nearly half of adults lacking access to formal financial services, mobile money and fintech wallets offer a scalable, immediate pathway to financial inclusion. Governments should focus on strengthening regulatory frameworks to foster competition and interoperability among providers while simultaneously instituting strong safeguards for users, including robust consumer protection, data privacy, and cybersecurity measures. The economic benefits are significant: digital payments not only broaden access to finance but could reduce informality and enhance tax collection efficiency, and boost productivity across the board, by drastically lowering transaction costs for all economic actors depending on public financial management and legal frameworks.

Second, accelerating the rollout of open, competitive, and interoperable fast payment systems (FPSs) promises to deliver substantial efficiency gains across SSA economies. These systems enable instant or near-instant transactions, which is crucial for improving liquidity management and stimulating faster economic activity. Policymakers must actively encourage public–private collaboration to ensure widespread access, fair and transparent pricing, and the development of resilient infrastructure. In SSA, FPSs are designed to complement existing mobile money networks by providing real-time settlement across different providers, thus deepening competition and financial inclusion. Strengthening the underlying digital and telecommunications infrastructure is therefore a non-negotiable prerequisite to guarantee the reliability and reach of these essential systems.

The third recommendation relates to consideration of CBDCs. These should be strategically considered as complements – not substitutes – to established private digital payment systems and mobile money. As the use of physical cash naturally declines, CBDCs offer a unique and timely opportunity to modernise central bank money, enhance payment system resilience, and preserve public trust in the stability of money. Issuance, however, should not be rushed. Central banks could explore a complementary role for CBDCs to address market failures that continue to hinder financial development or financial inclusion to facilitate settlement, ensure greater payment resilience, and reduce fragmentation,[2] or for meeting strategic needs. There could also be other strategic rationales for the development of CBDCs. These include mitigating risks of failure of private digital payment solutions, reducing high costs of meeting demand for cash, having programmable public money in the digital payment space, and interacting more efficiently with well-advanced digital markets, including tokenised markets. Careful preparation is vital, including dedicated investment in building technical

2 See the IMF's CBDC Virtual Handbook at https://www.imf.org/en/Topics/digital-payments-and-finance/central-bank-digital-currency/virtual-handbook.

capacity, ensuring state-of-the-art cybersecurity, and comprehensive engagement with all stakeholders (Tourpe et al. 2023). Central banks should draw on lessons from ongoing global CBDC pilots to design systems that are efficient, interoperable, and fully tailored to the specific local conditions, backed by coordinated communication and sound macroeconomic policy.

Fourth, crypto-assets should be properly regulated, but not adopted as official currency or legal tender. While stablecoins and other crypto-assets can serve as powerful engines for financial innovation, they simultaneously introduce distinct risks to financial stability, monetary sovereignty, and consumer protection. Policymakers must prioritise comprehensive and adaptive regulation that covers prudential, conduct, and oversight requirements for all participants, including exchanges. Specifically, fully backed stablecoins may offer beneficial roles in areas like payments and cross-border remittances, and regulators must distinguish between fully backed crypto assets, which carry lower risks, and unbacked ones. It is also important to note that granting official currency status to crypto-assets would threaten monetary sovereignty and financial stability.

Finally, it is essential to place the digital reform agenda in the context of sound macroeconomic policies. Designing an effective digital development plan and regulatory framework alone is insufficient to ensure financial development and stability. Such efforts must be accompanied by sound macroeconomic policies and adequate governance arrangements that buttress confidence in the local currency and in the economy, as well as fostering consumer trust and protection.

REFERENCES

BIS – Bank for International Settlements (2023), "CBDC Information Security and Operational Risks to Central Banks", Consultative Group on Risk Management, November (https://www.bis.org/publ/othp81.pdf).

BIS (2024), "Embracing Diversity, Advancing Together—Results of the 2023 BIS Survey on Central Bank Digital Currencies and Crypto", BIS Papers No. 147 (https://www.bis.org/publ/othp73.htm).

Dobler, M C, J M Garrido, D J Grolleman, T Khiaonarong, and J Nolte (2021c), "E-Money: Prudential Supervision, Oversight, and User Protection", IMF Departmental Paper 2021/027 (https://doi.org/10.5089/9781513593401.087)

IMF – International Monetary Fund (2021a), "2021 Trends and Developments", Financial Access Survey, IMF Statistics Department.

IMF (2021b), "The Rise of Public and Private Digital Money: A Strategy to Continue Delivering on The IMF's Mandate", IMF Policy Paper 2021/055 (https://doi.org/10.5089/9781513592039.007).

IMF (2023), "Elements of Effective Policies for Crypto Assets", IMF Policy Paper 2023/004 (https://doi.org/10.5089/9798400234392.007).

Powell, J (2020), "Fed's Powell: More important for U.S. to get digital currency right than be first" Reuters, 19 October (https://www.reuters.com/world/asia-pacific/feds-powell-more-important-us-get-digital-currency-right-than-be-first-2020-10-1)./

Tourpe, H, A Lannquist, and G Soderberg (2023), "A Guide to Central Bank Digital Currency Product Development", IMF Fintech Note 2023/007 (https://doi.org/10.5089/9798400253690.063).

Ricci, L A, C Ahokpossi, A Belianska et al. (2024), "Central Bank Digital Currency and Other Digital Payments in Sub-Saharan Africa: A Regional Survey", IMF Fintech Note 2024/001 (https://doi.org/10.5089/9798400273025.063).

Ricci, L A, C Ahokpossi, S N Quayyum et al. (2025), "Digital Payment Innovations in Sub-Saharan Africa," IMF Departmental Paper 2025/004 (https://doi.org/10.5089/9798400232220.087).

World Bank (2022), *The Role of Digital in the COVID-19 Social Assistance Response* (http://documents.worldbank.org/curated/en/099830009302217091).

World Bank (2023), *Remittance Prices Worldwide Quarterly* 46 (https://remittanceprices.worldbank.org/sites/default/files/rpw_main_report_and_annex_q223.pdf).

ABOUT THE AUTHORS

Luca Antonio Ricci is Assistant Director and Mission Chief at the International Monetary Fund, and a CEPR Research Fellow. He is Mission Chief for the West African Economic and Monetary Union and leads the African Department Working Group on Digital Payments. He previously was Mission Chief for the Ivory Coast, Chile, Ecuador, Panama, and Oman, and held positions in the Research Department, publishing over 40 papers in refereed journals. In 2010 he was Managing Director and Head of International Economics at Barclays Capital. Prior to joining the IMF, he was a visiting fellow at Harvard University and the University of Konstanz. Mr. Ricci received a Ph.D. and an M.A. in Economics from The Graduate Institute in Geneva, and a B.A. from the University of Rome "La Sapienza", summa cum laude.

Calixte Ahokpossi is Advisor and Mission Chief at the International Monetary Fund. He is currently Mission Chief for the Democratic Republic of Congo. He held other mission chief and economist positions in the African Department, the Asia Pacific Department, Strategy Policy and Review Department, and Middle East and Central Asia Department. His research focuses on monetary policy, financial sector development and debt dynamics. He holds a Ph.D. in economics from Boston University.

Saad Quayyum is a Senior Economist in the African Department at the International Monetary Fund. His research focuses on international finance, growth, and development. Previously, he has worked in Strategy Policy and Review Department, Middle East and Central Asia Department and Finance Department at the Fund. Prior to the Fund, he worked at the Federal Reserve Bank of Chicago. He has a Bachelor of Arts in Economics from Dartmouth College, and Ph.D. in Economics from University of Wisconsin-Madison.

Rima Turk serves as the IMF's resident representative in Comoros, after working since 2013 on advanced economies (Sweden, Denmark), emerging (Nigeria) and frontier (Tunisia) markets, and low-income countries (Moldova). She was a lead contributor to the IMF's strategy on fragile states and the departmental paper on digital payments in SSA. Prior to that, she was a tenured professor in finance at the Lebanese American University and a regular visiting scholar to the Bank of Finland and the Université de Strasbourg. She published more than 30 peer-reviewed papers in top-tier journals and presented them at more than 40 international conferences including at the Chicago Fed and Banca d'Italia. Her research focuses on bank stability, macro financial linkages, corporate financing and investment, economic diversification, migrant integration, and impact of IMF programmes. Ms. Turk holds a Ph.D. in Finance from Cardiff Business School.

Anna Belianska is an economist at the International Monetary Fund, where she covers a wide range of macroeconomic issues in the Strategy, Policy and Review Department. She also serves as external sector economist for Mozambique. Previously, Anna covered financial sector issues in the context of Saudi Arabia Financial Sector Assessment Program (FSAP), the Comoros mission team and in technical assistance, and served as a desk economist for CEMAC. Anna holds a Ph.D. in Economics from Aix-Marseille School of Economics (France).

Mehmet Cangul is a senior economist at the International Monetary Fund where he has been covering emerging policy challenges in diverse parts of the world for the last 15 years. Prior to his current position at the Strategy, Policy and Review Department where he is the lead economist on quota reform and the IMF's engagement with the G20, he was the Resident Representative of the IMF in Niger and desk economist in various parts of Africa from Sierra Leone during the Ebola crisis to Namibia more recently. He is the author of a book, and numerous papers and original research published at the IMF. Most recently, he co-authored an IMF Board Paper on the current challenges facing the Global Financial Safety Net. He holds an undergraduate degree in international economics (magna cum laude) from the School of Foreign Service, Georgetown University, and a master's degree in econometrics and statistics from Harvard University.

Habtamu Fuje is the current IMF Resident Representative in Rwanda. He has extensive experience at the IMF and World Bank. At the IMF, he has worked in the Middle East and Central Asia Department (covering Armenia and Turkmenistan) and in the African

Department's Regional Studies Division. His research focuses on central bank digital currencies (CBDCs), sovereign spreads and the Debt Service Suspension Initiative (DSSI), de-dollarisation, the fiscal impacts of climate disasters, and regional inequality. Prior to the IMF, he was an Economist at the World Bank, leading analytical, capacity development, and lending projects across Sub-Saharan Africa and Asia, including in Bangladesh, Cambodia, Ethiopia, Kenya, Malawi, Mongolia, Mozambique, Rwanda, Sudan, Tanzania, and Uganda. His work has addressed fiscal reforms, trade and market integration, jobs and structural transformation, climate change, poverty, and inequality. His research has been published in leading academic journals, and the World Bank's and IMF's working paper series. He holds a PhD from Columbia University and a master's degree from Harvard University.

Sunwoo Lee is an Economist at the International Monetary Fund, currently serving as a desk economist for Malawi. She previously worked as an economist on the Tanzania and South Sudan teams in the African Department, and in the Financial Policies division within the IMF's Institute for Capacity Development, where she delivered capacity development on financial sector-related topics. She holds a PhD and MA in Economics from Cornell University.

Grace Li is a Senior Economist at the International Monetary Fund. Her expertise spans macro-finance, macro-fiscal, and growth and development. Since joining the IMF, she has worked in the African Department European Department, Fiscal Affairs Department, Research Department, and Western Hemisphere Department, as country economist for G7 economies — including the United States, China, Australia, Canada — and for a range of developing countries. She has published extensively in top peer-reviewed academic journals on banking, development, and policy issues. She was an adjunct assistant professor at Johns Hopkins University's Paul H. Nitze School of Advanced International Studies (SAIS) where she taught Development and Growth. Ms. Li holds PhD. and M.A. degrees from the University of Chicago.

Yibin Mu is a Senior Economist in the IMF's Western Hemisphere Department. He previously worked in the African Department on South Africa, Lesotho, and Sierra Leone. Before joining the IMF, he spent 11 years at the World Bank as a Senior Financial Economist across Asia, Europe, and the Financial Vice Presidency, and eight years at the Hongkong Monetary Authority and the People's Bank of China, where he supervised foreign banks and contributed to China's financial reform policies. His expertise covers macro-financial, monetary, and fiscal policies, as well as prudential supervision and regulation and financial market development. He holds an MC-MPA from Harvard University and a PhD in economics and a master's degree in finance from Tsinghua University, China. He was a CFA charter holder (2006-13).

Nkunde Mwase is a Senior Economist at the IMF, where she has worked since 2004 in departments including Monetary and Capital Markets, Strategy Policy and Review, African, and Western Hemisphere. She has completed missions to 13 countries across Africa, Europe, the Middle East, and the Caribbean. She contributed to the Financial

Sector Assessment Program for Bosnia-Herzegovina. Ms. Mwase coordinates the African Working Group on Digital Payments and led the CBDC chapter. She developed the Reserve Adequacy Metric for credit-constrained economies, the "Week at the Beach" Index, and the Frontier Market Economies classification framework. Before the IMF, she was a macroeconomist at the Bank of Tanzania and holds graduate degrees from Oxford and Warwick.

Jack Joo Ree is a senior economist who has worked for International Monetary Fund (IMF) since 2006. His major assignment at the institution include IMF's Resident Representative for Malawi, IMF's Mission Chief for Tonga, and senior desk for Korea, Nigeria, Zambia and Lesotho (current).

Prior to joining the IMF, Mr. Ree worked for Bank of Korea for 17 years during the time of Korea's dynamic transformation from emerging to an advanced economy. He graduated from Seoul National University (Economics, B.A.) and got his Ph.D. in Economics from Cornell University.

Haiyan Shi serves as the IMF's resident representative in Equatorial Guinea. She has extensive experience at the IMF, where she has worked in the African Department (covering Central African Republic and Lesotho), the Middle East and Central Asia Department (covering Sudan) and the Western Hemisphere Department (covering Antigua and Barbuda, Aruba, Nicaragua, and Panama). She also led technical assistance missions to seven countries while she was the senior economist in the Statistics Department of the IMF. Her research focuses on central bank digital currencies, financial development and growth, and housing market development. Prior to the IMF, she also worked in the World Bank. She holds a PhD from American University, and a master's degree in finance from Tsinghua University.

Vitaliy Kramarenko is a Deputy Director at the International Monetary Fund African Department, overseeing country work on Angola, Zimbabwe, Ghana, and WAEMU countries. Previously, he was overseeing the CEMAC countries, and served as a Director of the African Training Institute and the AFRITAC South in Mauritius. He also worked in the Strategy and Policy Review department (heading the Lending Policy Division), the European department, and the Middle East department. Mr. Kramarenko holds a PhD in International Economics from the University of Grenoble.

CHAPTER 4

The tokenised US dollar ecosystem

Michael Junho Lee[1]
Federal Reserve Bank of New York

The US dollar system is undergoing dramatic digital transformation, with stablecoins leading the way. With the passage of stablecoin legislation and more regulations to come, the United States strives to provide regulatory clarity and support the growing tokenised US dollar system. In this chapter, I outline the implications of payment stablecoin regulatory framework on the existing stablecoin ecosystem, and the development of other tokenised US dollar assets. I highlight the two key dimensions that will sculpt the future of the tokenised ecosystem: access and return.

THE EVOLVING LANDSCAPE FOR US DOLLAR TOKENISATION

The Executive Order on "Strengthening American Leadership in Digital Financial Technology",[2] announced on 23 January 2025, aims at positioning the United States as a leader for blockchain-based markets and systems by promoting innovation and calling for regulatory clarity.

It signalled two tectonic shifts in the national approach to the financial infrastructure. First, it lays out a national strategy that prefers private to public innovation in the digital asset space, particularly in the provision of payment services. Explicitly, it prohibits work on central bank digital currency (CBDC) and affirms the need for regulatory clarity on stablecoins. Second, it pivots the national stance towards blockchain-based innovations, including the potential use of public blockchains. Explicitly, it recognises the principles of personal liberties and freedom in permitting blockchain-based activity for "lawful" purposes, and emphasises the need for a "technology-neutral" approach to regulation.

These shifts in the national stance towards blockchain-based innovations have resulted in tangible developments, notably with regard to stablecoins and forms of tokenised dollars. On 18 July, the Guiding and Establishing National Innovation for US Stablecoins (GENIUS) Act was signed into law, establishing a federal framework for issuance of payment stablecoins. This was against the backdrop of efforts to codify bans on the issuance of CBDC.[3]

1 Special thanks to Janine Wang for excellent research assistance. The views expressed are mine and not necessarily those of the Federal Reserve Bank of New York or the Federal Reserve System.
2 https://www.whitehouse.gov/presidential-actions/2025/01/strengthening-american-leadership-in-digital-financial-technology/
3 https://www.congress.gov/bill/119th-congress/house-bill/1919/text

Today, banks,[4] fintechs,[5] and non-financial companies[6] are exploring stablecoin issuance, as well as other forms of tokenised US dollar, including treasury securities, money market funds,[7] and deposit tokens.[8]

TAKING STOCK OF STABLECOINS

Stablecoins have undergone explosive growth, both in terms of interest and market capitalisation. Today, there are 340 stablecoins, and the number continues to grow. At the same time, the stablecoin market is highly concentrated. By currency, 97% of the market is denominated in US dollars, with a total market capitalisation of over $270 billion. Furthermore, the market is dominated by a centralised issuance model, whereby a single entity controls the issuance of stablecoins. Finally, stablecoins are predominantly fiat-backed, i.e. they are backed by a reserve of financial assets denominated in the target currency. Two centralised issuers alone of fiat-backed stablecoins – Tether (USDT) and Circle (USDC) – account for over 85% of all stablecoins.[9]

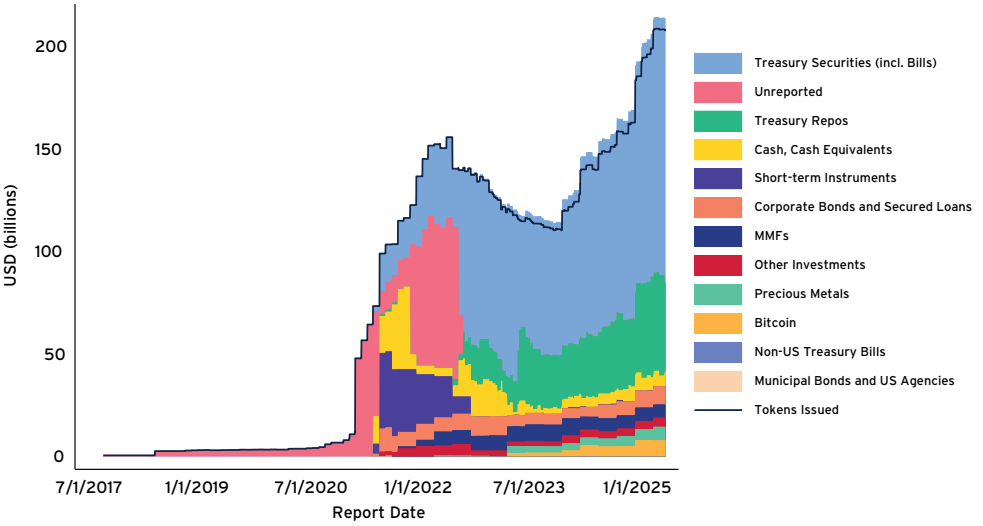
The GENIUS Act aims to provide regulatory clarity for this segment of the stablecoin market that involves fiat-backed stablecoins with centralised issuance. It sets forth a federal regulatory framework for "payment stablecoins". Payment stablecoins are digital assets designed to be used for payment or settlement, are pegged to fiat currency, and provide redemption rights to its holders. Among other requirements, the GENIUS Act prohibits issuers of payment stablecoins from directly paying interest or yield, requires issuers to offer at-par redemption to stablecoin holders, and sets standards on disclosure and reserve requirements. Stablecoin issuers must also obtain approval from an appropriate federal or state banking regulator before issuing a payment stablecoin and will be subject to supervision and/or oversight.

How close is today's stablecoin market to meeting anticipated regulatory requirements? A key requirement is that US dollar stablecoin issuers must hold cash and cash equivalents in US dollars. Given similarities, the requirements for government money market funds are a good benchmark. The set of permissible assets includes commercial bank deposits, short-term Treasury securities, repo, and agency debt. Most, if not all, fiat-backed stablecoin issuers disclose some information on the composition of their reserves. I examined the ten largest fiat-backed stablecoins over a sample period using historical public disclosures.[10]

4 https://www.reuters.com/business/finance/bank-america-expects-launch-stablecoins-morgan-stanley-weighs-use-2025-07-16/
5 https://fintechmagazine.com/articles/exploring-fiservs-entry-into-stablecoin-market-with-fiusd
6 https://www.theinformation.com/briefings/walmart-amazon-explore-issuing-stablecoins
7 https://www.coindesk.com/business/2024/11/13/blackrock-expands-tokenized-fund-buidl-beyond-ethereum-to-five-new-blockchains
8 https://www.jpmorgan.com/kinexys/content-hub/deposit-tokens
9 Stablecoin statistics are Federal Reserve Bank of New York staff estimates based on data from Coingecko.
10 This set includes USDT (Tether), USDC (Circle), FDUSD (First Digital), PYUSD (Paypal), RLUSD (Ripple), USDG (Paxos), BUSD (Binance), USD1 (World Liberty Financial), GUSD (Gemini), and USDP (Paxos).

Do stablecoins meet this basic requirement? At the aggregate level, not quite. Figure 1 shows the aggregate stablecoin reserves over time. Transparency on stablecoin reserves has improved in the past several years. A significant fraction of reserves remained unreported until late 2022, reflecting greater demand by users for transparency on how stablecoins are managed. Still, as of mid-2025, almost 13% of stablecoin reserves are held in non-compliant assets, including precious metals, cryptocurrencies, and unspecified financial assets. In comparison, , as of mid-2025 the US government money market fund industry holds – for retail and institutional segments, respectively – 38% and 35% in Treasuries, 47% and 50% in repo, and 15% and 15% in other assets including floating rate notes, foreign bank obligations, cash, and deposits.[11] Non-compliant assets are predominantly held by non-US stablecoin issuers, notably Tether. In contrast, US stablecoin issuers hold a combination of treasury securities, treasury repo, and bank deposits, highlighting the importance of establishing regulatory oversight for non-US issuers as well.

FIGURE 1 ASSET DECOMPOSITION OF AGGREGATE FIAT-BACKED STABLECOIN RESERVES



Source: FRBNY staff estimates.

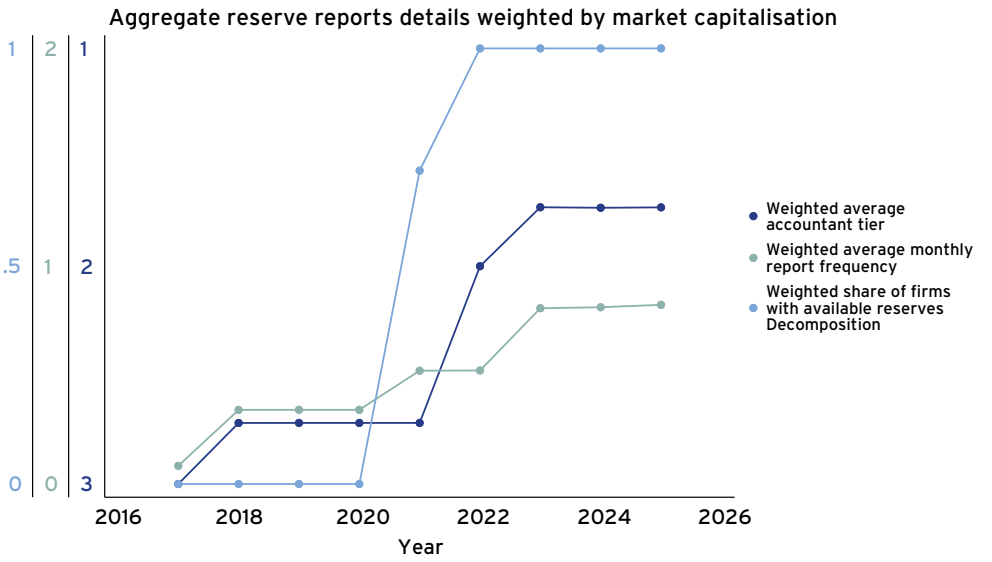
The asset decomposition of reserves is based on voluntary disclosures with third-party attestations. Thus, the accuracy of these disclosures is subject to how credible the reporting is – an aspect often under question.[12] To track and compare the quality of stablecoin issuers' disclosure practices, each stablecoin is evaluated based on three dimensions:

11 Money market statistics are Federal Reserve Bank of New York staff estimates based on data from iMoneyNet.
12 A notable example is TrueUSD, an off-shore stablecoin whose reserves were revealed to be held in long-term illiquid assets, in contrast to its attestations.

1. availability of reserve decomposition;
2. frequency of disclosures; and
3. tier of auditing firm.

Qualitatively, the disclosure practices of stablecoin issuers have improved significantly in the last five years in all three dimensions (Figure 2). In addition to issuers adopting a regular cadence of disclosing their reserves, the average issuer has increased the frequency of their disclosures, as well as engaging with a higher tier of auditing firms. There is, of course, ample room for improvement. With regards to assets, money market funds are required to report security-level and fund-level details on their reserves at a monthly frequency and share their holdings of liquid assets and net asset value at a daily frequency, exceeding what is provided by even the most rigorous stablecoin issuer. In addition, according to an industry report,[13] 98% of money market funds are audited by the Big Four (PwC, EY, Deloitte, and KPMC).

FIGURE 2 STABLECOIN ISSUERS' DISCLOSURE AND AUDITING PRACTICES



Source: FRBNY staff estimates.

An important feature is that stablecoin issuers are required by the GENIUS Act to provide redemption at par to stablecoin holders. Stablecoin issuers vary significantly in their policies on eligibility and fees associated with redemptions. Major fiat-backed

13 https://blog.auditanalytics.com/who-audits-mutual-funds-fund-type-market-share/

stablecoins, such as USDT and USDC, provide significant connectivity between the banking and blockchain systems by providing redemption at par, either directly through the issuer or indirectly through partners and third-party services.[14]

As such, like money market funds, stablecoins are likely to experience nontrivial flows on a daily basis. Today, the accessibility and speed with which user can move cash in and out of stablecoins vary significantly. Over the course of January 2021 to December 2024, the second-largest stablecoin provider, Circle, provided redemption of $464 billion in USDC, or a daily average of about $318 million.[15] This implies a daily redemption rate of about 0.93% of total market capitalisation, and a daily absolute percentage change in market capitalisation for USDC of about 0.62% – levels reasonably in line with those observed for US government money market funds. In comparison, the 25th and 75th percentile of daily absolute percentage change in market capitalisation of US government money market funds in 2024 is 0.4% and 2.79%, respectively.

However, stablecoin issuers may be expected to provide greater access and speed in redemptions. For example, Circle offers up to "near-instant" redemptions.[16] This feature explains a key difference between Circle's reserves and those of money market funds, which typically provide T+0 or T+1 settlement. Stablecoin providers issue stablecoins after receiving US dollars from customers, and fulfill customers' redemption requests after receiving stablecoins by sending a corresponding amount in US dollars. Both processes require stablecoin providers to hold commercial bank deposits. Consequently, redemptions are processed closer to a gross, rather than net, basis, resulting in greater intraday payment volatility. Second, greater integration to support stablecoin usage for day-to-day payment needs could also increase gross redemptions, transmitting payment-related liquidity shocks to banks and the Treasury market.

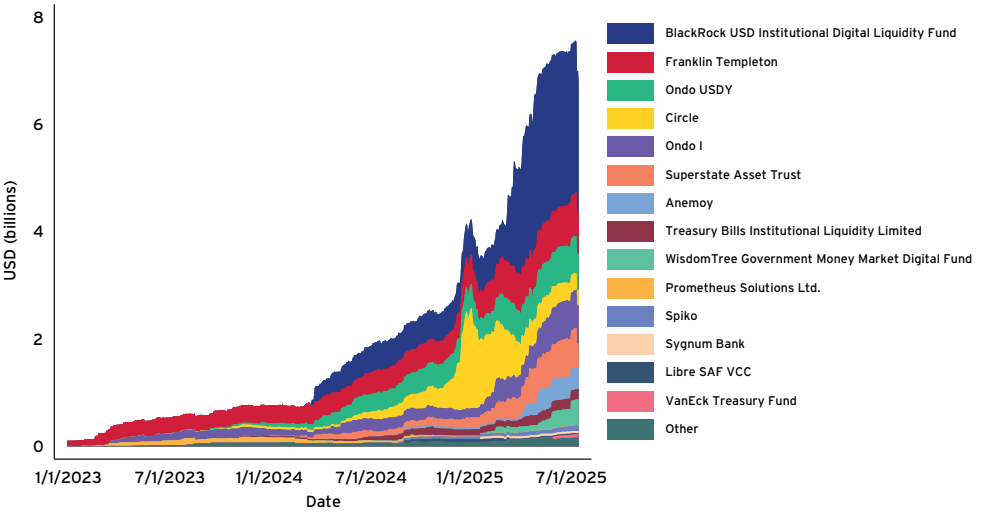
TOKENISATION OF DEPOSITS AND MONEY-LIKE ASSETS

Tokenisation refers to the digital representation of traditional assets on blockchain systems. Although US dollar stablecoins represent the majority of the tokenised US dollar market, financial institutions have begun tokenizing other US dollar assets. There are broad efforts to tokenise various asset classes spanning securities, real estate, and commodities. Here I focus on tokenisation of money-like assets, notably Treasury funds and deposits.

14 Circle offers direct redemptions for USDC through Circle Mint, and indirectly through centralized exchanges, such as Coinbase, and third-party payment providers, such as MoonPay.
15 Based on disclosures from Circle's IPO prospectus.
16 Circle offers redemption at progressively higher fees and expected settlement times based on the size of the redemption request.

A nascent but fast-growing segment is tokenised Treasury and money market funds. Figure 3 shows the growth of the tokenised Treasury market by issuer. The issuer of a tokenised fund creates and distributes tokens that represent shares of the underlying fund and offers redemption, fulfilled with stablecoins or traditional payments.

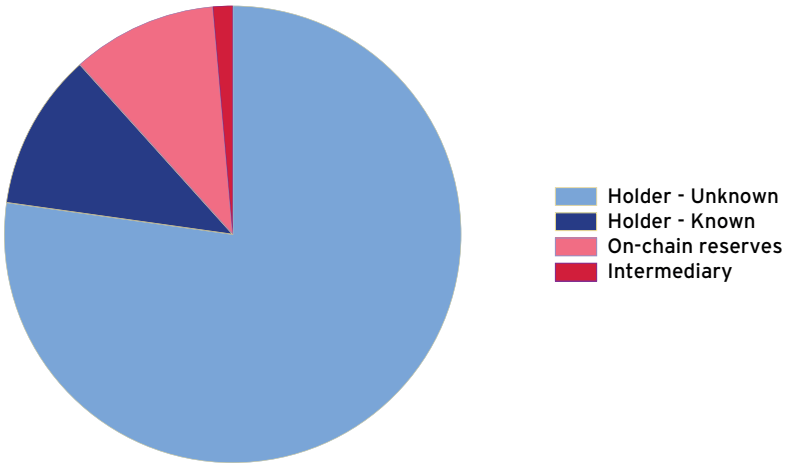
FIGURE 3 TOKENISED TREASURY FUNDS DECOMPOSITION BY ISSUER



Source: RWA.xyz.

I hand-collected cross-chain holder-level data on tokenised funds. In aggregate, tokenised funds reached about $7 billion as of June of this year and have grown $5.5 billion since a year ago. There are 49 tokenised Treasury products made available across 35 issuers, and about 53,000 (and growing) holders. I classify holders into four categories. An "intermediary" is a holder whose activities are characteristic of exchanges or intermediaries and who engages in significant activity with other tokens and addresses. "On-chain reserves" are holders linked to entities holding with the intention of using the token to back another token they issue, such as a Treasury fund token or a stablecoin. The remaining are "holders", who typically buy and hold. Figure 4 provides a breakdown in the types of holders with over $5 million as of August 2025. The majority of tokenised funds are held in 'buy-and-hold' accounts, and a sizeable fraction of tokenised funds are held for on-chain reserves.

FIGURE 4 TOKENISED TREASURY HOLDERS BY TYPE



Source: FRBNY staff estimates.

In reaction to the changing regulatory climate and increased competition from stablecoins, several banks are exploring the issuance of deposit tokens – native representation of bank deposits in token form on permissionless blockchains – and tokenised deposits – token forms that mirror holdings in traditional commercial bank accounts. Several banks have announced pilot projects, including JP Morgan Chase's JPMD.

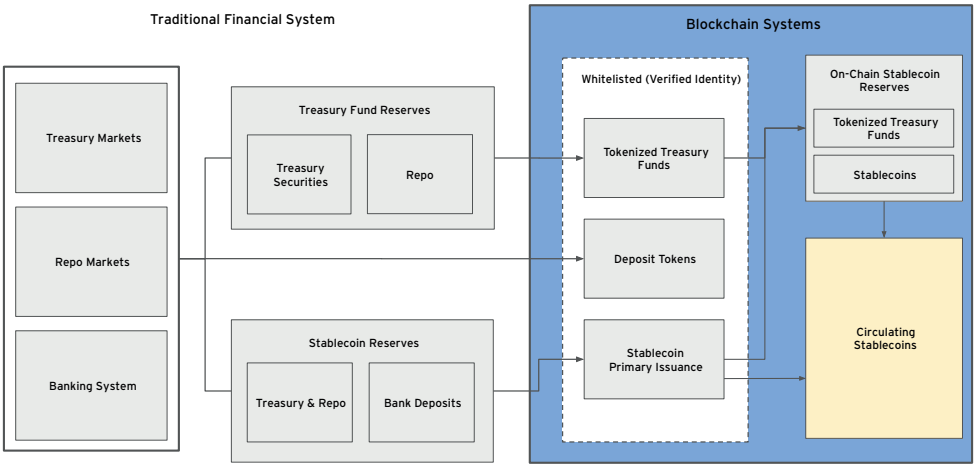
Stablecoins, tokenised Treasury funds, and deposit tokens all comprise claims on some combination of safe and liquid US dollar assets. Figure 5 provides a diagram of the linkage between blockchain systems and the traditional financial system vis-à-vis the tokens and the assets held as backing in the traditional system. Although stablecoins and other tokenised assets bear strong similarities in terms of their economic structure, they differ in terms of their legal and regulatory approach. In contrast to stablecoins, for which there is no existing equivalent, token forms of money market funds and deposits generally conform to existing regulatory frameworks for the traditional forms of these assets. This difference in approach has implications regarding access and return.

First, the issuer of tokenised Treasury funds and deposit tokens must directly verify any and all token holders. Like any traditional financial service arrangement, all potential clients undergo standard compliance processes, including know-your-customer (KYC) and anti-money laundering (AML) checks. Cleared clients are then granted access to respective tokens issued on the blockchain through a procedure called 'whitelisting', with only those on the whitelist able to interact with the tokens. The whitelist acts as a permissioned boundary in an otherwise permissionless environment and allows the issuer to control and manage access to their tokens. Any transaction, including peer-to-peer transactions, can only be made between those explicitly part of the whitelist. Under the GENIUS Act, stablecoin issuers are expected to meet similar standards of user verification for primary markets. At the issuance stage, stablecoin issuers functionally

manage a 'whitelist' as well. However, once issued, stablecoins are free to circulate, reaching a much broader base of users to own and access stablecoins without a direct relationship with the issuer. This flow is depicted in Figure 5, where issued stablecoins circulate outside of the whitelisting environment.

Second, as with their traditional counterparts, tokenised Treasury funds and deposit tokens are able to offer interest and yield to token holders. Tokenised Treasury and money market funds offer competitive money market rates to investors. Because stablecoins are forbidden from paying interest, yield-bearing US dollar assets are viewed as an integral part of the broader tokenised US dollar system. Correspondingly, issuers commonly accept and redeem in stablecoins, which enables investors to manage liquidity on blockchains more efficiently.

FIGURE 5 TOKENISED ISSUANCE DIAGRAM



There are, however, several important considerations. While the GENIUS Act prohibits payment stablecoin issuers from paying interest and yield directly to their holders, payment stablecoin issuers leverage partnerships with key distribution channels (for example, centralised exchanges) to circumvent direct interest and yield payments to holders. In doing so, stablecoin issuers can retain rate-sensitive holders, including institutional investors, who represent a sizeable portion of stablecoin users. For example, roughly a quarter of Circle's USDC is held at Coinbase, which provides competitive rewards to investors that custody their USDC at Coinbase. Banks and stablecoin issuers disagree about whether this form of indirect yield transfers violates the GENIUS Act, and it will be a hotly debated issue as regulators and market participants turn to the implementation of the Act. Second, novel blockchain-based arrangements grant stablecoin holders with various ways to obtain yield from their holdings.

CONCLUSION

Major tailwinds are underway, with potential transformation in the way traditional financial transactions are settled and in the form and utility of money itself. Stablecoins, tokenised Treasuries, and deposit tokens each strike a different balance between access and return – a balance that will determine their role in payments and intermediation, and their implications for financial stability. The potential adoption of permissionless blockchains for traditional financial activity marks a big, if uncertain, evolution in how finance works. This puts utmost importance on cultivating and developing a regulatory environment that manages innovation for a safe and resilient financial system.

ABOUT THE AUTHOR

Michael Junho Lee is a Financial Economist at the Money and Payment Studies Department at the Federal Reserve Bank of New York. His recent work explores issues at the intersection of technology and finance, and focuses on financial system architecture and the future of money. Michael received his PhD in Finance from the Wharton School at the University of Pennsylvania.

CHAPTER 5

Central bank electronic cash and monetary sovereignty

Ulrich Bindseil and Piero Cipollone[1]
TU Berlin; European Central Bank

1 INTRODUCTION

The digitalisation of large parts of everyday life and of the economy also extends to payment transactions. According to the ECB's 2024 SPACE report, the share of cash payments at the point of sale (i.e. in physical shops) in the euro area declined from 79% to 52% between 2016 and 2024, mainly in favour of card payments. If one includes e-commerce (which does not allow for the use of cash, and which plays an ever-increasing role), the share of cash in day-to-day transactions was as low as 40% in 2024, and just 24% in value terms. Overlay solutions like ApplePay, enabling seamless mobile payments at the point of sale based on an underlying card, appear to be accelerating this trend. If these trends, which can be observed globally, continue or even accelerate, the role of cash and thus of central bank money could become negligible.

Against this backdrop, a growing number of central banks have started preparations to issue central bank electronic cash alongside physical cash, including the People's Bank of China (in 2014), the Riksbank (in 2016), the Reserve Bank of India (in 2017), and the ECB (in 2019).[2] The envisaged design features of central bank electronic cash that have emerged consistently across these projects include non-remuneration and limitation of holdings – both emphasising that central banks do not want to crowd out the private sector with a form of central bank money that would be attractive as a large-scale store of value. By issuing electronic cash, central banks instead seek to preserve the benefits for citizens of the co-existence of central bank money alongside commercial bank money by the doing the following:

- Modernising central bank money available to citizens by also offering the advantages of electronic payments, such as convenience (e.g. integration into mobile phones), broader use cases (e.g. e-commerce transactions that can only

1 Views expressed are our own and not necessarily those of the European Central Bank. We would like to thank Jean-Francois Jamet for very helpful comments.
2 Since 2015, the term 'retail central bank digital currency (CBDC)' has been widely used to designate such central bank electronic cash, but as the term is misleading for several reasons (Bindseil et al. 2025), we avoid it in this chapter.

be settled electronically), overcoming the need to warehouse cash in a separate wallet, and reducing risk of theft (without denying the specific strength of cash and the benefits of continuing to support its usability).

- Preserving choice for citizens and merchants and preventing abuse of market power by a few dominant private firms, since payment instruments have strong network effects.
- Avoiding excessive dependence on payment firms headquartered abroad for reasons of strategic autonomy.
- Preserving the anchoring of all forms of private money in an effective convertibility promise into usable central bank money. Indeed, private money is so far defined by a promise to be converted 'at sight' into central bank money. During the gold standard, when all forms of money (central bank and commercial bank issued) were ultimately anchored through a convertibility promise into gold, this would have appeared to be less of an issue. Still, even under the gold standard it was ultimately concluded, for efficiency and financial stability reasons, that central banks should be the dominant, or even exclusive, issuers of cash.

In parallel to the work of payment experts at central banks, a heated academic debate about central bank electronic cash began in 2016. When central bank electronic cash first started being discussed in 2015/2016 by central bank researchers (e.g. Barrdear and Kumhof 2016), uncertainty over design features was high. Many academic researchers imagined central bank electronic cash would be remunerated and reach large scale, so that it mattered in their macro models. The central bank electronic cash as actually proposed by central banks has little to do with these assumptions, and the predictions of various macroeconomic models of its impact thus have limited practival relevance (Bindseil and Senner 2023). In particular, electronic cash as favoured by central banks is not aimed at enhancing the effectiveness of monetary policy or at imposing a 'sovereign money' system on society, as envisaged for example by Dyson and Hodgson (2016). The use of central bank money is currently retreating, and – contrary to what is assumed in academic macro models, and emphasised by its critics – central bank electronic cash as designed by central banks is aimed at preventing this trend from continuing and thereby preventing the loss of monetary sovereignty that would be implied by the disappearance of widely usable public money (Cipollone 2024).

In the next section, we review the concept of monetary sovereignty more generally. On that basis, Section 3 explains in more detail why central bank electronic cash is key to preserving monetary sovereignty in a world of ever-increasing electronic payments and geopolitical deterioration. Section 4 concludes.

2 MONETARY SOVEREIGNTY

The idea of national sovereignty is often attributed to Jean Bodin (e.g. Bodin 1576) and to the Peace of Westphalia of 1648, which recognised that states have authority over their respective territories, without interference from foreign parties (such as, for example, the Papal state on religious matters). Relatedly, a sovereign state, to come into existence and be recognised, must have a population, a territory, and effective political power. Each state is equal under international law, and none should have power over another state.

Sovereignty implies rights and obligations, both of which have a domestic and an international dimension. A key domestic right of a sovereign state is to act independently and without imposed constraint within its territory. Internationally, states have the right of representation in international forums and the obligation to comply with international law, including the obligation to recognise other states as sovereign, to refrain from intervening in other states, and to take responsibility and control over actions of parties within its territory that could harm foreign states. The duty to recognise the sovereignty of other states is, of course, consistent with the right of a state to exercise its own sovereignty and with the principle of equality. In claiming the rights that come with sovereignty, there is an implicit recognition of the right of others to make similar claims and exercise similar rights (e.g. Jackson 2007). Krasner (1999: 3-4) does not simply distinguish between domestic and international sovereignty but considers four key distinct meanings of sovereignty, of which the last three have rich applications in the field of money:

- **International legal sovereignty** consists in "the practices associated with mutual recognition, usually between territorial entities that have formal juridical independence". A state is sovereign in this sense if it is generally recognised by other states.
- **Westphalian sovereignty** refers to "political organisation based on the exclusion of external actors from authority structures within a given territory" (Krasner 1999: 20-21). Specifically, external actors should be excluded, de facto or de jure, from the territory of a state. Westphalian sovereignty can be undermined both by coercive and voluntary actions (i.e. intervention and invitation). Foreign rulers can dictate or coerce changes of domestic authority structures and even place their agents in those structures; more generally, they can intervene in domestic affairs through interventions of various kinds. Rulers of a state can also voluntary agree to "supranational or extranational authority structures that constrain their own domestic autonomy" (p. 20).

- **Domestic sovereignty** refers to both authority and control. First, there is a final and absolute authority for a territory, which is the state, and there is no other such authority (p. 11). Second, the state organs must be able to exercise effective control within the borders of its territory. A lack of domestic control per se does not question international or Westphalian sovereignty.

- **Interdependence sovereignty** refers to "the ability of public authorities to regulate the flow of information, ideas goods, people pollutants, or capital across the borders of their state". Such sovereignty is reached if the state is in control of its borders, i.e. it "can regulate movements across its borders" (p. 21). A loss of interdependence sovereignty does not undermine international or Westphalian sovereignty. With regards to domestic sovereignty, it implies a loss of control, although not necessarily a loss of authority.

Monetary sovereignty was identified as a major issue of sovereignty as early as in the writings of Jean Bodin, who stated that "only he who has to the power to make the law can regulate the coinage".[3] Money and finance are core to a modern society based on the division of labour and production and relying on the credit financing of an extensive stock of (illiquid) real capital. Ever since the first coins of the Lydians, coinage has been a sovereign right claimed by supreme authority of the state. That money relies on a sovereign is illustrated, for example, by the concept of legal tender – the legal right to discharge debt obligations with public money. Moreover, money today means financial money – that is, money relying not only on the recognition and enforcement of property rights by the state, but also the more subtle regulation of insolvency, default, and law enforcement and creditors' rights. The 'denationalisation' of money due to globalisation and the internet is therefore largely a chimer.

Monetary sovereignty is a particularly complex and interesting field of sovereignty for several reasons. First, money and finance have strong network effects and public good properties. Second, in a globalised world, these network effects are also global and imply that international dominance and potential abuse of power will inevitably also challenge the international aspects of monetary sovereignty. Ever since the first Lydian coins, money has circulated beyond the borders of the state in which it is issued and has competed for dominance in global payments (e.g. Suchodolski 2007). Financial crises – from the European crisis of 1763 (Schnabel and Shin 2004) to the great financial crisis of 2008 – consistently demonstrate that the global externalities and contagion of unsound money and finance (including regulatory failures), and their scale, are sufficient to undermine economies and public finances of other states. Financial crime and illicit payments are a global phenomenon, and a lack of sovereignty and control in one country can become important threats to the sovereignty of other nations.

3 More recent discussions of monetary sovereignty include Gianviti (2004), Zimmermann (2013), Aglietta (2016), Murau and van't Kloster (2023), Villeroy de Galhau (2023), Zellweger-Gutknecht (2023), Landau and Nicole (2024), Martino (2024), Pistor (2017), and Bindseil and Senner (2025).

Monetary sovereignty can be broadly defined as a nation's freedom and ability to control the creation and circulation of monetary and financial instruments, and to control domestic as well as cross-border payments and other financial flows, for the benefits of its citizens and the strength of the nation state. Bindseil and Senner (2025) distinguish ten dimensions of monetary sovereignty, relating to (1) money issuance, (2) unit of account, (3) means of payment, (4) store of value, (5) monetary and FX regime, (6) (international) lender of last resort, (7) international currency, (8) financial market infrastructures, (9) fraud prevention, and (10) cyber protection.

More recently, **the struggle for monetary sovereignty seems to have dramatically intensified** with the globalisation of electronic money thanks to the internet and ever-declining ICT costs, the advent of new technologies such as public blockchains and their use for illicit payments, and a surge of nationalism and imperialism (as illustrated, for example, by the invasion of Ukraine by Russia and a general trend for governments to play the populist card and dismiss in that context the merits of international cooperation). Last but not least, the economic rise of what has recently been (mis-)named the 'Global South' – nation states such as China, India, Indonesia, Brazil, Mexico, Saudi Arabia, and the UAE – has led to a more multi-polar world in which the predominance of Western countries, and the US in particular, in international monetary and financial instruments and infrastructures is questioned, including the role of the US dollar as the dominant international currency (e.g. James 2009, Cohen 2015).

In the field of account-to-account payments in commercial bank money, monetary sovereignty manifests itself in an effective regulatory and legal framework that ensures the safety and efficiency of commercial bank deposits (which includes the safety of commercial banks themselves) and their non-intermediated use for payments. Moreover, the central bank typically provides the ultimate settlement layer between banks in the form of a real-time gross settlement (RTGS) wholesale payment system in central bank money (i.e. based on accounts of banks with the central bank). However, point-of-interaction (POI) payments are dominated in some countries by global companies such as Visa, Mastercard, and PayPal, and also rely to a growing extent on mobile phone-linked solutions such as ApplePay. Such companies will understandably aim to benefit from their market power, by setting prices beyond marginal and average costs. Moreover, they have strong incentives to lobby to prevent regulation curtailing their power (and instead to have regulation that makes market entry more difficult) and they have the financial fire power to so, which is an additional potential challenge to sovereignty.

Bindseil and Senner (2025) identify five specific benefits of monetary sovereignty:

1. **Macro-financial stability and growth**. Monetary sovereignty allows monetary and other policies (exchange rate policies, capital flow regimes, financial regulation of financial intermediaries and capital markets, and the lender of last resort function) to be used in such a way to achieve macroeconomic efficiency

and avoid undue macroeconomic fluctuations and financial instability issues, thus achieving greater average economic growth and use of production potential over time.

2. **The ability to achieve microeconomic public policy objectives**. The efficiency of money for payments, accounting and invoicing, and storing value is a key requirement for the efficiency of any economy based on the division of labour. Through sovereign legislation and law enforcement, states can, for example, (i) prevent fraudulent and illicit payments, which undermine the economy and society, and the values on which it is built; (ii) prevent the abuse of market power in pricing; (iii) protect consumers against other forms of abuse; (iv) set market standards for the sake of interoperability and contestability; (v) through the sovereign public provision of money and financial services (e.g. issuing central bank money, public FMIs), realise network effects without abuse of market power and contain the market power (and abuse of that power) by private offers; and (vi) through free trade of monetary and financial services – agreed by the nation state as part of international trade agreements and participation in international organisations like the WTO or unions of states like the EU – reap the benefits of global network effects, competition, and comparative advantage; while (vii) controlling against related risks of globalisation.

3. **The generation of public income and the lowering of public funding costs**, with direct financial benefits. Strong public finances are the very basis of an effective state and therefore a key element of sovereignty in general. Public currency issuance creates direct public seigniorage income – i.e. interest income generated by the central bank's financial assets 'financed' through the issuance of its (typically non-remunerated) monetary liabilities). The income from domestic private issuance of money (e.g. the spread between sight deposits issued by banks and alternative funding costs; the interest income earned by e-money institutions and stablecoins) contributes to national income and can be taxed by the sovereign state territory in which the private money is issued, and thus also benefit public finances. Seigniorage income can be increased through international circulation of a currency (undermining to some extent, however, the monetary sovereignty of the affected foreign countries). Taxable private income is also generated by payments and financial services more generally, as illustrated by the high profitability and market capitalisation of some dominant global payment service providers (Visa, Mastercard, PayPal). Specific to a currency's use as an international payment and reserve currency is the financial advantage of have lower funding costs, often referred to in the case of the United States as 'exorbitant privilege', since the US dollar is the dominant reserve currency of the world.

4. **The avoidance of dependency that would provide leverage for foreign actors**. Monetary sovereignty protects against foreign threats to withdraw a crucial monetary or financial service. Being exposed to such threats ex ante weakens the bargaining position of a state on any matter of international negotiation, and ex post (i.e. if the threat materialises) can lead to serious financial and economic damage. For example, Puglierin and Zerka (2022) argue that "powers such as China, Russia, the United States, and Turkey are increasingly weaponising the EU's global economic interdependencies". Regardless of whether a threat (for example, sanctions against Russia and the freezing of Russian assets after its aggression against Ukraine) appears illegitimate or legitimate, from the perspective of the threatened or affected state, it infringes its financial and economic interests. The threat of withdrawal of services by third-party providers that indirectly support money and finance (cloud services, mobile phones, etc.) is potentially as relevant as the threat to directly target monetary and financial services. The degree of diversification of supply sources across several foreign countries, and the existence of credible alternatives, are crucial in this context.

5. **Information advantages**. Payments contain substantial information on private and institutional economic activity and relations between economic actors. This information can have economic value for competitors or can be used to harm public figures (for example, if payments reveal sexual preferences or illicit activity). Finally, payment data from e-commerce and electronic POS payments allow client behaviour to be understood and can be used (or misused) for marketing purposes. Control of payments data is therefore valuable for a nation, and it can be detrimental to have payments data unprotected and known by foreign nations.

Bindseil and Senner (2025) also identify five categories of instruments to strengthen monetary sovereignty.

1. **Legislation, regulation, enforcement and oversight**. The ability to legislate, regulate, enforce, and oversee is itself a key element of general sovereignty. Assuming that this ability is given, these tools can be used to strengthen monetary sovereignty specifically. Good general legislation contributing to the efficiency of the domestic monetary and financial system – including property law, labour law, corporate law, and data protection law – is the basis for the competitiveness of the domestic payments and financial industry vis-à-vis foreign firms. Regulation also includes numerous laws regulating payments and finance for the purpose of safety, consumer protection, and efficiency. Some legislation specifically targets the sovereignty of technology and industry, but could also support monetary sovereignty indirectly. Other legislation aims to ensure IT/cyber security and IT autonomy. Another crucial legal field supporting monetary sovereignty is competition law and its enforcement.

2. **Public service provision and operations in the field of money and finance**. At the core of public services and operations in money and finance is the creation of a strong, independent, and accountable central bank with an adequate mandate and resources and the ability to issue currency (in the form of banknotes or central bank electronic cash), provide payment and market infrastructures such as the RTGS system, and act in money and other financial markets (the key asset-side activity of central banking). Important operational capacities of public authorities can also reside outside the central bank, such as those relating to cyber operations and warfare, or within the public issuance and treasury function associated with the finance ministry.

3. **Subsidisation or other forms of support of domestic industry to achieve strategic autonomy**. If trust in other nation states is limited, the pursuit of monetary sovereignty must include a sufficient degree of autonomy, and some network effects and efficiency gains from scale that global firms, infrastructures, and products could offer will not be reaped. Support for the domestic industry to develop sufficiently and in a self-sufficient way in order to be resilient in case foreign powers threaten to withdraw services can be based on regulation (e.g. forcing domestic users to rely, at least partially, on the domestic industry), on subsidisation and tariffs, or on making the life of foreign companies difficult in less transparent ways.

4. **Choices regarding the monetary architecture**. Choosing an exchange rate and convertibility regime is key to achieving the monetary sovereignty objective of macro monetary and financial stability. There is an extensive macroeconomic theoretical literature (e.g. Mundell 1961) and applied literature (e.g. Bart and Wong 1994) on choosing a foreign exchange regime and how to manage it to achieve macroeconomic stabilisation.

5. **International cooperation**. Going beyond the domestic individual choice of an FX regime (e.g. whether or not to peg to another currency), international cooperation includes establishing a global or regional monetary order (e.g. a monetary union) and an international lender of last resort (such as the IMF), or agreeing on openness of borders for the provision of financial services (including payments) as foreseen in the General Agreement on Trade and Services (GATS). It can also include agreements on cross-border circulation of stablecoins and CBDC, establishing a supervisory college, and so on. International cooperation allows significant benefits to be achieved that can be shared amongst nations (i.e. Pareto improvements).

3 CENTRAL BANK ELECTRONIC CASH TO PRESERVE MONETARY SOVEREIGNTY

Issuing central bank electronic cash falls into the second of the five types of instruments to strengthen monetary sovereignty listed above, namely, "public service provision and operations in the field of money and finance". At the same time, it is effective across all of the five types of benefits of monetary sovereignty listed previously.

1. **Macro-financial stability and growth**. This may be the type of benefit of monetary sovereignty where the issuance of central bank electronic cash appears least relevant. The right choices for the macroeconomic regime and the ability of the central bank to act as a lender of last resort do not appear to depend directly on the existence of central bank electronic cash. However, the absence of a domestic public means of payment could facilitate 'dollarisation'. In a world without usable central bank money and abuse of market power by dominant domestic providers, it becomes more likely that foreign currency-denominated instruments such as US stablecoins, or even tokens referenced to unbacked crypto-assets such as Bitcoin, will achieve growing acceptance in payments. This could also lead to growth in the role of such instruments as a store of value and eventually as units of account. Dollarisation weakens the ability of monetary policy to shield the domestic economy from shocks and undermines the ability of the central bank to act as lender of last resort. Moreover, the anchor function of public money, stemming from the fact that all private moneys to date have been based on a promise of convertibility into central bank money, requires preserving usable central bank money from a monetary architecture and financial stability perspective.

2. **Ability to achieve microeconomic public policy objectives**. Through the sovereign public provision of money in the form of banknotes or central bank electronic cash, network effects in money and payments can be realised without abuse of market power. The central bank has no profit-maximisation objective but works with the aim of providing public goods in such a way that maximises social welfare and is consistent with its mandate. The availability and usability of central bank money also constrains the abuse of market power by providers of private payment instruments. The design of central bank electronic cash can also take into account a variety of societal objectives, such as inclusiveness, interoperability, and universality in its usability through legal tender status (Cipollone 2024).

3. **Direct financial benefits in the form of generating public income and lowering public funding costs**. The decline in use of cash will eventually also reduce its circulation (as has already been the case in countries with a very high degree of digitalisation) and therefore seigniorage income. Low seigniorage income puts the financial independence of the central bank at risk and reduces the central bank profits that can be disbursed to governments (Claessens

et al. 2025). In a world of high government debt and ageing populations, preserving the seigniorage income of the central bank for the government is not unimportant and contributes to the solvency, and thus the sovereignty, of the state. This is even more important in the context of central bank balance sheets that have suffered from past asset purchases at very low interest rates. Bindseil et al. (2024) analyse the role of central bank electronic cash in preserving the profitability of central banks and their ability to disburse seigniorage income to governments. Since central bank electronic cash will not be remunerated, it is almost undistinguishable from cash from a seigniorage income perspective, and what really matters is only the sum of banknotes and such electronic cash circulating. Seigniorage income can also be increased through international circulation of a currency, as has been the case in particular with US dollar and euro banknotes. So far, central banks that are considering issuing electronic cash have suggested different approaches with regards to international circulation. The draft legislation on the digital euro, for example, introduces relatively high hurdles, while the Bank of England appears less inclined to constrain circulation of the digital pound abroad. The US – which, under the current administration, has rejected the issuance of electronic cash by the central bank while allowing private stablecoins to safeguard their funds at the Federal Reserve, thus de facto allowing for a hybrid digital dollar – is instead considering the global circulation of US-issued and US dollar-denominated stablecoins to generate domestic income (and to increase the demand for Treasury securities for the backing of such stablecoins). The circulation of currencies (public or privately issued) abroad generates domestic income and thus also supports sovereignty, but often at the expense of the sovereignty and income of the foreign countries in which the currency circulates. The current proposal for stablecoins in the US, by creating a de facto hybrid digital dollar, implies the circulation of public money on private rail, with the implicit transfer of seigniorage from the public to the private purse.

4. **Avoiding dependency that would provide leverage for foreign actors**. The availability of central bank-issued electronic cash will reduce dependencies and thus strategic vulnerabilities to hostile threats and blackmail by foreign actors, which appears increasingly important in today's world of deteriorating global geopolitics (Cipollone 2024). As retail payments are the very basis of modern society, the threat of such payments becoming unavailable is serious and can prevent the government from taking decisions that would be best for society (for example, not giving in to an external threat). Central bank electronic cash which aims at this objective must follow certain design principles, including not being overly dependent on foreign third-party providers (payment firms and general ITC providers such as network, cloud, or mobile phone providers). Moreover, the electronic cash itself must have an extremely high degree of cyber-resilience

and be based on a settlement platform and technology that are somewhat independent of those of private payment instruments (regardless of whether the latter are offered by domestic or foreign companies).

5. **Information advantage**. A high reliance on foreign payment instruments and third-party providers (cloud and network services, mobile phones, mobile payment overlay solutions, etc.) makes it very challenging to contain the circulation of private information within Europe. Private solutions under domestic governance may help, but central bank electronic cash should also be carefully designed to maximise data privacy and to prevent data leaks – and not only to foreign actors. Privacy should be achieved 'by design' and should include the central bank itself having no access to the identities of individuals. Some have argued that even if the design of central bank electronic cash maximises privacy, a future abusive government could quickly change the design so the instrument can be used to spy on citizens and possibly control their expenses. While it is true that this theoretical possibility cannot be avoided, it is equally true that future dictatorial governments could just as easily control payment flows of private electronic means of payments and demonetise cash from one day to the next.

4 CONCLUSIONS

Monetary sovereignty has a variety of dimensions, including the appropriate choice of numeraire and exchange rate regime, the ability to act as lender of last resort, and the ability to protect the domestic payments and financial industry from cyber-attacks and to prevent illicit payments which undermine the rule of the law. The issuance of a widely used central bank money to provide a society based on the division of labour with an efficient and inclusive means of payment, co-existing with private solutions, is certainly amongst those dimensions which are strictly necessary to consider a state to be monetary sovereign, with all its societal advantages.

In a world of ever-progressing convenience of electronic payments and of e-commerce, citizens are increasingly paying electronically. It is far-fetched to argue that central banks must always rely on paper money and therefore must, in a possible future era of purely electronic payments, exit from their service provision to society and thereby renounce monetary sovereignty. At the same time, it should not come as a surprise that various negative narratives against central bank electronic cash are spread – for example, it is not needed because private payment solutions are so successful, it will not be successful because central banks are not able to compete, or it will endanger financial stability, freedom, and privacy. Banks and the non-bank payment industry would prefer that the central bank exits from the issuance of retail money, to increase the cake to be shared by the industry alone and to reduce competition and thus increase pricing power in a market dominated by network effects.

Under the assumption of ongoing electronification of payments, the economic effects of issuing central bank electronic cash should be identified starting from the counterfactual. If retail payments are exclusively left to the private sector and central bank money is marginalised, payment costs will increase (due to increasing market power), monetary and financial stability will be weakened (as the unifying convertibility test of all private moneys – i.e. of being exchangeable at sight against central bank money – will have become remote or inexistant), seigniorage income will vanish, dollarisation will become more likely, and strategic autonomy will be undermined – with negative consequences under scenarios of further geopolitical deterioration. These are core issues for a modern society and for the sovereignty of a democratic state.

REFERENCES

Aglietta, M (2016), *La Monnaie entre dettes es souverainité*, Odile Jacob.

Barrdear, J and M Kumhof (2016) "The Macroeconomics of Central Bank Issued Digital Currencies", Bank of England Working Paper No. 605 (published in 2021 in the *Journal of Economic Dynamics & Control*).

Bindseil, U, C-E Coste, and G Pantelopoulos (2024), "Digital money and finance: a critical review of terminology", ECB Working Paper Series No. 3022.

Bindseil, U, M Marrazzo and S Sauer (2024), "The impact of central bank digital currency on central bank profitability, risk-taking and capital", ECB Occasional Paper 360.

Bindseil, U and R Senner (2023), "Macroeconomic modelling of CBDC: a critical review", ECB Working Paper No. 2978.

Bindseil, U and R Senner (2025), "Revisiting national, economic and monetary sovereignty" (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5486546).

Bodin, J (1576), *Six livres de la république* (republished in 1986 by Fayard).

Cipollone, P (2024), "Monetary sovereignty in the digital age: the case for a digital euro", Keynote Speech at the Economics of Payments XIII Conference organised by the Oesterreichische Nationalbank.

Claessens, S, T Glaessner and D Klingebiel (2025), "Future Proofing Central Banks' Financial Strength", CEPR Discussion Paper 20049.

Dyson, B and G Hodgson (2016), *Digital cash: why central banks should start issuing electronic money*, Positive Money.

ECB – European Central Bank (2024), Study on the payment attitudes of consumers in the euro area (SPACE) – 2024 (https://www.ecb.europa.eu/stats/ecb_surveys/space/html/ecb.space2024~19d46f0f17.en.html).

Gianviti, F (2004), "Current legal aspects of monetary sovereignty", IMF note.

Jackson, R (2007), *Sovereignty: The Evolution of an Idea*, Polity.

Krasner, S D (2001), *Sovereignty: Organized Hypocrisy*, Princeton University Press.

Landau, J-P and S Nicole (2024), "Monetary sovereignty in a digital world", Policy Brief, Sciences Po.

Martino, E D (2024), "Monetary sovereignty in the digital era: The law & macroeconomics of digital private money", *Computer Law & Security Review* 52, 105909.

Murau, S and J van't Klooster (2023), "Rethinking monetary sovereignty: the global credit money system and the state", *Perspectives on Politics* 21(4): 1319-1336.

Pistor, K (2017), "From Territorial to Monetary Sovereignty", 18 *Theoretical Inquiries in Law* 491.

Puglierin, J and P Zerka (2022), "European sovereignty index", European Council on Foreign Relations.

Villeroy de Galhau, F (2023), "Monetary sovereignty in the 21st century", speech at the Council of State Conference on "Monetary sovereignty in the 21st century", Paris, 14 November.

Zellweger-Gutknecht, C (2023), "CBDC and monetary sovereignty", ECB Legal Conference 2023.

Zimmermann, C D (2013), "The Concept of Monetary Sovereignty Revisited", *The European Journal of International Law* 24(3).

ABOUT THE AUTHORS

After his economic studies, Ulrich Bindseil worked for 31 years in central banking at Deutsche Bundesbank, the EMI, and at the ECB, where he was Director General for Market Operations (2012-2019) and for Market Infrastructure and Payments (2019-2025). He has written numerous articles and several books on central banking, including Monetary Policy Implementation and the Financial System (OUP, 2014), Central Banking before 1800 – a Rehabilitation (OUP, 2019), Introduction to Central Banking (together with A. Fotia; Springer, 2021); Introduction to Market Infrastructure and Payments (together with G. Pantelopoulos, 2024). He is currently working on his new book on Monetary Sovereignty with R. Senner and lectures as Honorary Professor at TU Berlin.

Piero Cipollone has been a member of the Executive Board of the European Central Bank since 1 November 2023. He is responsible for the Directorate Banknotes, the Directorate General International and European Relations and the Directorate General Market Infrastructure and Payments.

Before joining the ECB, Mr Cipollone was Deputy Governor of the Banca d'Italia and a member of the Board of the Italian Institute for the Supervision of Insurance. He also served as a member of the Coordination Group for the Cross-border payments programme at the Bank for International Settlements. He previously served as an Executive Director on the Board of the World Bank Group.

Mr Cipollone graduated with honours in economics from the Sapienza University of Rome. He holds a Master of Arts in economics from Stanford University and was a visiting scholar at the economics department of the University of California, Berkeley.

Mr Cipollone is the author of several books. His papers have been published in international journals such as the *American Economic Review*, the *Journal of the European Economic Association* and the *Journal of Policy Modeling*.

CHAPTER 6

Transforming the digital euro proposal from a threat into an opportunity for privacy

Maarten R.C. van Oordt[1]
Vrije Universiteit Amsterdam

AN UNPRECEDENTED TRANSITION

The euro area is witnessing a strong trend away from cash payments. The share of point-of-sale payments made with cash has decreased from close to 80% to around 50% over the past decade (Esselink and Hernández 2017, ECB 2024). The downward trend has been particularly pronounced in the Netherlands, where the share of cash payments declined to less than 20% of the point-of-sale payments by 2022, a decrease from over 80% in 2002 (DNB 2022a, Brits and Winder 2005). In addition, the share of *remote* payments, for which cash is not a practical option, has also increased considerably (e.g. ECB 2024).

The shift away from cash payments is resulting in an unprecedented erosion of privacy in payments. Payments service providers, including banks, automatically record detailed data for conventional electronic payment methods. These data typically include information such as the sender, recipient, amount, and timestamp of a transaction. If the same payment were made with cash, then only the consumer – and in some cases the merchant – would have access to this information. Legislation requires financial institutions to conduct granular surveillance of collected payment data linked to both individual and corporate accounts (e.g. EU 2024/1624). Payment service providers may, within certain boundaries, also use payment data for commercial purposes.

POTENTIAL ROLE OF THE DIGITAL EURO

The advancement of the legislative proposal of the European Commission (2023) for the introduction of the digital euro presents a critical moment for society to reflect on the appropriate level of privacy in payments.[2] First, it is plausible that the use of cash will come under further pressure due to the introduction of a competing payment instrument

1 This opinion piece relies extensively on a translation from Dutch of Van Oordt (2023). Both pieces build on Garratt and Van Oordt (2021) and Van Oordt (2022).

2 The amendments to the legislative proposal suggested in the draft report by the European Parliament Committee on Economic and Monetary Affairs (2024) do not have a substantial impact on the analysis in this chapter. As of 20 June 2025, no vote on the draft report with amendments had taken place.

such as the digital euro (Li 2023, Huynh et al. 2024). Second, there exists a wide array of technical possibilities that could ensure greater privacy in digital euro payments than in existing electronic payment systems. These range from cryptographic techniques that render online balances completely untraceable to methods that enable more targeted privacy. Such techniques can, for example, ensure that the sender of funds is untraceable while received amounts remain visible, that small payments are untraceable, that the payer or payee can voluntarily share otherwise unreadable payment data, or that payments are untraceable but originate exclusively from whitelisted sources (Tinn and Dubach 2021, Groß et al. 2021, Chaum et al. 2021, Buterin et al. 2023). Depending on its design, the digital euro could either undermine or enhance privacy in payments.

The importance of privacy considerations in the design of the digital euro is evident from concerns voiced by the public. Privacy received by far the most votes as the most desired feature in the public consultation by the European Central Bank (ECB 2021). Surveys on the digital euro by some of the national central banks also reveal a strong public support for privacy. For example, privacy received an average Likert score of 4.5/5.0 in a survey by De Nederlandsche Bank (Bijlsma et al. 2024); strict protection of personal data an approximate score of 4.5/5.0 in a survey by the Oesterreichischen Nationalbank (Abramova et al. 2022); high privacy protection a score of 2.8/3.0 in a survey by the Národná Bank Slovenska (Cupak et al. 2024); and the importance of payment information staying private an approximate score of 4.7/5.0 in a survey by the Deutsche Bundesbank (2021).[3] Meanwhile, the US House of Representatives recently passed the tellingly titled "Anti-CBDC Surveillance State Act," prohibiting the Federal Reserve from issuing a retail central bank digital currency.[4]

RETHINKING PAYMENT PRIVACY

A commonly heard justification for the extensive erosion of privacy in electronic payments is that monitoring payments helps to prevent crime and tax evasion. These are undeniably important objectives. However, they do not automatically justify the implementation of extensive surveillance of payments in a state under the rule of law. For example, law enforcement might be more effective if authorities could search homes or install surveillance equipment without restriction – yet such powers are limited. These limits safeguard the protection of fundamental rights, including respect for individuals' private lives, correspondence, and their homes (ECHR Art. 8). The emergence of legislation to establish a near-universal surveillance infrastructure for citizens' electronic payments may be considered as a remarkable deviation in this

3 The scores for Austria and Germany do not appear directly as numbers in the aforementioned sources. Those scores are estimated from high-resolution versions of, respectively, Figure 5 in Abramova et al. (2022) and the figure on page 74 in Deutsche Bundesbank (2021).

4 The Anti-CBDC Surveillance State Act has not passed the US Senate at the time of this writing.

context. That the surveillance is not conducted by government officials but by employees of private sector entities with a reporting obligation (e.g. EU 2024/1624, Art. 69–72) seems, to a large extent, a matter of optics.

The rapid decline of privacy in payments raises pressing questions about the appropriateness of extensive information gathering and government control over payments in a liberal democracy. Access to payment data – whether direct or indirect – can reveal sensitive personal details such as political orientations and religious beliefs, through patterns like media subscriptions or charitable donations. The power of payment information lies not only in the ability to extract data but also in the capacity to censor payments or restrict access to payment services. A striking example occurred during the COVID-19 pandemic when the Canadian government invoked emergency powers and instructed financial institutions to freeze without court order the accounts of anyone financially supporting the so-called convoy protests – regardless of the donation amount (Canada Gazette 2022, Canadian House of Commons 2022).

Beyond direct government action, banks themselves are also known to terminate client relationships due to reputational concerns, negative media coverage, environmental considerations, or broader societal factors (DNB 2022b).[5] While such practices may be framed as prudent risk management, they can easily evolve into processes that de facto suppress dissenting voices and marginalise individuals and groups based on ideology or belief. If a group cannot accept or make payments because its not-for-profit organisation cannot obtain a bank account, then the ability to exercise the fundamental right to freedom of association (ECHR Art. 11) is effectively undermined.[6]

FURTHER INSIGHTS FROM ECONOMIC THEORY

Economic theory offers various further insights into arguments in favour of privacy in payments – or at least the option to choose for privacy. A distinction is made between the intrinsic and the instrumental value of privacy. The intrinsic value refers to the importance individuals attach to not being observed, regardless of the consequences. The instrumental value pertains to the benefits privacy offers by mitigating the potential consequences of information disclosure (Acquisti et al. 2005). These include avoiding intimidation (e.g. based on donations to social movements or sensitive payments such as for medical treatments), avoiding spam or targeted advertising, and preventing data misuse such as identity theft (Kahn et al. 2005, Kahn 2018).

5 De Nederlandsche Bank (2022b) found that only a minority of terminated client relationships at the largest banks was due to legislation to prevent money laundering and terrorist financing. About 83% of the relationships were terminated by banks because of other reasons, including fraud, reputation risk to the bank, commercial reasons, environmental reasons or societal factors. The same report cites negative reports in the media as a potential reason for terminating services.

6 It is worth noting that not-for-profit organisations are facing challenges in opening or maintaining bank accounts in various jurisdictions (e.g. UK Charity Commission 2024, Dutch Association for Charities 2024).

Market failures can also contribute to a lack of payment privacy. The model of Garratt and Van Oordt (2021) illustrates how the sharing of payment data can become the norm, even when society as a whole places a high value on payment privacy. The root cause is a negative externality: marketeers can train models with the payment data of one consumer to predict the purchasing behaviour of others – even of those who have taken steps to protect their own data. Privacy is a public good because it protects all consumers collectively – in this model, specifically, against harmful price discrimination. As with other public goods, such as clean air, the societal benefit of an individual's contribution accrues only marginally to that individual. As a result, individuals may exert inefficiently low effort to protect their own payment privacy. A cost-effective electronic payment method that protects privacy could offer a solution.

A privacy-preserving payment instrument can enhance consumer welfare even in models where the sharing of payment data has a direct positive effect. In the model of Garratt and Lee (2022), firms use payment data to develop products that better match consumer preferences. However, the benefits of these data-driven improvements do not accrue to consumers. Instead, they lead to a market structure where a single firm dominates with a data monopoly. The monopolist is only willing to share the benefits of payment data with consumers if consumers could opt to protect their data using a privacy-preserving payment instrument. Another mechanism appears in the model of Ahnert et al. (2025), where monitoring payments enhances banks' lending decisions. Introducing a privacy-preserving electronic payment method in their model can help to curtail the data monopoly of the primary bank.

THE PRIVACY GAP FOR REMOTE PAYMENTS

With conventional payment methods, the possibility to maintain one's privacy in payments depends on whether a transaction is conducted in-person or remotely (Table 1). For in-person payments, cash offers a relatively high degree of privacy; relatively little privacy is provided by conventional electronic payment methods such as credit cards, debit cards and payment apps. For remote payments, there are no conventional payment methods that offer a similar degree of payment privacy as physical cash. This privacy gap in the retail payment landscape is illustrated by the empty cell in the lower-left quadrant of Table 1.

The privacy gap in the conventional retail payment landscape is becoming increasingly significant. There is a steady increase in the share of remote transactions. Additionally, there is a sharp rise in the use of new technologies for processing and analysing large volumes of data for both commercial and compliance purposes. Even for in-person payments, cash does not guarantee the same freedom of choice for privacy as before; this freedom is under pressure due to both the decline in acceptance of cash and the rising effective costs of its use.

TABLE 1 PRIVACY CHOICES IN THE CONVENTIONAL RETAIL PAYMENT LANDSCAPE

	More privacy	Less privacy
In-person	Physical cash (proposal: offline digital euro)	Bank account (e.g. card, transfer) (proposal: online digital euro)
Remote	– (proposal: –)	Bank account (e.g. card, transfer) (proposal: online digital euro)

PRIVACY IN THE DIGITAL EURO PROPOSAL

The digital euro proposal aims to complement the retail payment landscape with online and offline holdings of digital euro balances. The digital euro balances form a direct liability of the central bank (European Commission 2023, Art. 4), and hence constitute retail central bank digital currency.[7] Access to digital euro services will be offered through third-party payment service providers, including banks and possibly other entities (Art. 14). Payments using online and offline balances are envisioned to have different privacy characteristics.[8] We will discuss the characteristics of both separately.

Online digital euro payments

Online digital euro payments will be settled by recording them in the central digital euro infrastructure (Art. 23 and 30). Hence, completing an online digital euro payment will require some sort of a data connection with a payment service provider or the central bank. It will be possible to use online digital euro balances for both in-person and remote payments (see also Table 1).

From a privacy perspective, payments using online digital euro balances will, broadly speaking, not represent an improvement over the status quo in the current proposal. The intermediary that provides the customer with online digital euro services will store and access in essence the same payments data as with conventional electronic payment methods. The proposal stipulates that transactions using online digital euro balances will be subject to the same surveillance regulation as conventional electronic payments (Art. 5).

The fact that all online digital euro payments will be processed through the digital euro infrastructure may introduce additional privacy challenges.[9] The digital euro proposal envisions the use of pseudonymisation techniques to avoid a situation where

7 This chapter uses the term "central bank" in the context of the euro area to refer to the Eurosystem which comprises the European Central Bank and the national central banks.
8 See Kahn et al. (forthcoming) for an explanation on why separate balances are used for online and offline payments.
9 An online digital euro payments would store data across more institutions than a conventional wire transfer between two accounts held at the same bank. Such a wire transfer would traditionally settle in the books of the bank where both accounts are held. The privacy comparison is more nuanced for conventional wire transfers between accounts held at different banks, because of the data that would be stored in existing payment systems. The prevalence of these scenarios depends on the proportion of *interbank* versus *'on us'* transactions, for which the data availability varies across jurisdictions. For the Netherlands, the Dutch Payment Association (2025, p. 26) estimates that there were 499 million *interbank* instant payments and approximately 600 million *'on us'* instant payments in 2024.

payments data stored in the digital euro infrastructure can immediately be attributed to individual users (for example, through the use of user aliases and account numbers rather than identities; see European Commission 2023, Art. 2, 35 and Annex IV). Privacy outcomes will depend on the implementation, with weaker techniques, such as a single pseudonym per user, resulting in poorer outcomes.[10]

Offline digital euro payments

Payments using offline balances are intended to function in a similar fashion as payments with former e-purses such as Avant in Finland and Geldkarte in Germany.[11] Offline digital euro balances will be stored locally using a secure element in a payment card or mobile phone. These balances can then be used for device-to-device payments without connecting to a payment service provider or the central bank (European Commission 2023, Art. 37). The proposal stipulates that the use of offline balances will be restricted to in-person payments, where devices are in close proximity, so that they cannot be used for remote payments (Art. 2).

The proposal envisions that payments with offline digital euro balances will offer a relatively high degree of payment privacy compared to online payments. For example, it is intended that offline payments between two devices will not be recorded by payment service providers or the central bank. However, the proposal does require detailed data to be recorded when offline balances are deposited into or withdrawn from a device. These data include a unique device code, amounts and account information (Art. 37).

There are several caveats to the privacy envisioned for offline digital euro payments. First, the privacy it can provide for daily transactions is likely to be undermined by the lower limits that will apply (Art. 37). The precise level of the limits is still subject to discussion. However, it doesn't bode well that even central bank analysis based on a "user-centred approach" aims for limits that are substantially lower than the prevailing limits for physical cash payments (Van der Horst and Van Gent 2025).[12] Second, there are doubts about the technical feasibility of the proposed privacy objectives for offline balances from a security perspective. A critical issue for offline balances is the prevention of double-spending. For example, a malicious actor could try to spend the same balance multiple times by circumventing protections that prevent users from copying the offline balances stored in one device onto multiple other devices. Detecting double-spending requires verifying whether instances occur where recipients of offline payments try to deposit the same offline funds. Targeted intervention once double-spending is detected becomes harder if it is truly impossible to trace the origin of those balances. Moreover,

10 A single pseudonym for each user is vulnerable to guessing the identity behind a pseudonym once the payment history grows. Moreover, a single pseudonym would provide insight in the entire payment history of an individual once the user's identity is established for a single payment. The ECB (2023) has also experimented with bitcoin-like data models based on unspent transaction outputs (UTXOs), where pseudonyms can change for each payment and multiple pseudonyms may represent a single user simultaneously. Although such data models may help, blockchain analytics firms show that they do not provide bullet-proof privacy.

11 See Grym (2020) for a review of Avant as the first retail central bank digital currency.

12 One of the stated goal of the limits for payments with offline digital euro balances is to combat the financing of terrorism (European Commission 2023, Art. 37). Real-world experience shows, unfortunately, that terrorist attacks often require very limited financial resources (Oftedal 2015).

technical limits on the number of 'hops' – i.e. how often funds can be transferred from one device to another before reconnecting – undermine the credibility of the intrackability of payments when detailed data on deposits and withdrawals are stored.

FROM A THREAT TO AN OPPORTUNITY

Based on my assessment, it is likely that the introduction of a digital euro designed in accordance with the current legislative proposal of the European Commission will further erode payment privacy. Compared to the conventional retail payment landscape, digital euro payments represent a deterioration rather than an improvement from a privacy perspective in many scenarios. Moreover, the digital euro is likely to further crowd out physical cash. Given technological developments and the societal demand for payment privacy, there is a real risk that the digital euro will miss a crucial opportunity if no amendments are made to the legislative proposal.

With a different design, the digital euro could promote payment privacy – particularly by enabling remote payments with high degree of privacy. A straightforward approach could be to include a provision in the digital euro proposal that guarantees one can use offline digital euro balances to make remote payments via existing data connections.[13] This functionality would fill the privacy gap that currently exists in the conventional payment landscape for remote payments – provided, of course, that device-to-device transactions using offline digital euro balances will be designed to be truly private. To avoid undermining payment privacy, the proposal could combine this amendment with a safeguarding provision that prevents the imposition of operationally restrictive limits on offline digital euro balances – ensuring that payments with offline balances are not subject to stricter constraints than those applied to physical cash transactions.[14] A more ambitious approach would be to update the digital euro proposal so that users are provided with the option to pay with online digital euro balances in a manner that emulates, as far as technically feasible, the privacy characteristics of physical cash.

13 Device-to-device payments with offline balances are 'offline' only in the sense that the payments occur without connecting to a payment service provider or the central bank. Remote device-to-device payments could be facilitated by allowing the use of a data connection between devices to relay the communication that would normally occur during a device-to-device payment in close proximity. Truly restricting the use of offline balances to in-person device-to-device payments, as envisioned in the digital euro proposal, would in fact require security measures such as imposing limits on the roundtrip time of data transmissions to prevent the use of relay techniques that enable remote device-to-device payments. In this context, it is also worth noting that remote payments were possible with Finland's anonymous Avant card in the 1990s (Grym 2020).

14 The privacy aspect of offline digital euro balances may gain further credibility if the proposal were to include a provision ensuring that offline digital euro balances can be transferred in a manner comparable to physical cash – allowing recipients to spend received funds without first establishing a data connection with a payment service provider or central bank

REFERENCES

Abramova, S, R Böhme, H Elsinger, H Stix, and M Summer (2022), "What Can CBDC Designers Learn from Asking Potential Users? Results From a Survey of Austrian Residents", Oesterreichische Nationalbank Working Paper No. 241.

Acquisti, A, C Taylor and L Wagman (2016), "The Economics of Privacy", *Journal of Economic Literature* 54(2): 442–492.

Ahnert, T, P Hoffmann, and C Monnet (2025), "Payments and Privacy in the Digital Economy", *Journal of Financial Economics* 169, 104050.

Bijlsma, M, C van der Cruijsen, N Jonker, and J Reijerink (2024), "What Triggers Consumer Adoption of Central Bank Digital Currency?", *Journal of Financial Services Research* 65: 1-40.

Brits, H and C Winder (2005), "Payments are no Free Lunch", De Nederlandsche Bank Occasional Study 3(2).

Buterin, V, J Illum, M Nadler, F Schär and A Soleimani (2023), "Blockchain Privacy and Regulatory Compliance: Towards a Practical Equilibrium", Working Paper.

Canada Gazette (2022), "Emergency Economic Measures Order: SOR/2022-22", Part II, 156 (Extra Number 1).

Canadian House of Commons (2022), "Standing Committee on Finance: Evidence (February 22)", Volume 44-1 FINA-21.

Chaum, D, C Grothoff, and T Moser (2021), "How to Issue a Central Bank Digital Currency", Swiss National Bank Working Paper No. 2021-03.

Cupak, A, P Gertler, D Hajdiak, J Klacso, and S Rychtárik (2024), "Survey of Potential Users of the Digital Euro: New Evidence from Slovakia", National Bank of Slovakia Occasional Paper No. 2/2024.

DNB – De Nederlandsche Bank (2022a), "Point of Sale Payments in 2022" (https://www.dnb.nl/media/moomskgh/points-of-sale.pdf).

DNB (2022b), *From Recovery to Balance* (https://www.dnb.nl/media/mdgafi3a/from-recovery-to-balance.pdf).

Deutsche Bundesbank (2021), "What do Households in Germany Think about the Digital Euro?", Deutsche Bundesbank Monthly Report, October.

Dutch Association for Charities (2024), *De Impact van De-risking op Goede Doelen* ["*The Impact of De-risking on Charities*"].

Dutch Payment Association (2025), *Annual Report 2024*.

Esselink, H and L Hernández (2017), "The Use of Cash by Households in the Euro Area", European Central Bank Occasional Paper No. 201.

ECB – European Central Bank (2021), *Eurosystem Report on the Public Consultation on a Digital Euro* (https://www.ecb.europa.eu/pub/pdf/other/Eurosystem_report_on_the_public_consultation_on_a_digital_euro~539fa8cd8d.en.pdf).

ECB (2023), *Digital Euro: Prototype Summary and Lessons Learned* (https://www.ecb.europa.eu/pub/pdf/other/ecb.prototype_summary20230526~71dob26d55.en.pdf).

ECB (2024), *Study on the Payment Attitudes of Consumers in the Euro Area (SPACE).*

European Commission (2023), "On the Establishment of the Digital Euro", Proposal for a Regulation of the European Parliament and of the Council, 2023/0212 (COD) (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023PC0369).

European Parliament Committee on Economic and Monetary Affairs (2024), *Draft Report on the Proposal for a Regulation of the European Parliament and of the Council on the Establishment of the Digital Euro*, 9 February (https://www.europarl.europa.eu/doceo/document/ECON-PR-758954_EN.pdf).

European Union (2024), "Regulation on the Prevention of the Use of the Financial System for the Purposes of Money Laundering or Terrorist Financing", Regulation of the European Parliament and of the Council, 2024/1624 (https://eur-lex.europa.eu/eli/reg/2024/1624/oj).

Garratt, R J and M J Lee (2022), *Monetizing Privacy with Central Bank Digital Currencies*, Federal Reserve Bank of New York Staff Report No. 958.

Garratt, R J and M R C van Oordt (2021), "Privacy as a Public Good: A Case for Electronic Cash", *Journal of Political Economy* 129(7): 2157–2180.

Groß, J, J Sedlmeir, M Babel, A Bechtel and B Schellinger (2021), "Designing a Central Bank Digital Currency with Support for Cash-Like Privacy", Working Paper.

Grym, A (2020), "Lessons Learned from the World's First CBDC", *Bank of Finland Economics Review* 8/2020.

Huynh, K, J Molnar, O Shcherbakov, and Q Yu (2024), "Demand for Payment Services and Consumer Welfare: The Introduction of a Central Bank Digital Currency", *Review of Network Economics* 23(4): 199-230.

Kahn, C M (2018), "The Threat of Privacy", *Journal of Financial Market Infrastructures* 6(2/3): 1-10.

Kahn, C M, J McAndrews and W Roberds (2005), "Money is Privacy", *International Economic Review* 46(2): 377-399.

Kahn, C M, M R C van Oordt, and Y Zhu (forthcoming), "Best Before? Expiring Central Bank Digital Currency and Loss Recovery", *Journal of Money, Credit and Banking.*

Li, J (2023), "Predicting the Demand for Central Bank Digital Currency: A Structural Analysis with Survey Data", *Journal of Monetary Economics* 134: 73-85.

Oftedal, E (2015), *The Financing of Jihadi Terrorist Cells in Europe*, Forsvarets Forskningsinstitutt (Norwegian Defence Research Establishment) Report No. 2014/02234.

Tinn, K and C Dubach (2021), *Central Bank Digital Currency with Asymmetric Privacy*, Technical Report.

UK Charity Commission (2024), "New Data Suggests Nearly Half of Charities Experience Issues when Banking", Press Release, 7 March (https://www.gov.uk/government/news/new-data-suggests-nearly-half-of-charities-experience-issues-when-banking).

Van der Horst, F and A van Gent (2025), "The Offline Digital Euro and Holding Limits: A User-centred Approach", De Nederlandsche Bank Occasional Study No. 25-02.

Van Oordt, M R C (2022), "Discussion of "Central Bank Digital Currency: Stability and Information", *Journal of Economic Dynamics and Control* 104, 104503.

Van Oordt, M R C (2023), "Wijzig het Digitale-Euro Voorstel van een Risico in een Kans voor Privacy", in K Bernoth, V Sterk and T Willems (eds), *Preadviezen van de Koninklijke Vereniging voor de Staathuishoudkunde*, Koninklijke Vereniging voor de Staathuishoudkunde.

ABOUT THE AUTHOR

Maarten van Oordt is Professor of Money and Banking at Vrije Universiteit Amsterdam. Before, he worked in increasingly senior roles at the Dutch Central Bank and the Bank of Canada. At the Bank of Canada, he worked as a Research Advisor on topics such as cryptocurrencies and central bank digital currency. His research has been published in academic journals such as *Management Science*, the *Journal of Money, Credit and Banking*, the *Journal of Financial and Quantitative Analysis*, and the *Journal of Political Economy*. He holds a PhD from Erasmus University Rotterdam (2013).

CHAPTER 7

Bank deposit outflows and the digital euro holding limit

Katrin Assenmacher and Oscar Soons[1]
European Central Bank

THE DIGITAL EURO AND ITS BENEFITS

In collaboration with European legislators, the Eurosystem is exploring the potential introduction of a central bank digital currency. The digital euro would be an electronic means of payment, accessible for everybody and accepted across all euro area countries. It would bring several benefits for individuals and society at large, be issued by the European Central Bank (ECB), and serve as an electronic complement to euro banknotes and coins.[2]

After more than 25 years of monetary union, a European digital payment option that can be used in all euro area countries still does not exist. Moreover, a majority of member states rely on non-European payment solutions even for payments within their own countries (ECB 2025a). The digital euro would establish a European alternative that would reduce the euro area's reliance on foreign payment companies and could serve as the foundation for further innovation by the private sector. It would provide citizens in an increasingly digitalised world with an online payment option at a higher level of privacy than currently available. Additional offline functionalities aim to enable payments even in emergency situations such as power or network outages (ECB 2025c). Finally, the digital euro would strengthen euro area financial stability and monetary sovereignty by preserving the role of public money in the European economy (Lane 2025; see also the contribution by Bindseil and Cipollone in this eBook).

THE DESIGN OF A DIGITAL EURO

An eventual introduction of the digital euro requires European legislation. On 28 June 2023, the European Commission presented a draft legislative proposal establishing the legal framework for a digital euro, including its status as legal tender and the absence of remuneration.[3] This proposal, which tasks the ECB to "*develop instruments to limit the use of the digital euro as a store of value, including holding limits*", is currently under

1 We would like to thank Piero Cipollone and Alessandro Giovannini for helpful comments. The views reported are those of the authors and do not necessarily reflect those of the European Central Bank.
2 More information on the digital euro can be found at https://www.ecb.europa.eu/euro/digital_euro/html/index.en.html
3 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023PC0369

review by the European Parliament and the European Council (European Parliament 2024). The ECB's Governing Council will decide on the issuance of the digital euro only after the legislation has been adopted (ECB 2023c).[4]

In line with the legislative proposal, the ECB is working on a methodology to calibrate holding limits for the digital euro (ECB 2023b, 2024a), in close cooperation with a broad range of stakeholders, including banks, merchants, and consumer groups (Cipollone 2025). By capping the amount of digital euros that individuals and businesses can hold, such limits can restrict the potential outflow of deposits from banks into digital euro wallets. In this way, they provide an important device to safeguard financial stability and the effectiveness of monetary policy, particularly in crisis situations.

THE CALIBRATION OF DIGITAL EURO HOLDING LIMITS

The legislative proposal states that digital euro holding limits need to balance three objectives (see Figure 1): (i) ensuring that the digital euro can be used as a convenient means of payment;[5] (ii) securing a smooth implementation of monetary policy and an effective transmission to bank lending and the real economy; and (iii) safeguarding financial stability. In this chapter, we will focus on the third objective. A holding limit needs to be high enough to allow for a convenient use of the digital euro for payments, but it must not be set so high that bank deposit outflows could undermine bank funding and thereby jeopardise financial stability.[6] Taking the above trade-off into account, and in line with the legislative proposal, the ECB is considering a uniform holding limit for euro area citizens. Businesses and merchants would be able to receive and process digital euro but not hold them (ECB 2023a).

Determining the appropriate individual holding limit from a financial stability perspective is a complex task. It involves estimating the demand for the digital euro – a form of digital currency that does not yet exist – and predicting banks' potential deposit outflows. These outflows are influenced by various factors – including digitalisation trends, substitution effects with banknotes, and the declining use of cash – and may not necessarily align with the demand for the digital euro. Moreover, it requires an analysis of deposit outflows at the individual bank level, assessing how banks might respond to

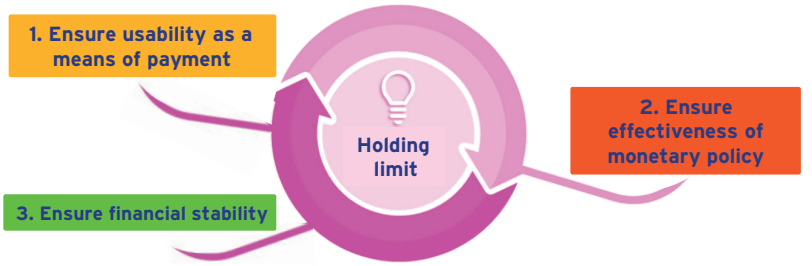
4 The issue of a possible digital euro has featured prominently in the Eurogroup's work programme. In September 2025, the Eurogroup reached a political agreement on the institutional framework for establishing holding limits and outlined the process leading to the potential issuance of the digital euro (Eurogroup 2025).

5 A successful adoption of the digital euro would also enhance financial stability compared to a future scenario, in which new forms of private money would gain widespread acceptance in an increasingly digital economy.

6 It has been argued that the so-called waterfall functionality, by which payments are automatically withdrawn or transferred to a linked bank account, implies that the holding limit could be low, or even zero, and still ensure usability (e.g. ECB 2025b). There are at least three counterarguments: a zero holding limit with waterfall would exclude the unbanked from using the digital euro; potential users of a digital euro would not be given the choice whether to link a bank account or not; and such a restriction of public money could violate the proportionality principle, as other – less intrusive – solutions like a holding limit are feasible.

these outflows and combining this information with an identification of the source of funds (i.e. banknotes, deposits, or other assets) and the number of depositors per bank. Only in this way can the resulting effects on financial stability be evaluated.

FIGURE 1 TRADE-OFF UNDERLYING THE CALIBRATION OF THE DIGITAL EURO HOLDING LIMIT



Source: Own representation, following ECB (2024b).

DIGITAL EURO DEMAND AND BANKS' POTENTIAL DEPOSIT OUTFLOWS

Analysing the demand for a new form of money involves considerable uncertainty. Furthermore, the demand for the digital euro will depend on its final design, including the holding limit, and the economic context (in particular, the condition of the financial system). Consequently, in its preliminary methodology the ECB considers two different scenarios: a business-as-usual scenario, in which the digital euro is mainly used as a means of payment, and a flight-to-safety scenario, which assumes a loss of confidence in the banking system unrelated to the digital euro (ECB 2025d). The latter scenario leads to significantly higher deposit outflows from the banking system, with the digital euro representing an additional – though restricted – destination for these outflows (ECB 2024b). The flight-to safety scenario is highly unlikely and extremely conservative, and is intended to inform a prudent approach.

Business-as-usual deposit outflows

To gauge digital euro demand under normal circumstances, the economic literature pursues two main approaches – a direct and an indirect one.

The 'direct' approach asks euro area citizens about their intentions to adopt the digital euro and the amount they would hold. For instance, a survey by Bidder et al. (2024) of German households reports a 46% adoption rate of an unremunerated digital euro. Similarly, Bijlsma et al. (2024) find a 49% take-up rate among Dutch households, with median holdings around €100-500. Focusing on the offline version of the digital euro in an experimental setting, van der Horst and van Gent (2025) record an adoption rate of 67% among Dutch consumers and average (offline) digital euro holdings of between €175 and €1,275, depending on the participant's monthly budget and the certainty with which a card payment option is available. For a representative sample of European consumers, Georgarakos et al. (2025) report a 45% adoption rate, with respondents

allocating, on average, €500 of a hypothetical €10,000 windfall gain to the digital euro. Overall, these surveys suggest that between half and two-thirds of euro area consumers might decide to hold digital euros, with a modest amount of digital euro holdings which nevertheless exceeds the €59 in cash that consumers, on average, indicated as having readily available in their wallet, pocket, or bag at the start of the day (ECB 2024c). The ECB also conducted its own Digital Euro Holding Limits Survey on user behaviour and money demand across a representative sample of the euro area population. This survey informs digital euro demand in its business-as-usual scenario, in which the digital euro is primarily used as a means of payment (ECB 2025d).

The 'indirect' approach uses econometric techniques and data on banknote holdings, payment habits, and preferences to predict digital euro demand. Lambert et al. (2024a) estimate that aggregate digital euro demand could range from €100 billion to €1.1 trillion, depending on whether individuals perceive the digital euro to be closer to cash or deposits, with median holdings of between €70 and €600. Similarly, Adalid et al. (2022) present an illustrative take-up scenario in which the digital euro is assumed to partially replace other means of payment, resulting in an aggregate demand of €488 billion.[7] By contrast, Nocciola and Zamora-Perez (2024) highlight the adoption cost for a new means of payments, which would result in a much lower transactional demand for digital euros.

Flight-to-safety deposit outflows

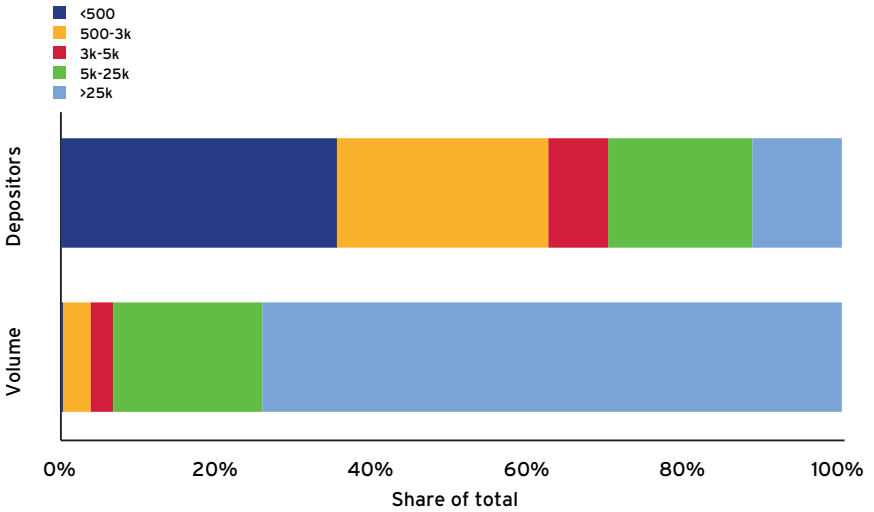
The flight-to-safety scenario aims to analyse the maximum possible impact of the digital euro on the banking system in an extreme case in which retail sight deposits are rapidly and simultaneously withdrawn from all banks.

Maximum aggregate deposit outflows can be roughly approximated by assuming that every euro area citizen withdraws an amount equal to the holding limit from their bank accounts (e.g. Meller and Soons 2023, Panetta 2022). This approximation, however, significantly overestimates deposit outflows for various reasons. First, it assumes that in this scenario all citizens switch to digital euro and hold balances up to the holding limit, whereas in reality individuals may choose not to hold digital euros. Second, in such a situation typically deposit outflows into banknotes would have surged, which now digital euro demand may have at least partly substituted for.[8] Finally, the more citizens that use the digital euro under business-as-usual conditions and exhaust part of their holding limits, the smaller the flight-to-safety moves would be. Considering these fact leads to significantly lower potential flight-to-safety deposit outflows.

7 Of this €488 billion, €180 billion would come from bank deposit outflows.
8 For a digital euro that is mainly used for payments, Adalid et al. (2022) assume a 50% banknote substitution and calculate an outflow of 12.5% of banks' customer deposits. For seven advanced economies, the Group of Central Banks (2021) present some illustrative scenarios for varying levels of digital currency demand that suggest an outflow of 2%-7% of bank deposits with a 50% banknote substitution.

To accurately estimate the maximum potential deposit outflows a bank could experience, it is necessary to analyse the distribution of deposits at each bank across depositors that are eligible to hold digital euros.[9] The ECB methodology to calibrate a holding limit utilises bank-level data on the number of depositors and their deposit holdings from a representative sample of euro area banks (ECB 2025d). Figure 2 shows that, for instance, more than 60% of sight depositors have accounts with balances below €3,000 and that these accounts represent only 4% of the total sight deposit volume. It becomes apparent that, in the light of the observed deposit distribution, deposit outflows would be much less significant because not every individual would be able to shift corresponding funds into digital euros.

FIGURE 2 DISTRIBUTION OF SIGHT DEPOSITS



Note: The upper bar shows the share of depositors with sight deposit account balances within a certain range. The lower bar shows the share of sight deposits held in accounts with a balance within a certain range.

Source: Ad hoc data collected by ECB banking supervision (see ECB 2025d).

BANKS' RESPONSES AND FINANCIAL STABILITY IMPLICATIONS

To assess financial stability implications from deposit outflows into digital euros, banks' responses to such outflows need to be estimated. The ECB's methodology is based on Meller and Soons (2025) and assumes that banks respond to deposit outflows in a profit-maximising manner, constrained by factors such as their liquidity risk preference, regulatory requirements, availability of reserves and eligible collateral, and

9 Lambert et al. (2024b) account for the distribution of household deposit balances based on the Household Finance and Consumption Survey, which leads to an estimated maximum outflow of 9% of bank deposits for a holding limit of €3,000.

market liquidity conditions (ECB 2025d).[10] The model considers the impact on several important liquidity metrics for each bank, such as the liquidity coverage ratio (LCR), the net stable funding ratio (NSFR), Supervisory Review and Evaluation Process (SREP) scores, collateral availability, and the encumbrance of eligible collateral.

Assuming the digital euro was introduced in the third quarter of 2021 with a €3,000 holding limit, Meller and Soons (2025) find that banks would have primarily relied on drawing down their excess reserves. However, under scenarios involving higher outflows or lower reserve holdings, banks would have increasingly relied on additional central bank and wholesale market funding. The authors' analysis, which conservatively uses the unadjusted maximum aggregate deposit outflows, indicates that concerns related to financial stability and monetary policy could only emerge if the holding limit exceeded €5,000.

CONCLUSIONS

A digital euro would complement the existing monetary system with a secure, efficient, and innovative digital form of money. As a digital alternative to cash, it would offer euro area citizens an alternative to private bank deposits and foreign payment providers. Additionally, the digital euro would ensure that the ECB retains control over monetary policy in an increasingly digital economy, thereby enhancing monetary sovereignty. Overall, the analyses presented in this chapter indicate that using the digital euro for daily payments will not compromise financial stability, banking supervision, or monetary policy (Cipollone 2025). Additionally, it is shown that a quantitative framework can inform the appropriate calibration of limits on digital euro holdings to prevent excessive outflows from commercial banks while ensuring individuals have access to secure digital money (Lane 2025).

REFERENCES

Adalid, R, A Álvarez-Blázquez, K Assenmacher et al. (2022), "Central bank digital currency and bank intermediation", ECB Occasional Paper 293 (https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op293~652cf2b1aa.en.pdf?985167870ac2551e31097f06382d01d9)

Bidder, R M, T P Jackson and M Rottner (2024), "CBDC and banks: Disintermediating fast and slow", Deutsche Bundesbank Discussion Paper No. 15/2024 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4838345).

10 A bank's access to liquidity depends on interbank market conditions, available monetary policy facilities, and its banking group structure. Additionally, its response to deposit outflows depends on its liquidity preferences (i.e. its willingness and ability to deplete available liquidity buffers) and the prevailing macroeconomic and financial conditions (i.e. the interest rate environment and excess liquidity levels). Each bank's balance sheet adjustment also affects its funding costs, which has implications for its net interest margin (NIM) and loan supply.

Bijlsma, M, C van der Cruijsen, N Jonker and J Reijerink (2024), "What triggers consumer adoption of central bank digital currency?", *Journal of Financial Services Research* 65(1): 1-40 (https://link.springer.com/article/10.1007/s10693-023-00420-8).

Cipollone, P (2025), "Digital euro - The future of money", speech at the conference on "The interplay between tax and financial regulations in a new digital environment", Rome, 7 April (https://www.ecb.europa.eu/press/key/date/2025/html/ecb.sp250407~669a57f2e2.en.pdf).

ECB – European Central Bank (2023a), "Progress on the preparation phase of a digital euro - First progress report" (https://www.ecb.europa.eu/euro/digital_euro/progress/shared/pdf/ecb.deprp202406.en.pdf).

ECB (2023b), "Opinion of the European Central Bank of 31 October 2023 on the digital euro" (https://www.ecb.europa.eu/pub/pdf/legal/ecb.leg_con_2023_34.en.pdf).

ECB (2023c), "ECB welcomes European Commission legislative proposals on digital euro and cash", press release, 28 June (https://www.ecb.europa.eu/press/pr/date/2023/html/ecb.pr230628~e76738d851.en.html).

ECB (2024a), "Progress on the preparation phase of a digital euro - Second progress report" (https://www.ecb.europa.eu/euro/digital_euro/progress/shared/pdf/ecb.deprp202412.en.pdf).

ECB (2024b), "Preliminary methodology for calibrating holding limits ERPB meeting – Item 3", 10 December (https://www.ecb.europa.eu/euro/digital_euro/timeline/profuse/shared/pdf/ecb.deprep241212_14erpb_Update_on_work_on_methodology_for_holding_limit_calibration.en.pdf).

ECB (2024c), "Study on the payment attitudes of consumers in the euro area 2024" (https://www.ecb.europa.eu/stats/ecb_surveys/space/html/ecb.space2024~19d46f0f17.en.html#toc54).

ECB (2025a), "Most EU countries rely on international card schemes for card payments, ECB report shows", press release (https://www.ecb.europa.eu/press/pr/date/2025/html/ecb.pr250228_1~7f0697af45.en.html).

ECB (2025b), "EBF, EACB, ESBG, and EPIF written feedback to ECB preliminary methodology for calibrating digital euro holding limits", January (https://www.ecb.europa.eu/euro/digital_euro/timeline/profuse/shared/pdf/ecb.deprep250304_15erpb_writtenfeedback_holdinglimits.en.pdf).

ECB (2025c), "Progress on the preparation phase of a digital euro - Third progress report" (https://www.ecb.europa.eu/euro/digital_euro/progress/shared/pdf/ecb.deprp202412.en.pdf).

ECB (2025d), "Technical data on the financial stability impact of the digital euro" (https://www.ecb.europa.eu/euro/digital_euro/timeline/profuse/shared/pdf/ecb.deprep251010_technical_annex_financial_stability_impact_digital_euro.en.pdf?f55d1581c257d73d86ad560edce18c17).

European Parliament (2024), "Committee on Economic and Monetary Affairs draft report on the proposal for a regulation of the European Parliament and of the Council on the establishment of the digital euro", 9 February (https://www.europarl.europa.eu/doceo/document/ECON-PR-758954_EN.pdf).

Eurogroup (2025), "Framework for launching the digital euro and setting the ceiling for the holding limit" (https://www.consilium.europa.eu/en/meetings/eurogroup/2025/09/19/).

Georgarakos, D, G Kenny, L Laeven and J Meyer (2024), "Consumer attitudes towards a central bank digital currency", ECB Working Paper No. 3035 (https://www.ecb.europa.eu/pub/pdf/scpwps/ecb~cde4bd616e.wp3035en.pdf).

Group of Central Banks (2021), *Central bank digital currencies: financial stability implications* (https://www.bis.org/publ/othp42_fin_stab.pdf).

van der Horst, F and A van Gent (2025) "The offline digital euro and holding limits: a user-centred approach An online experiment among Dutch consumers", DNB Occasional Study, April (https://www.dnb.nl/media/vbrkbg4x/dnb-os-a5-holding-limieten-digitale-euro.pdf)

Lambert, C, C Larkou, C Pancaro, A Pellicani and M Sintonen (2024a) "Digital Euro Demand: Design, Individuals' Payment Preferences and Socioeconomic Factors", ECB Working Paper No. 2024/2980 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4958524).

Lambert, C, B Meller, C Pancaro, A Pellicani, P Radulova, O Soons and A van der Kraaij (2024b) "Digital euro safeguards – protecting financial stability and liquidity in the banking sector", ECB Occasional Paper No. 346 (https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op346~3b4318a919.en.pdf?e9f109a29abbcb2997ae5629b5918d33).

Lane, P (2025), "The digital euro: maintaining the autonomy of the monetary system", Keynote speech at the University College Cork Economics Society Conference 2025, 20 March (https://www.ecb.europa.eu/press/key/date/2025/html/ecb.sp250320_1~41c9459722.en.html)

Meller, B and O Soons (2023) "Know your (holding) limits: CBDC, financial stability and central bank reliance", ECB Occasional Paper No. 2023/326 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4543369).

Meller, B and O Soons (2025) "Know your (holding) limits: CBDC, financial stability and central bank reliance", available at SSRN (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4984785).

Nocciola, L and A Zamora-Pérez (2024), "Transactional demand for central bank digital currency", ECB Working Paper No. 2926 (https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2926).

Panetta, F (2022), "The digital euro and the evolution of the financial system", speech at the Committee on Economic and Monetary Affairs of the European Parliament, 15 June (https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220615~0b859eb8bc.en.html).

ABOUT THE AUTHORS

Oscar Soons works as a Financial Stability Expert at the European Central Bank contributing to the digital euro project. He is on secondment from De Nederlandsche Bank, where he worked as a Senior Economist. He holds a PhD and an MPhil in Economics from the University of Amsterdam and the Tinbergen Institute. His research focuses on central bank digital currency, banking, financial stability, and European integration.

Katrin Assenmacher is Head of the Stress Test Modelling Division at the European Central Bank. From 2016 to 2023, she led the ECB's Monetary Policy Strategy Division and held a similar position at the Swiss National Bank from 2010 to 2016. Katrin has a professional background in monetary policy and time series econometrics and has published numerous articles in international journals. She was a visiting scholar at the Federal Reserve Banks of St. Louis and Atlanta, the Oesterreichische Nationalbank and the Universities of Copenhagen and Southern California. Katrin holds a doctorate and a diploma in economics from the University of Bonn, where she also received her *Habilitation*.

PART II
STABLECOINS

CHAPTER 8

Stablecoins: How research can inform policy

Hans Gersbach,[ac] Hugo van Buggenum,[ab] and Sebastian Zelzner[a1]
[a]ETH Zurich; [b]Tilburg University; [c]CEPR

1 INTRODUCTION

Stablecoins are digital assets designed to maintain a stable value relative to a reference asset (usually a national fiat currency like the US dollar). Unlike volatile cryptocurrencies such as Bitcoin or Ethereum, stablecoins peg their price one-to-one to an asset or basket of assets. Prominent examples of stablecoins include Tether (USDT) and USD Coin (USDC), which are backed by reserves of dollar-denominated assets and promise convertibility at par (1 token = 1 US dollar). In some ways, these tokens resemble traditional bank deposits or shares in money market mutual funds (MMFs) – promising a digital means of payment and store of value with minimal price fluctuation.[2]

Stablecoins emerged in the mid-2010s, but remained relatively niche until their market capitalisation rocketed from roughly $5 billion in early 2020 to over $250 billion by 2025 (see Figure 1). Fiat-backed stablecoins (like USDT, USDC) dominate, with about 90% of the market.

The appeal of stablecoins is clear: they promise to combine the features of crypto (e.g. programmability via smart contracts, fast and low-cost transactions, decentralisation) with the stability of traditional forms of money. Although no stablecoin has been able to maintain parity with its peg at all times, the largest fiat-backed stablecoins have exhibited relatively resilient performance (Kosse et al. 2023).[3]

Recent regulatory developments have begun to bring stablecoins into the mainstream. The European Union's Markets in Crypto-Assets (MiCA) regulation, fully effective since December 2024, and the United States' GENIUS Act, signed into law in July 2025, introduce comprehensive frameworks for the issuance and oversight of fiat-backed

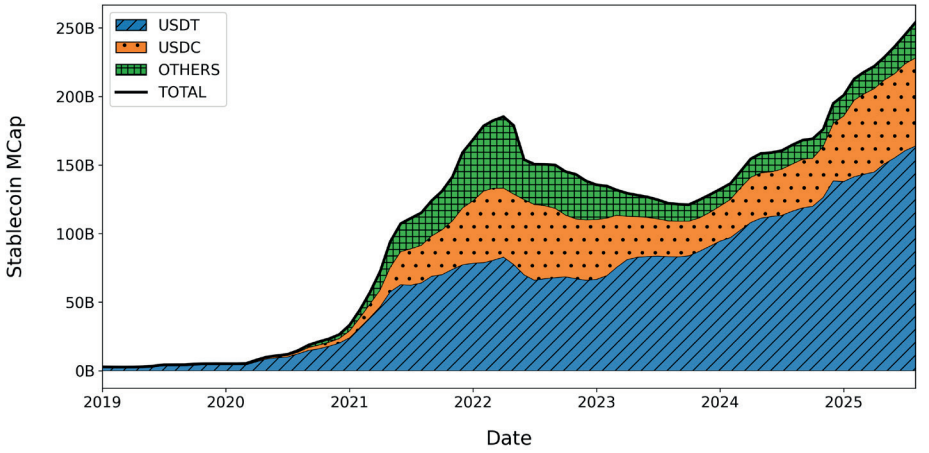
1 We are grateful to Mirjam Eggen for helpful comments and suggestions.

2 To situate stablecoins within the broader landscape of digital money, the BIS (2025) offers a useful taxonomy that distinguishes between account-based and token-based models as well as public versus private issuance. Within this framework, stablecoins are a form of privately issued, token-based money that – at least until recently – often operated outside the perimeter of traditional banking and securities regulation. By contrast, institutional alternatives such as tokenised deposits and CBDCs reflect efforts to digitize money within established financial infrastructures.

3 A notable exception occurred in March 2023, when USDC experienced a short but significant depegging following the collapse of Silicon Valley Bank (SVB), which temporarily impaired its reserve accessibility and triggered widespread market uncertainty.

stablecoins. These initiatives aim to strengthen reserve backing, redemption rights, and supervisory clarity – moving stablecoins closer to, and potentially enabling their integration into, the regulated financial system.

FIGURE 1 STABLECOIN MARKET CAPITALISATION



Source: Calculations based on data from coingecko.com and sentora.com.

In sum, stablecoins have rapidly evolved from a niche concept to a central pillar of the crypto economy. Their growth reignites age-old questions about private money. Can privately issued monies maintain stable value? What design features make a stablecoin resilient to runs? What happens when multiple private stablecoins compete? And how should policymakers oversee this new form of 'shadow banking' to safeguard monetary sovereignty and financial stability?

The remainder of this chapter explores these questions by reviewing the latest research on stablecoins, summarising our own contributions on stablecoin competition, contagion, and regulatory design, and outlining policy implications alongside key directions for future research.[4]

4 This chapter presents a condensed version of a longer article (van Buggenum et al. 2025b) in which we provide a more comprehensive review of the literature, including a detailed discussion of crypto-backed and algorithmic stablecoins. We also elaborate further on our own research on stablecoin competition and contagion, situating it within the broader academic debate. The longer version includes a more in-depth analysis of recent regulatory initiatives in the European Union (MiCA), the United Sattes (GENIUS Act), Switzerland, and other jurisdictions, highlighting current developments, deficiencies and open questions (e.g. Eggen 2025). Finally, it offers a more extensive discussion of stablecoins' role in the wider monetary and financial system.

2 OVERVIEW AND LITERATURE

2.1 Theoretical and historical background

Stablecoins can be understood as a new form of inside money, created by private intermediaries rather than the central bank (outside money). This concept has deep roots in monetary theory. Diamond and Dybvig (1983) and Bryant (1980) first modelled how banks issuing redeemable claims provide short-term liquidity but at the same time make themselves vulnerable to self-fulfilling runs. Their classic bank run framework, extended by many (e.g. Jacklin 1987, Goldstein and Pauzner 2005, Uhlig 2010), provides a tool to analyse stablecoins, which similarly entail short-term liabilities redeemable at par against a portfolio of assets.

Free banking and private currency competition

The emergence of stablecoins has also drawn parallels to historical episodes of free banking and private currency competition. In the 19th century, private banks in countries like Scotland, Canada, Switzerland, and the United States issued their own banknotes redeemable for specie – though with markedly different outcomes in terms of monetary stability, efficiency, and regulatory effectiveness (for a survey, see White 2014). Against this backdrop, Gorton and Zhang (2021) argue that stablecoin issuers resemble modern-day free banks. As a result, the literature on free banking (e.g. Gersbach 1998, Cavalcanti and Wallace 1999a, 1999b, Aghion et al. 2000, Martin and Schreft 2006) has regained relevance for understanding stablecoin competition.

2.2 Stablecoin design

The literature identifies four types of stablecoins: fiat-backed (e.g. USDC, USDT), commodity-backed (e.g. Paxos Gold), crypto-collateralised (e.g. DAI), and algorithmic (e.g. the now-defunct TerraUSD). The main category is fiat-backed stablecoins, where each coin is backed by safe assets (such as bank deposits, Treasury bills, or cash equivalents). These stablecoins currently dominate the market and are therefore the primary focus of regulatory debate, academic research, and our own analysis throughout this chapter. The design of fiat-backed coins is conceptually similar to an MMF, and its stability hinges on the quality and liquidity of reserves (van Buggenum et al. 2023, Oefele et al. 2024).

2.3 Peg stability, runs and financial fragility

A core concern in the literature is financial fragility. To what extent are stablecoins prone to runs or depegging under stress? Empirically, the major fiat-backed stablecoins have maintained tight pegs (Kosse et al. 2023), but events like the brief depegging of USDC during the collapse of SVB in March 2023 demonstrate that run risk is not hypothetical. Theoretically, stablecoin runs resemble those in banking and MMFs: just as a money market fund 'broke the buck' in 2008 (triggering a run on MMFs), a stablecoin can break its peg if reserve assets lose value or if holders suddenly lose confidence and rush to redeem.

Structural and informational drivers of runs

Stablecoin fragility can stem from both structural weaknesses and informational frictions. D'Avernas et al. (2022) and Li and Mayer (2022) show that peg instability can arise even in the absence of investor coordination failures, due to limited issuer commitment or sluggish recovery after a depeg. Empirically, Eichengreen et al. (2025) find that markets assign non-trivial probabilities of depegging for major stablecoins like Tether. Building on global games, Bertsch (2023) highlights that noisy signals about fundamentals can trigger redemptions, while Ahmed et al. (2025) warn that poorly timed financial statement disclosures can backfire when confidence is already fragile.

2.4 Competition and contagion in stablecoin markets

In our own research (van Buggenum et al. 2023), we examine how a fiat-backed stablecoin should be designed to be truly stable, and whether competition among stablecoins leads to stable and efficient market outcomes.[5] Investors in our model hold stablecoins to insure against idiosyncratic liquidity shocks that determine their (random) investment horizons. A distinctive feature of our model is that it explicitly incorporates the dynamics of secondary market pricing and their interplay with issuer redemption policies. As liquidity shocks materialise, investors value the ability to redeem coins with the issuer at par or to liquidate holdings via the secondary market.[6]

Focusing on how our analysis guides regulation, we highlight two central insights: (i) redemption limits can prevent self-reinforcing runs and stabilise individual stablecoins; and (ii) interest-bearing stablecoins introduce contagion and coordination problems that can undermine the stability and efficiency of the broader ecosystem.

Run dynamics and redemption limits

A widely held view is that stablecoin issuers should operate akin to narrow banks – maintaining full backing with high-quality liquid assets to ensure immediate redemption at par. Our research offers a more nuanced perspective on these liquidity requirements. Specifically, we show that even if a stablecoin is partially backed by illiquid assets (modelled as 'trees' in the spirit of Lucas 1978), issuer-run risk can be prevented through the use of well-designed redemption limits – rules that effectively cap redemptions during periods of stress, akin to a temporary suspension of convertibility in the Diamond–Dybvig framework.[7]

While Engineer (1989) demonstrates that such redemption restrictions are ineffective in multi-period banking models, since depositors may pre-emptively run to avoid future illiquidity, this logic does not directly apply to stablecoins. The key distinction lies in the presence of *active secondary markets* for stablecoins, which allow holders to

5 Relatedly but within a different framework, Fernández-Villaverde and Sanches (2019) analyse whether competition in private digital currencies can be compatible with price stability and efficient money supply.

6 The role of stablecoins as insurance against liquidity shocks parallels that of bank deposits in classical models such as Bryant (1980) and Diamond and Dybvig (1980). This liquidity insurance function is arguably central to the current role of stablecoins, given their widespread use for settlement in DeFi protocols and for facilitating trades on crypto-exchanges.

7 Such rules can be credibly enforced using smart contracts and blockchain-based mechanisms (Cong et al. 2022).

liquidate their positions even when issuer redemptions are constrained. This market-based, rather than issuer-based, liquidity unravels the incentive to front-run others in a redemption queue, thereby preventing the run dynamic. In this sense, our findings suggest that regulation should explicitly permit redemption restrictions for stablecoin issuers under stress – mirroring the flexibility granted to MMFs.

Interest on stablecoins and contagion effects

If different stablecoins compete with each other, interest-bearing stablecoins can introduce destabilising dynamics into the stablecoin system. Specifically, we find that even a single interest-paying stablecoin can exert contagion effects on others: unless competing coins also begin offering interest, they become uncompetitive and face redemption pressures. This dynamic creates coordination problems and multiple, potentially unstable and inefficient, equilibria in which stablecoin yields fluctuate widely.

These findings carry two main policy implications. First, a stablecoin's resilience should not be assessed in isolation. Regulatory monitoring and stress testing should consider the full competitive landscape of stablecoins and their systemic interdependencies. Second, regulatory frameworks that discourage interest-bearing stablecoins enhance stability. Such policies can shield stablecoins from return-driven contagion and help coordinate the market toward an efficient equilibrium.[8]

2.5 Stablecoins' role in the broader financial and monetary system

Stablecoins have gained prominence as the de facto medium of exchange and unit of account in crypto markets, enabling users to move in and out of volatile crypto assets without returning to fiat. They also play an important role in the DeFi ecosystem: smart contracts can use stablecoins as collateral, liquidity, and a settlement medium, automating functions such as lending, trading, and liquidation across protocols. Beyond the crypto sphere, their broader appeal stems from the promise of faster and cheaper transactions, especially in cross-border contexts.

At the macro level, researchers and policymakers are increasingly assessing the implications of large-scale stablecoin adoption. Some see them as a complement to bank deposits and central bank money that could spur competition and innovation in payments – echoing Hayek's vision of privately issued money. Others are more cautious, warning that widespread use could lead to disintermediation, weaken monetary policy transmission, threaten the singleness of money, and heighten financial instability.

Disintermediation risks and currency substitution

If households and firms begin holding significant funds in stablecoins, banks could lose deposits, shrinking their ability to lend. A sudden and substantial shift from bank deposits into stablecoins could even result in a situation akin to a systemic bank run.

8 More precisely, our model shows that from the perspective of optimal liquidity insurance, the efficient allocation is achieved when stablecoins offer a zero real interest rate – that is, when their nominal interest rate matches the prevailing inflation rate.

The IMF notes that some stablecoins are starting to find acceptance beyond the crypto space, raising the prospect of currency substitution in certain environments (Bains et al. 2022). For instance, in economies with unstable local currencies, dollar-pegged stablecoins might be seen as an attractive store of value, potentially undermining local monetary sovereignty (see also Brunnermeier et al. 2021, Garita et al. 2024). At the same time, this very threat could act as a disciplining force, pressuring policymakers to improve poor monetary policies in order to avoid stablecoins displacing the local currency.

Stablecoin shocks and spillovers to traditional finance

As of now, the scale of stablecoins relative to global finance is still small. Recent empirical work by the BIS (Cornelli et al. 2023, Aldasoro et al. 2024) reinforces this point: shocks within the crypto ecosystem, such as the collapses of Terra/Luna or FTX, substantially affected stablecoin capitalisation but had no discernible impact on traditional financial markets, including MMFs or equity indices. This underlines the still largely self-referential nature of crypto markets and suggests that external spillovers remain limited – for now. Still, if a stablecoin were to gain widespread traction as a medium of exchange for goods and services, it could rapidly achieve systemic scale. In turn, this competitive pressure could also spur innovation and efficiency gains within the traditional financial system.

3 IMPLICATIONS AND FUTURE DIRECTIONS

The rise of stablecoins poses a complex mix of opportunities and risks for regulators and policymakers. On the one hand, stablecoins promise more efficient payments (24/7 instant transfers, including cross-border), financial inclusion, and enhanced competition in the payments market. On the other hand, they present significant challenges: if not properly regulated, they can be subject to runs that echo classic bank runs, they may transmit shocks between crypto and traditional finance, and in extreme cases, widespread use of private stablecoins could lead to disintermediation and undermine monetary sovereignty.

Drawing on our review of the academic literature, historical experiences with financial innovation, and our own theoretical work, we outline a set of forward-looking implications for regulatory and policy design. Many of the risks are already being addressed, at least in part, by recent regulatory frameworks. The EU's MiCA regulation and the US GENIUS Act both establish minimum standards for reserve composition and quality, redemption rights, and disclosure obligations for fiat-backed stablecoins. The coming years will reveal how effective these frameworks are, where they fall short, and which regulatory gaps or loopholes may remain. Addressing these issues will be essential to achieving the following core policy objectives:

Ensure robust reserve safeguards and transparency. A foundational requirement is that stablecoins be fully (or very conservatively) backed by high-quality assets, and that issuers provide frequent, audited disclosures of reserves. Lack of transparency is a key concern that makes it difficult to assess the risk profile of a stablecoin – Tether, for instance, faced regulatory scrutiny and public criticism for years due to opaque and unaudited reserve disclosures. Regulators should mandate reserve audits, clear custodial structures (to protect reserve assets from issuer bankruptcy), and require that reserves be held with trusted institutions.[9]

Establish legal clarity and enforceability. While many issuers advertise 1-to-1 convertibility into fiat currency, coinholders frequently lack a clear contractual claim to underlying reserves (Bains et al. 2022, Bruce et al. 2022). In particular, stablecoins issued by offshore entities or through opaque legal structures may offer no effective legal recourse in the event of redemption delays or failures. Even when rights exist de jure, enforcing them can be difficult in practice – especially during stress events or cross-border disputes. As a result, many stablecoin redemption promises rely more on issuer reputation than on enforceable obligations. Echoing these concerns, the BIS (2025) notes that even fully backed stablecoins are only as stable as their issuers' legal structures.

Regulate interest payments on stablecoins. A key concern is that stablecoins could draw funds away from the traditional banking system, potentially disrupting monetary policy transmission, financial stability, and credit intermediation – especially if they gain traction as a medium of exchange. Restricting interest payments on stablecoins can mitigate these risks by reducing competitive pressure on banks and allowing time for adjustment. While regulatory frameworks such as MiCA and the GENIUS Act currently mandate a zero nominal interest rate, our model supports a slightly different benchmark: from the perspective of optimal liquidity insurance, the efficient allocation is achieved when stablecoins offer a zero real interest rate (van Buggenum et al. 2023). The stricter regulatory choice of prohibiting all interest payments can nonetheless be justified as a precautionary measure to prevent destabilising dynamics, especially in the early phases of adoption (see also Gersbach 1998 in the context of free banking). Over time, however, if risks related to disintermediation and broader systemic stability prove manageable, there may be scope to revisit this constraint. In particular, allowing moderate nominal interest payments, especially in inflationary environments, could become a desirable feature of stablecoin design.

Introduce redemption gates and fees. In times of market stress, stablecoin issuers may face sudden surges in redemption demand that threaten their reserve base and destabilise the peg. Large-scale, forced asset liquidations can also spill over into short-

9 Preliminary work of ours (van Buggenum et al. 2025a) investigates how asset diversion by malicious stablecoin issuers can undermine trust in the broader market and trigger contagion, harming even sound competitors. In extreme cases, where developers abscond with all investor funds, this constitutes a so-called 'rug pull'. High-profile examples include AnubisDAO and StableMagnet in 2021. The proposed measures are aimed at preventing such abuses and reinforcing credibility within the crypto ecosystem.

term funding markets, amplifying volatility and contagion – much like past runs on MMFs. An effective tool to mitigate these risks is the introduction of redemption barriers – mechanisms that temporarily limit or disincentivize withdrawals. These tools are already established in the regulation of MMFs (Voellmy 2021), where funds can impose temporary liquidity fees or suspend redemptions to prevent runs. The rationale applies equally to stablecoins, where excessive outflows can trigger self-reinforcing secondary market discounts and arbitrage-based run dynamics (van Buggenum et al. 2023). Nevertheless, the EU's MiCA and the US GENIUS Act currently take a more rigid approach, mandating prompt redemption at par, at minimal or no cost, thereby leaving little room for such stabilising tools.

Align international regulatory frameworks. Stablecoins are inherently cross-border – a US dollar-backed token issued in one country can be held anywhere in the world. Fragmented rules could lead to arbitrage and a 'race to the laxest jurisdiction'. International standard-setters such as the Financial Stability Board (FSB), the Committee on Payments and Market Infrastructures (CPMI), and the International Organization of Securities Commissions (IOSCO) have begun issuing principles to harmonize regulation. Policymakers should continue to coordinate on taxonomy (what is a stablecoin versus other crypto-assets), minimum standards for significant global stablecoins, and information sharing.

Prevent criminal abuse while preserving privacy. Beyond financial stability risks, stablecoins raise concerns about illicit finance: they can move value quickly and outside traditional banking, which can facilitate money laundering, terrorism financing, and sanctions evasion. Regulators must enforce anti-money laundering (AML)/countering the financing of terrorism (CFT) and sanctions compliance not only for issuers, but also across the broader stablecoin ecosystem, including wallet providers, exchanges, and custodians. These concerns are not merely hypothetical – Tether, in particular, has been repeatedly linked to illicit activity, including fraud networks, terrorist financing, and sanctions evasion (Chainalysis 2024). At the same time, safeguards should be designed to preserve user privacy as much as possible, building on recent proposals for privacy-preserving compliance frameworks (e.g. Duffie et al. 2025).

Directions for future research

Future research directions to inform the policy debate are plentiful. We need more empirical work on how stablecoins are actually used. Are they held mainly by crypto traders, or are they trickling into mainstream use? Do users treat them mainly as a store of value, or are they used as a medium of exchange?

Theoretical research should also explore potential future competition with central bank digital currencies (CBDCs). If central banks issue digital currencies, will private stablecoins be crowded out – much like the National Bank Act of 1864 effectively ended

the era of free banking in the United States?[10] Could stablecoins backed by central bank reserves lead to a new institutional arrangement – sometimes referred to as a *synthetic* CBDC – that combines private issuance with public backing?

Questions of monetary policy also arise. If much of the money supply in an economy became private stablecoins issued by firms, how would central banks implement policy? These are largely uncharted waters that merit our attention.

4 CONCLUSION

The rise of stablecoins requires us to revisit fundamental questions about money, banking, and regulation. They have underscored a fundamental principle of monetary economics: the viability of any currency – whether public or privately issued – ultimately depends on the credibility of its issuer and the confidence of its users. The academic literature, including our own contribution, suggests that stablecoins require careful design and regulation to avoid instability. With proper safeguards in place, the stablecoin sector could become a valuable part of the financial system's future architecture; without it, we risk repeating the mistakes of past episodes of unregulated banking.

REFERENCES

Aghion, P, P Bolton and M Dewatripont (2000), "Contagious bank failures in a free banking system", *European Economic Review* 44(4): 713–718.

Ahmed, R, I Aldasoro and C Duley (2025), "Public information and stablecoin runs", BIS Working Paper 1164.

Aldasoro, I, G Cornelli, M F Minesso, L Gambacorta and M M Habib (2024), "Stablecoins, money market funds and monetary policy", BIS Working Paper 1219.

Bains, P, A Ismail, F Melo and N Sugimoto (2022), "Regulating the crypto ecosystem: The case of stablecoins and arrangements", IMF Fintech Note 2022/008.

Bertsch, C (2023), "Stablecoins: Adoption and Fragility", Sveriges Riksbank Working Paper Series 423.

BIS – Bank for International Settlements (2025), "The next-generation monetary and financial system", Chapter III in *Annual Economic Report 2025*.

Bruce, K J, C K Odinet and A Tosato (2022), "The private law of stablecoins", *Arizona State Law Journal* 54: 1073–1160.

10 Chiu and Monnet (2024) already take a first step in this direction, arguing that the outcome depends on how a CBDC (or tokenised deposits) is designed.

Brunnermeier, M, H James and J-P Landau (2021), "The digitalization of money", BIS Working Papers 941.

Bryant, J (1980), "A model of reserves, bank runs, and deposit insurance", *Journal of Banking & Finance* 4(4): 335–344.

Cavalcanti, R and N Wallace (1999a), "Inside and outside money as alternative media of exchange", *Journal of Money, Credit and Banking* 31(3): 443–457.

Cavalcanti, R and N Wallace (1999b), "A model of private bank-note issue", *Review of Economic Dynamics* 2(1): 104–136.

Chainalysis (2024), *The 2024 crypto crime report*.

Chiu, J and C Monnet (2024), "Public and Private Money Creation for Distributed Ledgers: Stablecoins, Tokenized Deposits, or Central Bank Digital Currencies?", Staff Working Paper 2024-35, Bank of Canada.

Cong, L W, Y Li and N Wang (2022), "Token-based platform finance", *Journal of Financial Economics* 144(3): 972–991.

Cornelli, G, S Doerr, J Frost and L Gambacorta (2023), "Crypto shocks and retail losses", BIS Bulletin 69.

D'Avernas, A, V Maurin and Q Vandeweyer (2022), "Can Stablecoins be Stable?", Becker Friedman Institute Working Paper 2022-131.

Diamond, D W and P H Dybvig (1983), "Bank runs, deposit insurance, and liquidity", *Journal of Political Economy* 91(3): 401–419.

Duffie, D, O Olowookere and A Veneris (2025), "A note on privacy and compliance for stablecoins", Stanford GBS Research Paper.

Eggen, M (2025), "Schweizer Kryptoregulierung: Gesetzgeberischer Handlungsbedarf im Zivil- und Aufsichtsrecht", *sui generis*, pp. 55–65.

Eichengreen, B, M Nguyen and G Viswanath-Natraj (2025), "Stablecoin devaluation risk", *European Journal of Finance* 31: 1469–1496.

Engineer, M (1989), "Bank runs and the suspension of deposit convertibility", *Journal of Monetary Economics* 24(3): 443–454.

Fernandez-Villaverde, J and D Sanches (2019), "Can currency competition work?", *Journal of Monetary Economics* 106(C): 1–15.

Garita, M, C Bregni and R Asturias (2024), "Stablecoins and inflation in Latin America: the case of Argentina", *Journal of Strategy and Management*.

Gersbach, H (1998), "Liquidity creation, efficiency, and free banking", *Journal of Financial Intermediation* 7(1): 91–118.

Goldstein, I and A Pauzner (2005), "Demand-deposit contracts and the probability of bank runs", *Journal of Finance* 60(3): 1293–1327.

Gorton, G and J Zhang (2021), "Taming wildcat stablecoins", *Law Review* 90, University of Chicago.

Jacklin, C (1987), "Demand deposits, trading restrictions, and risk sharing", in E C Prescott and N Wallace (eds), *Contractual arrangements for intertemporal trade*, Vol. 2, University of Minnesota Press, pp. 26–47.

Kosse, A, M Glowka, I Mattei and T Rice (2023), "Will the real stablecoin please stand up?", BIS Working Paper 141.

Li, Y and S Mayer (2022), "Money Creation in Decentralized Finance: A Dynamic Model of Stablecoin and Crypto Shadow Banking", Fisher College of Business Working Paper Series 2020-03-030, The Ohio State University.

Lucas, R (1978), "Asset prices in an exchange economy", *Econometrica* 46: 1429–1445.

Martin, A and S L Schreft (2006), "Currency competition: A partial vindication of Hayek", *Journal of Monetary Economics* 53(8): 2085–2111.

Oefele, N, D G Baur and L A Smales (2024), "Are stablecoins the money market mutual funds of the future?", *Journal of Empirical Finance* 79.

Uhlig, H (2010), "A model of a systemic bank run", *Journal of Monetary Economics* 57(1): 78–96.

van Buggenum, H, H Gersbach and S Zelzner (2023), "Contagious Stablecoins?", CEPR Discussion Paper 18521.

van Buggenum, H, H Gersbach and S Zelzner (2025a), "Contagious currency competition?", mimeo.

van Buggenum, H, H Gersbach and S Zelzner (2025b), "Stablecoins: How research can inform policy – Extended version", mimeo.

Voellmy, L (2021), "Preventing runs with fees and gates", *Journal of Banking & Finance* 125, 106065.

White, L (2014), "Free banking in history and theory", in H W White, V Vanberg and E A Kohler (eds), *Renewing the search for a monetary constitution*, Vol. 9, Cato Institute, pp. 187–211.

ABOUT THE AUTHORS

Hans Gersbach holds the Chair of Macroeconomics: Innovation and Policy at ETH Zurich and serves as Co-Director of the KOF Swiss Economic Institute. He is a Research Fellow at CEPR and a member of the Academic Advisory Council to the German

Federal Ministry of Economics and Climate Action. His research spans the design of economic and political institutions, innovation and growth, monetary economics, financial stability, and digital currency competition. In these fields, he has published extensively in leading international journals, contributing to academic debates and policy discussions alike.

Hugo van Buggenum is an academic economist and financial practitioner affiliated with KOF-ETH Zürich and Tilburg University. His academic research focuses on macroeconomics, monetary economics, and labour search models. He is particularly interested in the nexus between macro and finance, with a focus on the macroeconomic repercussions of payments and liquidity. Hugo earned his PhD in Financial and Monetary Economics at Tilburg University in 2021, after which he joined ETH Zürich. He is currently working as a quantitative financial practitioner, focusing on interest-rate and credit-spread modelling.

Sebastian Zeizner is Section Head of Design of Financial and Monetary Systems at the KOF Swiss Economic Institute. He holds a PhD in Economics from the University of Regensburg and previously conducted postdoctoral research at ETH Zurich. His work focuses on financial stability, banking regulation, and the functioning and design of the current hierarchical monetary architecture. He is particularly interested in the emergence and regulation of novel forms of money, in particular digital currencies such as stablecoins. His research aims to inform sound policy frameworks for an evolving monetary system in the digital age.

CHAPTER 9

Banking on blockchain

Rodney Garratt[1]
University of California, Santa Barbara

INTRODUCTION

The stablecoin market stands at a pivotal juncture in its evolution. From a modest $6 billion market capitalisation in 2020, the US dollar-denominated stablecoin market exploded to $156 billion by 2022 and has continued its meteoric rise to over $280 billion today. This remarkable growth trajectory, coupled with projections suggesting the total stablecoin market could exceed $1 trillion in the coming years, underscores the profound transformation occurring in digital finance. However, perhaps more significant than the growth in market size is the fundamental shift in regulatory approach that is reshaping the competitive landscape and institutional adoption of stablecoins.

President Trump's Executive Order "Strengthening American Leadership in Digital Financial Technology," issued on 23 January 2025, and the GENIUS Act, which was enacted into law on 18 July 2025, represent a watershed moment for the stablecoin industry. These developments signal a clear departure from the regulatory uncertainty that has historically characterised the digital asset space towards a framework that not only provides clarity but may even encourage institutional participation. The implications of this regulatory evolution extend far beyond compliance requirements, fundamentally altering the competitive dynamics and strategic considerations for existing and prospective stablecoin issuers.

THE REGULATORY PARADIGM SHIFT

The transformation in regulatory stance represents a stark reversal from the cautious, often restrictive approach that characterised previous administrations. The Executive Order explicitly revokes Executive Order 14067 from March 2022, which had established a more sceptical framework for digital assets, and instead established a Presidential Working Group on Digital Asset Markets. The working group's mandate was to find ways to advance US leadership in digital assets, including stablecoins.

1 The author is an advisor to Ubyx. He thanks Kene Ezeji-Okoye, Tony McLaughlin, Maarten van Oordt and seminar participants at the 2025 UCSB FifTech Blockchain Summit and the 2025 CBER Crafting the Cryptoeconomy Conference for helpful comments and suggestions.

The GENIUS Act establishes the first comprehensive regulatory framework for payment stablecoins in the United States. The legislation creates a federal licensing and supervisory framework that provides regulatory clarity while ensuring consumer protection. Importantly, the Act does not merely tolerate stablecoin issuance but actively facilitates it by creating clear pathways for various types of financial institutions to participate in the market.

This regulatory evolution is particularly significant in its approach to institutional participation. Unlike previous frameworks that were largely reactive and restrictive, the new regulatory environment is proactive and enabling. The legislation explicitly contemplates and provides for the participation of traditional financial institutions, including commercial banks, in stablecoin issuance. This represents a fundamental shift from viewing stablecoins as parallel or alternative financial systems to recognising them as components of the broader financial ecosystem.

MARKET DYNAMICS AND COMPETITIVE LANDSCAPE

The current stablecoin market is dominated by a relatively small number of issuers, with Tether (USDT) and USD Coin (USDC) controlling the vast majority of market share.[2] This concentration reflects the first-mover advantages and network effects that have characterised the early development of the stablecoin market. It is still an open question how regulatory changes that are now underway will alter this competitive dynamic.

The entry of traditional financial institutions into the stablecoin market will introduce new competitive pressures and opportunities. Banks and other regulated financial entities bring several advantages to stablecoin issuance, including established regulatory relationships, robust risk management frameworks, and extensive customer bases.[3] These institutions also possess the operational infrastructure and compliance capabilities necessary to navigate the enhanced regulatory requirements that will govern the stablecoin market.

The competitive advantages of traditional financial institutions must be weighed against the expertise and innovative spirit that have characterised existing stablecoin issuers. Companies like Circle and Paxos have built their businesses specifically around digital asset infrastructure and have deep expertise in blockchain technology and cryptocurrency markets. Perhaps more importantly, the customers these entities serve often have different needs and requirements than those of new traditional finance (TradFi) entrants.

2 The discussion in this chapter pertains only to asset-backed stablecoins.
3 The focus of this discussion is on financial institutions from the traditional finance sector. The GENIUS Act includes provisions that restrict certain types of companies from directly issuing stablecoins, particularly large technology companies that are not predominantly engaged in financial activities. This approach reflects concerns about market concentration and the potential for technology giants to leverage their existing platforms to dominate the stablecoin market.

Stablecoins were originally introduced to meet the needs of crypto-native investors who sought refuge from the high price volatility of cryptocurrencies like Bitcoin. Later, stablecoins became commonly used for leveraged trading, decentralised finance (DeFi) yield farming, and liquidity provision. These use cases are not typically demanded by TradFi clients. So, while new legislation opens the door for an entire ecosystem of new entrants it is not clear that they will be competing head-to-head in all areas of the stablecoin market.

TradFi entrants have not built their businesses specifically around digital asset infrastructure, nor do they necessarily have deep expertise in blockchain technology and cryptocurrency markets. Furthermore, they are more limited in terms of who they can serve and what activities they can allow because of regulatory overhang from other aspects of their business.[4] These factors suggest a future where TradFi participants serve their traditional financial clients using public blockchains as new payment rails, while incumbent stablecoin issuers continue to compete for dominance within the crypto ecosystem.

To understand how banks will use stablecoins, it is necessary to first recognise what stablecoins really are: digital cheques. A stablecoin gives the holder a claim on value, denominated in a sovereign unit of account, in the form of commercial bank deposits recorded on traditional ledgers. This, in essence, is what a cheque does. In payments terminology, it is a *pull payment* instruction. Since the claim is on the account of the issuer, stablecoins are more like cashiers' cheques than personal cheques. To be more precise, the closest paper-based analogy would be travellers' cheques, because stablecoins are not made out to a particular recipient. The main difference between the situation where an individual acquires a travellers' cheque and personally presents it to a recipient as payment for a good or service, and the act of sending them a stablecoin, is the rails. In both cases the recipient, at least in principle, can redeem it for commercial bank deposits, at par value, from the issuer.[5]

In fact, many of the problems that we currently see with the current redemption process for stablecoins (redemption frictions, costs and deviations from par value; see Table 1) are similar to what we observed historically with cheque processing before the creation of cheque clearing houses. The post-Civil War period in the United States saw cheques being redeemed at below par value and, in some cases, cheques would be rerouted through several institutions, resulting in significant time delay (Harding 1925). These problems were pervasive, leading Congress to pass the Federal Reserve Act of 1913, which empowered the new central bank to establish a par clearing system. Over

4 Banks are subject to strict rules under frameworks like Basel III (capital and liquidity requirements), the Bank Holding Company Act (limits on commercial affiliations), and anti-money laundering and know your customer laws.

5 The fact that people tend to 'reuse' stablecoins (i.e. pass them on to others without redeeming them) does not invalidate their interpretation as cheques. While it is less common, paper cheques can also, in some instances, be signed over to the recipients rather than cashed. When stablecoins liabilities circulate without being redeemed they start to resemble private outside monies: assets issued by the private sector without a corresponding liability within it, such as unbacked cryptocurrencies (e.g. bitcoin). However, stablecoins are not private outside monies. They do not exist in positive net supply. We should therefore not interpret stablecoins as private competing currencies in the sense of Hayek (1976).

time, regional Federal Reserve banks redeemed cheques from their member banks, and eventually most non-member banks, at face value. As a result of the transition to centralised cheque clearing, issuer attributes became less important.

TABLE 1 REDEMPTION FRICTIONS AND COSTS FOR POPULAR STABLECOINS[6]

	USDT	USDC	DAI
Issuer	Tether Limited	Circle	Sky
Redeem via CEX with swapping fees	Yes	Yes	Yes
Redemption mechanism	Direct redemption for verified users	1:1 redemption via Circle's platform	Users must use Maker Vaults or decentralised exchanges.
Minimum redemption amount	$100,000	None for most users	None
Processing time	Several days	Standard users process instantly. Basic users may take up to two business days.	Instant through DeFi platforms.
Fees	$150 verification fee and 0.1% withdrawal fee. Bank processing fees may apply.	For standard users redeeming up to $2M are free.[7] No direct redemption fees for basic users. Bank processing fees may apply.	May incur gas fees on Ethereum. Bank processing fees may apply.
Restrictions	AML, KYC, CTF	AML, KYC	None
Centralised or decentralised	Centralised	Centralised	Decentralised

Just as we do not typically favour one issuing bank over another when it comes to cheques, stablecoins could achieve a similar uniformity through the right market structure. Imagine what would happen if stablecoins were cleared and ultimately settled in a manner similar to cheques. When someone receives a stablecoin, they would be able to deposit it at any bank and receive full value, regardless of which bank (or non-bank) issued it. Redemption agreements of this sort could be arranged on a pairwise basis through rules and procedures set up between each issuer and the many potential

6 I thank Nir Chemaya for his assistance in compiling this table.
7 See https://help.circle.com/s/article/USDC-redemption-structure?language=en_US&category=Fees_and_Billing

recipient banks. But that is inefficient, and it favours walled gardens that can lead to low surplus for consumers. This 'many-to-many' network problem is solved in traditional finance through clearing systems.

MARKET INFRASTRUCTURE AND ECOSYSTEM DEVELOPMENT

As new entrants from the TradFi sector enter the stablecoin market, we should expect that they will not only serve different clients but also process stablecoin transactions using different systems to meet these requirements. Within the crypto ecosystem stablecoins are often the only viable option for a stable store of value that can also serve as a US dollar-denominated medium of exchange. Issues such as depegging, suspensions of conversion, and costly redemption that are common to existing stablecoins are tolerated due to a lack of alternatives. TradFi users, in contrast, have many options for US dollar-denominated payments and liquidity storage. This includes accounts that are interest-bearing.

So why should TradFi participants be interested in stablecoins? Well, it is not entirely clear they will be in many use cases. The landscape of real-time payments has become increasingly competitive with the launch of FedNow, RTP, same-day ACH, and multiple other faster payment systems such as open loop P2P payments (Zelle), closed loop P2P payments (Venmo), wire transfers, and push-to-card payments. FedNow conveys money almost instantly, finally bringing the world's largest economy in line with payment advances in other countries. These developments represent a significant challenge to stablecoins' value proposition in US domestic payments.

Instant payment systems currently hold a key advantage over stablecoins for TradFi participants: they are regulated by central banks and embedded within established financial ecosystems, offering a level of security and trust that many cryptocurrencies lack due to their decentralised nature. This regulatory oversight and integration with existing banking infrastructure give legacy systems inherent benefits in terms of institutional adoption and consumer confidence. However, platforms like FedNow require both sender and receiver to maintain accounts with participating financial institutions, a constraint that may limit accessibility for unbanked or underbanked populations, as well as for international transactions that rely on correspondent banking networks. In contrast, stablecoins enable global financial access and on-chain transactions without such limitations. Their borderless nature offers distinct advantages for international payments, remittances, and cross-border commerce. While FedNow may excel in domestic person-to-person and business-to-business transactions, stablecoins have clear strengths in global payment scenarios.

The programmability of blockchain systems used to transfer stablecoins also provides unique capabilities that traditional payment systems cannot easily replicate (Garratt and Lee 2025). Smart contracts can automate complex payment flows, enable conditional payments, and integrate with decentralised applications in ways that

traditional banking rails cannot easily accommodate. This programmability opens new possibilities for business process automation and financial innovation (Kahn and van Oordt 2022, Aldasoro et al. 2023).

THE CASE FOR CLEARING

In a world with universal stablecoin clearing, stablecoins become just another payment option for customers of financial institutions. They are elastically supplied by banks to meet customer needs and add to payment convenience. Crucially, the ability to offer this convenience should be equal for all institutions. This would level the playing field in competition among banks for depositors, which, according to the theory presented in Garratt et al. (2023), leads to reduced market concentration, a narrower deposit interest rate spread between large and small banks, and, in some cases, higher average deposit rates. Empirical support for the consumer benefits of infrastructures that improve payment convenience is found in Sarkisyan (2024), which shows that following the launch of Pix in Brazil, small banks' deposit rates fell by 14 basis points relative to large banks, and their total deposits increased. Further arguments found in Garratt et al. (2023) suggest that payment infrastructures that foster more competitive deposit markets also improve monetary policy pass-through.

A stablecoin clearing system would allow any participating stablecoin to be deposited into any bank or fintech account at full face value. This would extend the institutional features of the current financial system, particularly the mechanisms that ensure all privately issued commercial bank monies trade at par, a property known as the *singleness of money*, to stablecoins.[8] Monetary singleness depends on institutional arrangements (Garratt et al. 2022), and even a fully backed stablecoin may not always trade at par if a clearing system is absent (Garratt and Shin 2023).

While stablecoins may serve as vehicles for transmitting payment instructions, recipients, at least in the near term, are likely to prefer holding deposits. As a result, stablecoins used as digital cheques and cleared through a clearing system would likely have a short lifecycle. They would be issued, transferred, and redeemed. This means we would not observe the massive build-up in the stock of stablecoins that is often predicted today. Such a dynamic has implications for liquidity usage and helps mitigate financial stability concerns associated with so-called 'runs' on stablecoins.

CONCLUSION

New legislation that permits the entrance of banks into the stablecoin market could be transformative, but not because banks will compete head-to head with current incumbents.

8 The term singleness of money first appeared in CPSS (2003) and was later used by then-CPSS Chair Tommaso Padoa-Schioppa in a speech (Padoa-Schioppa, 2003) at the Bank of Korea's Conference on Payment Systems.

Rather, it is because banks will utilise stablecoins to meet the payment needs of their own customers. To understand how they will do this requires recognition that stablecoins are a clearing instrument, not a privately issued money. Ultimately, they point back to value on a traditional ledger.

For banks to use stablecoins effectively, they will need a clearing system.[9] Some might ask whether a clearing system is necessary. After all, existing stablecoins have been quite successful despite the limitations raised above, and without being processed through clearing systems. This is because they serve the needs of a different clientele. Stablecoins are rarely used by crypto traders as a settlement leg in traditional market transactions. This means that while these instruments are best understood as digital cheques, their users rarely cash these cheques. Instead, they hold them as a store of value, deploy them for leveraged trading, DeFi yield farming, and liquidity provision, or transfer the liability when making payments to others who are equally comfortable taking on this type of liability. Under these circumstances, redemption frictions and small departures from singleness are not disqualifying factors. In TradFi applications, where value must travel seamlessly between stablecoins and deposit accounts, the full monetary utility that clearing systems provide becomes indispensable.

REFERENCES

Aldasoro, I, S Doerr, L Gambacorta, R Garratt and P Koo Wilkens (2023), "The Tokenisation Continuum", BIS Bulletin No. 72.

CPSS – Committee on Payment and Settlement Systems (2023), "The Role of Central Bank Money in Payments", currently available as CPMI Papers No. 55.

Garratt, R and M Lee (2025), "The Future of Payment Infrastructure Could be Permissionless", Liberty Street Economics, forthcoming.

Garratt, R and H-S Shin (2023), "Stablecoins versus Tokenised Deposits: Implications for the Singleness of Money", BIS Bulletin No. 76.

Garratt, R, M Lee, A Martin and J Torregrossa (2022), "The Future of Payments is not Stablecoins", Liberty Street Economics, 7 February.

Garratt, R, J Yu and H Zhu (2025), "Digital Payment and Interbank Competition", mimeo.

Harding, W P G (1925), *The Formative Period of the Federal Reserve System (During the World Crisis)*, Boston and New York: Houghton Mifflin Company, The Riverside Press, Cambridge.

Hayek, F A (1976), *The Denationalisation of Money*, Institute of Economic Affairs.

9 There is a private sector initiative called Ubyx that seeks to provide this type of infrastructure.

Kahn, C M and M R C van Oordt (2022). "The Demand for Programmable Payments", Tinbergen Institute Discussion Paper 2022-076.

Padoa-Schioppa, T (2004), "Shaping the payment system: a central bank's role", speech at the Bank of Korea's Conference on Payment Systems, Seoul, 13 May.

Sarkisyan, S (2024), "Instant Payment Systems and Competition for Deposits", Jacobs Levy Equity Management Center for Quantitative Financial Research Paper.

ABOUT THE AUTHOR

Rod Garratt is a professor of economics at the University of California, Santa Barbara. He has worked as a Senior Advisor at the BIS, a Research Advisor to the Bank of England and is a former Vice President of the Federal Reserve Bank of New York. He has also held visiting scholar positions at the Bank of Canada and the IMF. Garratt received his undergraduate degree from the University of Waterloo and his PhD from Cornell University. He is an Associate Editor of the E*uropean Economic Review* and serves on the editorial boards of the *Journal of Network Theory in Finance* and *Digital Finance*.

CHAPTER 10

Are stablecoins really the future of payments?

Stephen G. Cecchetti and Kermit L. Schoenholtz[1]
Brandeis University, European Systemic Risk Board and CEPR; NYU Stern School of Business

Since January 2025, the US Government has undertaken numerous measures to promote the use of crypto. The most prominent is enactment of the GENIUS Act, a regulatory framework for 'payments stablecoins'. These are fiat-backed tokens with value pegged to a government-issued currency, predominantly the US dollar.

Currently, the two largest stablecoins, Tether's USDT and Circle's USDC, have a combined market capitalisation of more than $250 billion and operate on the Ethereum blockchain. Each originated as a stable-valued means of payment for people trading inside the crypto world. They quickly turned into the primary bridge between the traditional financial system and the crypto world, allowing investors and speculators to shift funds between established financial instruments (equity, bonds, bank balances, and the like) and crypto assets (Bitcoin, Ether, Solana, etc.). At this writing, this remains stablecoins' primary use.

The original dream of crypto enthusiasts – a fully decentralised system operating without intermediaries or governments – has given way to a far less radical vision that requires government oversight and the legal enforcement of property rights. Indeed, stablecoin issuers (and some other promoters of crypto) are now strong advocates of government regulation.

Aside from populating the Trump administration with digital asset advocates, the GENIUS Act is the key result of crypto industry lobbying. The Act has three key provisions. First, it prohibits the issuers from paying interest (Sec 4. (11)). Second, it restricts the assets that an issuer must hold in the reserve backing the stablecoins (Sec 4. (a) (1) (A)). Third, issuers must meet the requirements of the Bank Secrecy Act, complying with know your customer (KYC), anti-money laundering (AML), and anti-terrorist financing (ATF) standards (Sec 4. (5)).

1 We thank Richard Berner, Yvan Dubravica, Jon Frost, John Lipsky, Richard Portes, and David Wessel for helpful comments and discussions.

THE GENIUS ACT

Interest payments

To be sure, history teaches us that there are many ways to evade restrictions on payment of interest, such as usury laws. Standard methods include charging higher prices to borrowers or offering other types of compensation to lenders.[2] In the case of stablecoins, Coinbase and PayPal already offer significant 'rewards' – currently 3–5% – to customers holding stablecoin balances (Bank Policy Institute 2025, Lutz 2025).

Reserve assets

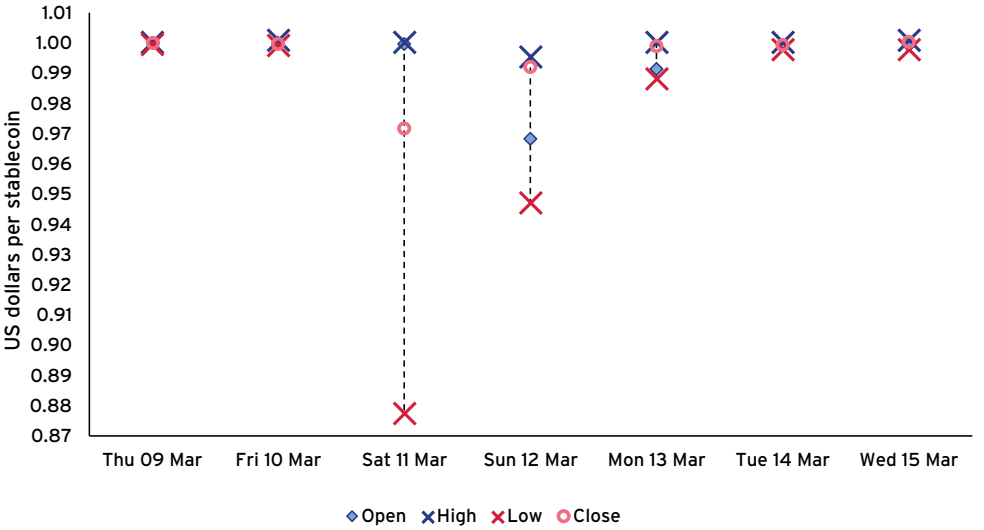
The list of eligible reserve assets is short, and most items on the list (like short-maturity Treasury instruments) are virtually free of risk. However, payment stablecoin reserves also may include prime money market funds (with variable net asset value) and bank deposits. A sufficient concentration of a stablecoin's reserves in a prime money market fund that faces a run could trigger a run in the stablecoin itself.

And uninsured bank deposits are a well-known source of runs on both banks and associated stablecoins (Jiang et al. 2024). The 2023 collapse of Silicon Valley Bank (SVB) and the subsequent run on USDC illustrates the fragility of stablecoin balance sheets that could persist even under GENIUS Act rules. Recall that Circle's reserves for USDC included a $3 billion deposit at SVB. Following SVB's failure on Friday, 10 March 2023, doubts emerged that uninsured depositors like Circle would be able to recover their funds. The next day, USDC's price plunged, falling as low as $0.8774 (see Figure 1). USDC returned close to parity only after US policymakers undertook emergency actions on Sunday 12 March to protect all SVB's depositors, including the uninsured ones like Circle. Importantly, the run on USDC extended well beyond price instability: between 7 and 20 March 2023, USDC's market capitalisation fell from $43.6 billion to $35.3 billion, indicating that over a two-week period Circle sold 20% of USDC's assets to meet redemptions.

Despite these risks, payment stablecoins face no capital requirement. Moreover, regulators need not impose a capital requirement on the *issuers* of payment stablecoins. If they opt to do so, capital requirements on these issuers may not exceed what is "sufficient to ensure the ongoing operations" (Sec. 4. (4) (A) (ii)). Absent some capital to buffer potential losses, it is doubtful that stablecoins would become a safe, information-insensitive asset in the sense of Dang et al. (2019).

2 Islamic law (Sharia) prohibits paying or receiving interest. In place of traditional (Western) debt contracts, Islamic banks offer arrangements where the bank purchases something like a house or a car, selling it to the customer at a higher price, with repayment in periodic installments.

FIGURE 1 DAILY TRADING RANGE OF USDC, 9 MARCH 2023 - 15 MARCH 2023



Source: Coinmarketcap.com.

Bank Secrecy Act standards

When it comes to KYC, AML, and ATF standards, matters are a bit more complicated. There are two common ways for an individual to hold crypto assets, including stablecoins. One is through a licensed or registered intermediary and the second is using a noncustodial or self-hosted wallet. In the first case, the custodian (such as Coinbase) will have a consolidated 'account', holding all the stablecoins it has in custody at its address (or addresses) on the blockchain. As a registered intermediary, this custodian must ensure that their customers are not using stablecoins for an illicit purpose.

The alternative is that the holder uses a noncustodial wallet, maintaining full control of their crypto holdings. Since stablecoins are bearer instruments, ownership is not registered and the holder can remain anonymous. In this case, there is no guarantee that the stablecoins will be used solely for legal activities. But under the GENIUS Act, stablecoin issuers must abide by the Bank Secrecy Act, both ensuring that their customers are not using their stablecoins for an illicit purpose and reporting them to enforcement authorities if they detect suspicious actions. At this stage, it is unclear how they will do it.[3]

3 Related to this is the question of whether it is possible to determine the physical location of the owner of a stablecoin. Authorities would like to ensure that the reserves backing stablecoins are held inside the same jurisdiction of the people who hold the stablecoins. This 'co-location' would ensure that they can enforce redemption guarantees. Whether this is possible remains to be seen.

STABLECOINS VERSUS TOKENISED DEPOSITS

Ultimately, the key question is whether people will want to hold stablecoins for use as a payment instrument outside of the crypto world. To address this question, we compare the two largest stablecoins to a specific version of what we see as their most likely competitor: tokenised deposits. Table 1 compares Tether's USDT and Circle's USDC with JPMorganChase's JMPD. Of the 15 features that we consider, the three instruments share only two: they clear and settle around the clock (24/7/365), and they are subject to the anti-crime provisions of the Bank Secrecy Act (KYC/AML/ATF).

Looking at the two stablecoins, they are the same across many dimensions. They are both recorded on the Ethereum blockchain, are unregistered bearer instruments, pay no interest (explicitly), face the same tax treatment, have no relationship with the central bank, no government guarantees, and allow for noncustodial wallets. USDT and USDC differ primarily in their transparency, the nature of their auditing, the composition and segregation of their reserve assets, and the location of their headquarters. In all these areas, USDC appears less risky. Most notably, it has faced a complete audit by a Big Four accounting firm, it holds most of its reserves (currently 85%) in the Blackrock Circle Reserve Fund,[4] and its location is in New York City, where it faces oversight by the State of New York Department of Financial Services (2015).[5]

The characteristics of stablecoins stand in sharp contrast to those of a tokenised deposit, in this case JPMorganChase's JPMD, which aims at institutional clients and is in an experimental stage.

JPMD largely has the same properties as an existing deposit. Importantly, this means that it can rely on the established governance that exists for deposits both domestically and internationally. JPMD pays interest, liquidates at par, is insured by the Federal Deposit Insurance Corporation (FDIC), is issued by a too-big-to-fail bank with central bank access, and is backed by JPMorganChase's entire balance sheet. In addition, it can be issued in various currencies, allowing for an internal market for cross-border and foreign exchange settlements. If our reading is correct, the design of JPMD would allow, for example, two institutional clients, one in Europe and one in the United States, to instantly settle a payment in dollars or euros (or even a payment that involves a currency conversion) on the balance sheet of JPMorganChase.

4 See https://www.blackrock.com/cash/en-us/products/329365/circle-reserve-fund
5 The New York stablecoin rules regarding reserves, redemption and external attestation established a precedent for much of the GENIUS Act framework (New York Department of Financial Services 2022).

TABLE 1 KEY FEATURES OF TOKENISED PROGRAMABLE PAYMENT VEHICLES

	Stablecoin (Tether USDT)	Stablecoin (Circle USDC)	Tokenized Deposit (JPMorganChase JPMD)
Platform	Permissionless (Ethereum)	Permissionless (Ethereum)	Permissioned (Kinexys)
Bearer instrument	Similar (unregistered)	Similar (unregistered)	No (registered)
Clearing and settlement	24/7/365 On exchange netting	24/7/365 On exchange netting	24/7/365 On-us netting
Pays interest	No	No	Yes
Taxation of sale	Taxable event (excise tax if treated as bearer bond)*	Taxable event (excise tax if treated as bearer bond)*	Not taxable (liquidates at par)
Central bank relationship	None	None	Transaction finality and central bank access
US regulator	Registered with FinCEN (foreign pathway under GENIUS Act)	Registered in 46 states and with FinCEN (OCC under GENIUS Act)	Bank regulators (Fed & FDIC)
Government guarantees	No	No	Deposit insurance (and TBTF)
Custody	Allows non-custodial wallet	Allows non-custodial wallet	Custodian is issuing bank
Bank Secrecy Act (AML, ATF, KYC)	Yes	Yes	Yes
Assets (reserves)	Cash (about 80%), precious metals, bitcoin, secured loans, and other	Govt MMF (> 85%) and bank deposits	Various bank assets
Transparency	Limited	Effective	NA
Market cap	~$177 billion	~$75 billion	Experimental
Headquarters	El Salvador	New York	US
External audits and disclosures	Partial (BDO) No full audit Limited disclosure	Deloitte Annual audit Monthly attestation Weekly reserve holdings	Big Four Annual audit Quarterly supervisory and SEC filings

Note: * Excise tax under Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA)
Source: Authors, except where stated.

JPMD differs from existing deposit accounts in three important ways. First, it clears and settles around the clock. Second, the plan is that it will allow for programmable settlement and automated functions through smart contracts.[6] Third, it can trade either on a proprietary centralised ledger operated by JPMorganChase or, using smart programming to provide access only to approved clients, on a public, distributed ledger.

THE ADVANTAGES OF TOKENISED DEPOSITS

For an institutional client, JPMD would seem to offer compelling advantages over stablecoins.[7] First and foremost, the issuing entity (JPMorganChase) has a reputation for integrity that it has established globally over decades. It operates in multiple regulatory environments, serving customers in more than 100 countries. It has long experience both with cross-border transactions and with data protection in multiple jurisdictions. It can credibly ensure continuity of operation based on a deep and broad pool of high-quality employees and a robust physical infrastructure. Operating under strict regulation and supervision, JPMorganChase's safe-haven status has allowed it to gain strength repeatedly amid (and in the aftermath of) financial crises. And, especially for institutional clients, there is additional comfort from the exclusion of illicit players from the firm's proprietary platform. That is, users can rest assured that JPMorganChase will police hackers, sanctions evaders, terrorists, and other criminals. As a result, the latter will almost surely view public, distributed ledgers and pseudonymous coins without location markers as easier venues and tools to ply their trade.

To this already lengthy list of advantages, we should add one big one: the ability of a behemoth bank to exploit network externalities. Recall that a network externality occurs when the value of a good or service rises with the breadth and intensity of use. Technology platforms are famous for such externalities. Examples include operating systems (Microsoft, Apple and Linux), search (Google), and internet shopping (Amazon).

Outside of China, JPMorganChase is the largest global bank (with assets of roughly $4.5 trillion). When it offers customers a product, they are drawn into an ecosystem with tens of millions of existing customers and a wide array of complementary products and services. In this context, as the number of customers using JPMD increases, the internal ('on us') market will grow more liquid, with the potential for instant settlement both within and across borders at minimal cost.

To what extent can stablecoin issuers compete? Outside of specific crypto-related niches, who would prefer an instrument that lacks common global governance standards, pays no interest (at least from the issuer), has no insurance, is issued by an entity that lacks

6 Programmable money has the advantage of creating automated conditional payments that streamline things like payment of recurring bills, conditional payments in supply chains and trade finance, insurance claim payouts, government aid benefits, and the like. Furthermore, since it is possible to build eligibility directly into the instrument itself, it can embed compliance (Lightspark, 2025).

7 Liang (2025) speculates that tokenised deposits and faster payments may suffice for the needs of most consumers, too.

central bank access, has less experience in meeting compliance and data protection requirements in multiple jurisdictions, lacks an internal market of behemoth breadth and scale, and may have a history of illicit use and reputational problems?[8]

We should add that tokenised deposits could become even more competitive than the instruments issued by a single institution that we discuss. Imagine, for example, that a few internationally active, systemic banks decide to accept each other's tokenised deposits instantly at par. In effect, they would be implementing a digital version of the 19th century US cheque clearinghouses that assured the expeditious settlement of most payments, imposed credit standards, and even acted as private lenders of last resort (Bernanke 2011). Such a 21st century clearinghouse would be a too-big-too-fail juggernaut.

Finally, we mention three important problems with stablecoins that tokenised deposits and MMFs do not have. First, because they are issued and controlled by banks, tokenised deposits can afford holders the privacy protection that meets the standards in their home location while still providing for the ability to monitor and transfer funds across jurisdictions. By contrast, since stablecoin ownership is recorded on a public blockchain, transactions are traceable by anyone with the appropriate tools.

Second, tokenised deposits need not create the same cross-border risks as stablecoins. As Portes (2025) notes, the fungibility of stablecoins means that redemption may not occur in the same place as issuance. To see the risk, consider a case where two issuers (possibly subsidiaries of the same parent) issue the same stablecoin in two jurisdictions (possibly with different reserve-backing requirements). Suppose that someone purchases this stablecoin in one jurisdiction and redeems it in the other. Fungibility means that no one (except possibly the holder) knows who originally issued the stablecoin. Will reserve assets automatically migrate to the place where stablecoin redemptions occur? If not, limited mobility of reserves could augment stablecoin run risks and transmit them across borders. In contrast, for tokenised deposits the assets are all on the consolidated balance sheet of the issuing entity. As a result, the issuer can redeem tokens in cash in any jurisdiction where they have a branch.

Third, unlike stablecoin issuers, whose products are mostly dollar-linked, the world's largest banks already accept deposits in a number of currencies. And while payment stablecoins may remain predominantly dollar-based, going forward, banks likely will seek to create tokenised deposits in the currencies where they find opportunities to lend. Non-US regulators are likely to find such bank innovation far less troubling than an expansion of Treasury-backed stablecoins that may invite currency substitution.

8 For a discussion of illicit uses of crypto, see Chainalysis (2025). For an analysis of governance issues in the crypto ecosystem, see Berner et al. (2023). Stablecoins also lack three essential features of any payments instrument: "singleness," "elasticity" and "integrity" (Bank for International Settlement 2025). We address these shortcomings by highlighting: (1) the tendency for stablecoins to deviate from their par value of one dollar (a violation of singleness, see Figure 1); (2) the fact that nonbank stablecoin issuers lack access to the lender of last resort (a violation of elasticity); and (3) the continuing use of crypto for illicit purposes (a violation of integrity).

REFERENCES

Bank for International Settlements (2025), "The next-generation monetary and financial system", *Annual Report*, Chapter 3, June.

Bank Policy Institute (2025), "Closing the Payment of Interest Loophole for Stablecoins", August 12.

Bernanke, B.S. (2011), "Clearinghouses, Financial Stability, and Financial Reform", 2011 Financial Markets Conference, Stone Mountain, Georgia, 4 April.

Berner, R., W. Coen and C. Wilkins (2023), "Addressing Governance Issues in the Crypto Ecosystem," The Bretton Woods Committee No. 5, April.

Chainalysis (2025), "2025 Crypto Crime Trends: Illicit Volumes Portend Record Year as On-Chain Crime Becomes Increasingly Diverse and Professionalized", 15 January.

Dang, T.V., G. Gorton and B. Holmström (2020), "The information view of financial crises", *Annual Review of Financial Economics* 12: 39-65.

Jiang, E.X., G. Matvos, T. Piskorski, and A. Seru (2024), "Monetary tightening and U.S. bank fragility in 2023: Mark-to-market losses and uninsured depositor runs?", *Journal of Financial Economics* 159.

Liang, N. (2025), "Essential features for a safe and trusted payment stablecoin", Brookings, 8 May.

Lightspark (2025), "What Is Programmable Money, and Why Does It Matter for Fintech?", 8 August.

Lutz, S. (2025), "Coinbase, PayPal Press Forward with Stablecoin Rewards Despite GENIUS Prohibitions—Here's How", decrypt, 4 August.

New York Department of Financial Services (2015), "NYDFS Announces Approval of First BitLicense Application from a Virtual Currency Firm", 22 September.

New York Department of Financial Services (2022). "Virtual Currency Guidance", 8 June.

Portes, R. (2025), "The stablecoin loophole that could expose the EU", *Financial Times*, 25 July.

ABOUT THE AUTHORS

Stephen G. Cecchetti is Rosen Family Chair in International Finance at Brandeis University, Research Associate at the NBER, Research Fellow at the CEPR, and Vice Chair of the Advisory Scientific Committee of the European Systemic Risk Board. From 2008 to 2013, Cecchetti served as Economic Adviser and Head of the Monetary and Economic Department at the Bank for International Settlements in Basel, Switzerland.

From 1997 to 1999 he was Director of Research at the Federal Reserve Bank of New York. In addition, he has been on the faculty of The Ohio State University and the New York University Stern School of Business. In 2016, he received an Honorary Doctorate in Economics from the University of Basel.

Kermit L. Schoenholtz is Clinical Professor Emeritus in the Economics Department of NYU Stern School of Business, where he taught courses on money and banking and macroeconomics and directed the Stern Center for Global Economy and Business. Prior to his academic career, Schoenholtz had served as the global chief economist at Citigroup, and as the chief economist at Salomon Brothers and at Salomon Smith Barney. Schoenholtz is a member of the Council of Foreign Relations. Previously, he was a panelist of the U.S. Monetary Policy Forum and served on the Financial Research Advisory Committee of the U.S. Treasury's Office of Financial Research. Schoenholtz is the co-author of a popular textbook on money, banking, and financial markets.

CHAPTER 11

Tether and the fragility of unregulated dollar substitutes

David Andolfatto
University of Miami

INTRODUCTION

Stablecoins are private monetary instruments that aim to maintain a fixed exchange rate against a government-issued currency, typically the US dollar. In this respect, they resemble bank deposits and shares in money market mutual funds, which are also priced at par in normal times. The distinguishing feature of stablecoins is not the promise of price stability per se, but the technological infrastructure supporting their issuance and transfer. By leveraging blockchain settlement systems, stablecoins provide a workaround to some of the frictions and inefficiencies embedded in traditional banking and payment networks.

This chapter asks whether these technological workarounds – or features such as balance sheet transparency – offer any meaningful improvement in financial stability. Specifically, are stablecoins immune to the run dynamics that afflict traditional maturity-transforming institutions? If not, what tools are available to policymakers to mitigate these risks?

While the issue of stability applies broadly to all stablecoins, the discussion here focuses on Tether (USDT) for two reasons. First, with a market capitalisation exceeding $160 billion, Tether is by far the largest and most systemically important stablecoin in circulation. Second, unlike its closest competitor, USDC, which is issued by the US-regulated entity Circle, Tether is incorporated outside the United States. As a result, it lies beyond the direct reach of US financial regulators. In principle, USDC could be brought under the same regulatory framework that governs US money market funds or one day even granted access to Federal Reserve infrastructure via a master account. No such option is likely to exist for Tether.[1] This makes Tether a particularly relevant case for evaluating the limits of current US regulatory authority – and for thinking through potential extensions of that authority in the interest of financial stability.[2]

1 The Genius Act (Giving Useful Information to Enhance Regulatory Security Act) was introduced in 2023 to establish disclosure and oversight requirements for stablecoin issuers operating in or marketing to US users. While the Act had not passed as of mid-2025, it signaled a regulatory push to bring dollar-pegged tokens under US prudential supervision. Tether, incorporated in the British Virgin Islands, would likely fall outside its direct scope, though US-based custodians like Cantor Fitzgerald could be indirectly affected. See the 2023 White House Fact Sheet on the Genius Act(https://www.whitehouse.gov/fact-sheets/2025/07/fact-sheet-president-donald-j-trump-signs-genius-act-into-law).

2 See also the discussions in Andolfatto (2024) and Aldasoro et al. (2025).

TETHER BASICS

Tether (USDT), the first and most widely used stablecoin, has become a central fixture in the global crypto-financial ecosystem. Launched in 2014 as Realcoin, it was designed to combine the price stability of the US dollar with the settlement efficiency of blockchain-based tokens.

Tether Limited, the entity that issues USDT, provides a degree of transparency uncommon in early stablecoin projects. It publishes regular attestations of its reserve composition and balance sheet, most recently through audited statements made available on its website.[3] It also outlines the redemption terms in its publicly available terms of service. Yet despite these disclosures, the legal nature of the tokens and the precise obligations Tether assumes towards users remain only partially defined.

Specifically, Tether does not guarantee par redemption for all holders. Redemption at par (1 USDT = 1 US dollar) is available only to verified institutional customers that meet know your customer (KYC)/anti-money laundering (AML) requirements and a minimum redemption threshold (currently $100,000 per transaction). Retail users, who typically acquire USDT through exchanges or peer-to-peer transfers, have no direct contractual claim on Tether Ltd. Instead, they rely on the expectation that secondary market liquidity and arbitrage activity will keep the token trading close to par.

This creates a de facto two-tier structure: institutional clients may redeem directly with Tether, while retail users depend on intermediaries and market forces. Moreover, Tether explicitly reserves the right to delay or deny redemptions, stating:

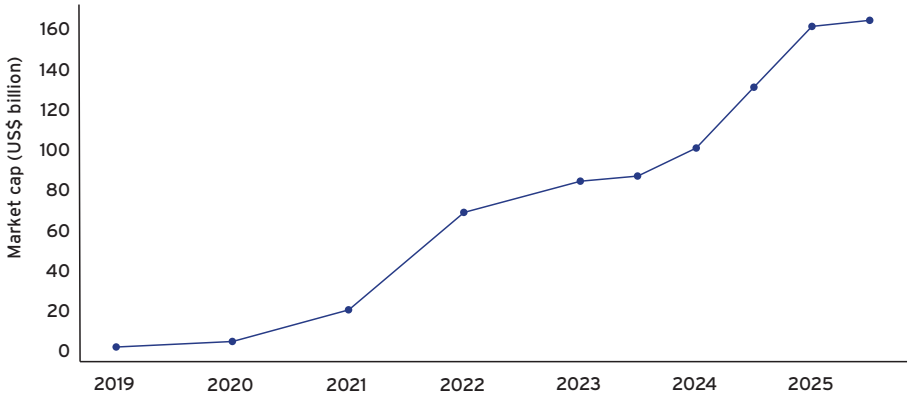
> "*Tether reserves the right to delay the redemption or withdrawal of Tether Tokens if such delay is necessitated by the illiquidity or unavailability or loss of any Reserves or … for any other reason.*"
> — Tether Terms of Service, updated December 2023, Section 6.3.

While USDT is marketed as a stable substitute for the US dollar, it is not a bank deposit and does not enjoy deposit insurance. Nor is it subject to the regulatory oversight applied to US government money market funds, which must comply with SEC Rule 2a-7, including liquidity requirements, portfolio restrictions, and daily disclosure obligations.

Against this legal and institutional backdrop, Tether's scale is striking. As of mid-2025, USDT's market capitalisation exceeds $160 billion, with an estimated 400 million users worldwide and over 100 million active on-chain wallets (see Figures 1 and 2). This growth, especially since 2017, reflects its role as the dominant trading pair on centralised exchanges, a settlement layer in decentralized finance (DeFi), and an informal dollar substitute in jurisdictions with unstable local currencies and restricted access to the US dollar.[4]

3 See https://tether.to/en/
4 See https://www.coindesk.com/markets/2024/09/17/tether-issued-stablecoin-usdts-market-share-grows-to-75-as-market-cap-tops-118b and https://cointelegraph.com/news/tether-usdt-market-cap-hits-160b-emerging-markets-growth

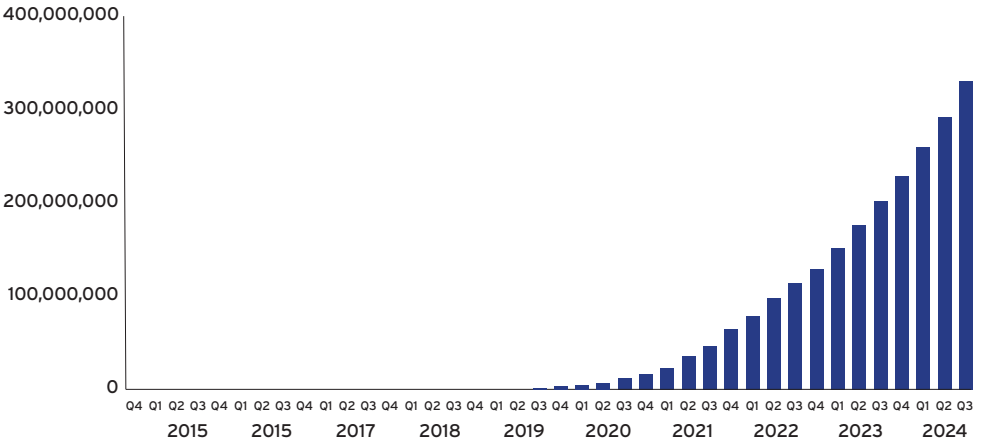
FIGURE 1 TETHER (USDT) MARKET CAPITALISATION OVER TIME



Note: This figure illustrates the growth in Tether's market capitalization from 2019 through mid-2025. After a relatively modest rise through 2020, growth accelerated markedly in 2021, reflecting increased adoption on centralized exchanges, expansion in DeFi applications, and greater use in emerging markets as a substitute for US dollars. As of mid-2025, USDT's market cap exceeds $160 billion.

Source: Tether Ltd., CoinGecko, compiled by author.

FIGURE 2 ESTIMATED NUMBER OF TETHER (USDT) USERS OVER TIME



Note: This figure shows the estimated growth in the number of Tether users worldwide from 2019 through mid-2025. User adoption remained modest through 2021 but accelerated sharply thereafter, reaching approximately 400 million users by mid-2025. This surge reflects both institutional integration and increasing use among retail users in emerging markets seeking dollar exposure amid local currency instability.

Source: Tether Ltd., Chainalysis, compiled by author.

TETHER USERS

Tether's appeal lies in its simplicity: a dollar-pegged token that moves across blockchains with minimal friction. But what sustains its demand is not the design – straightforward and easily copied – but the breadth of economic roles it fills.

Tether's user base is diverse, spanning retail traders, institutional investors, centralised and decentralised platforms, and users in both mature and fragile financial systems. Understanding who uses Tether, and for what purposes, sheds light on how a non-state monetary instrument can scale globally.

The most obvious users are crypto traders. Tether serves as the stable leg in trading pairs against volatile digital assets. Traders frequently shift into USDT to hedge risk without off-ramping into fiat. On most major exchanges – especially those operating outside US jurisdiction – USDT is the dominant quote asset. Its deep liquidity and broad acceptance make it a de facto base currency for crypto trading.

Exchanges themselves are major users. Centralised platforms use Tether for quoting, internal accounting, and customer balances. Decentralised protocols rely on USDT in liquidity pools and automated market makers. Its cross-chain presence – on Ethereum, Tron, Solana, and others – reinforces its role as a settlement and clearing layer.

In emerging markets, Tether functions as an informal dollar substitute. In countries with inflation, capital controls, or weak banking infrastructure, USDT is a practical store of value and medium of exchange. Peer-to-peer platforms like Binance P2P and Telegram bots support resilient informal exchange networks. In Argentina, Nigeria, Lebanon, and Venezuela, holding USDT is less about speculation and more about financial survival.

Institutional users – hedge funds, trading firms, and certain cross-border businesses – use Tether to move capital quickly across regions and exchanges. Unlike the traditional banking system, Tether operates 24/7. It is a tool for arbitrage, rebalancing, and cross-platform settlement, particularly where banking rails are slow or unreliable. While some crypto-native firms use Tether as an alternative to money market funds for short-term liquidity management, there is limited evidence that traditional corporate treasurers have adopted Tether for core cash management. Concerns around legal clarity, counterparty risk, and regulatory uncertainty remain significant barriers to adoption in conventional treasury operations.[5]

Tether is also embedded in DeFi. It is used as collateral in lending protocols, as liquidity in trading pools, and as a base asset in synthetic financial products. Platforms like Aave, Compound, and Curve routinely list USDT as a core asset, reflecting its perceived stability and market depth.

5 Conventional corporate treasurers have shown limited interest in Tether due to concerns over legal ambiguity (e.g., limited redemption rights per Tether's Terms of Service), counterparty risk (as highlighted in the 2021 settlement with the New York Attorney General), and ongoing regulatory uncertainty (see President's Working Group on Financial Markets et al. 2021). These factors contrast with the transparency, enforceability, and regulatory oversight typically required for treasury assets like government money market funds or insured bank deposits.

Cross-border payments represent another area of demand. Importers, small businesses, and individuals in developing economies increasingly use Tether to send and receive payments. For many, it is faster and cheaper than SWIFT, Western Union, or local remittance channels. A US-based client can pay a service provider in Kenya or the Philippines in minutes, without FX intermediaries or banking delays.

Finally, over-the-counter brokers and market makers use Tether to settle large trades off-exchange. As well, arbitrageurs and speculators use Tether to execute cross-exchange and cross-stablecoin trades. For these agents, USDT is a transactional instrument, not a store of value.

What unites these users is a shared need for a dollar-linked instrument that operates at internet speed. Tether may not be perfect, but it is useful. And in monetary history, usefulness beats perfection.

IS TETHER RUN-PROOF?

In the United States, retail bank runs have been exceedingly rare since the establishment of the Federal Deposit Insurance Corporation (FDIC) in 1933. The institutional framework – including deposit insurance, regulatory oversight, and access to Federal Reserve liquidity – has largely succeeded in eliminating panic-driven withdrawals at scale. Even in March 2023, when Silicon Valley Bank (SVB) experienced one of the fastest digital bank runs in US history, the event did not trigger a broader crisis. Authorities intervened decisively: all depositors were made whole, and systemic spillovers were contained. This outcome was possible because SVB was a regulated US bank with access to the Federal Reserve's discount window and the newly created Bank Term Funding Program.

Tether, by contrast, operates outside this institutional safety net. It is not subject to US bank regulation, has no direct access to central bank liquidity, and does not offer legal redemption rights to the public. To its credit, Tether claims that its tokens are fully backed by reserves, the majority of which are now held in short-term US Treasury securities – assets considered highly liquid and safe under normal market conditions. Proponents of cryptofinance often argue that stablecoins like USDT are more transparent than traditional financial institutions, since their token issuance and transfers are visible on-chain and reserve attestations are published regularly.

However, attestations are not full audits. An attestation merely confirms, at a specific point in time, that the issuer's stated reserves match its reported liabilities, based on information provided by the issuer. It does not independently verify the underlying legal claims, the quality or liquidity of specific assets, or the consistency of reserve practices over time. A full audit would involve more rigorous and continuous scrutiny, including testing for operational risk, legal enforceability, and off-balance-sheet exposure. These

structural gaps – combined with the absence of lender-of-last-resort support – may leave Tether vulnerable to run dynamics, especially if confidence in its reserve quality or redemption infrastructure were to deteriorate.

These concerns are not hypothetical. In May 2022, Tether briefly lost its peg, trading as low as $0.95 on major exchanges following the collapse of the TerraUSD stablecoin (see Figures 3 and 4). Although the peg was restored within days, the episode revealed the fragility of Tether's market-based redemption mechanism. During the depegging, smaller holders had no direct access to par redemption and were forced to sell into volatile secondary markets. Meanwhile, Tether reported processing several billion in redemptions – available only to large, verified institutions with direct accounts. This two-tiered structure, in which redemption privileges are not uniformly distributed, leaves most users dependent on arbitrage dynamics that can break down under pressure.

FIGURE 3 TETHER (USDT) DEPEG EVENT, MAY 2022

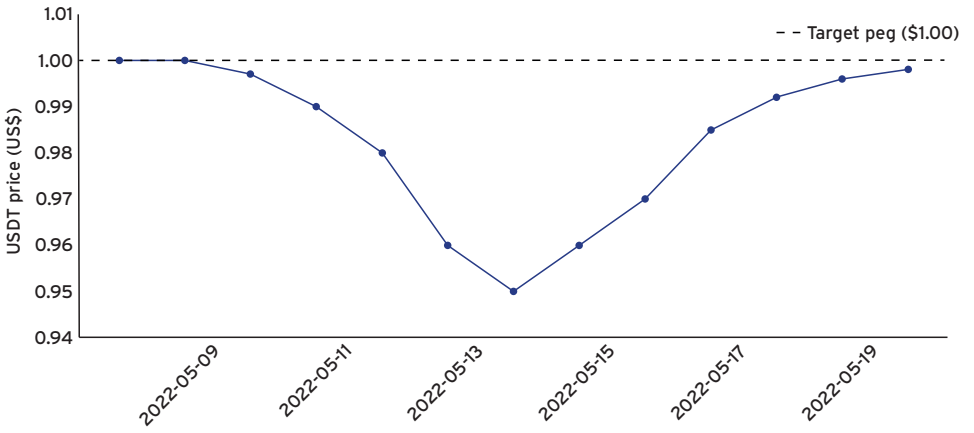
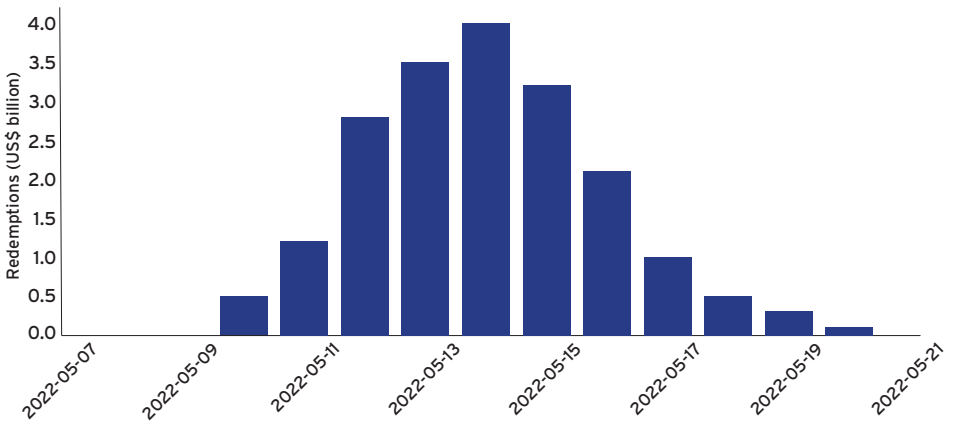


FIGURE 4 TETHER (USDT) ESTIMATED DAILY REDEMPTIONS, MAY 2022



The rapid recovery of the peg in that instance suggests that Tether's reserves were sufficiently liquid to meet institutional outflows. But the incident also underscored a key structural vulnerability: without guaranteed access to redemption for all holders, and without a regulated framework to enforce liquidity backstops, the question is whether confidence in Tether remains susceptible to sudden shifts in sentiment. Whether those shifts result in a temporary dislocation or a broader run depends not just on asset quality, but on governance, trust, and institutional safeguards – none of which is embedded in the current model.

TETHER'S BALANCE SHEET

Tether's big selling point is highlighted prominently on its website, which states that "[a]ll Tether tokens are pegged at 1-to-1 with a matching fiat currency and are backed 100% by Tether's Reserves. Information about Tether Tokens in circulation is typically published daily. The Tether Issuer's assets exceed its liabilities."

Is transparency and 100% backing of "reserves" sufficient to render Tether run-proof? It is of some interest to note that the canonical Diamond-Dybvig model of bank runs features banks with fully transparent balance sheets and perfectly safe (but illiquid) assets (Diamond and Dybvig 1983). Note that in the commercial banking system, "reserves" refers to the funds banks have deposited in their accounts with the Federal Reserve. Tether does not have access to Federal Reserve accounts.

To its credit, a large fraction of Tether's assets consists of "cash and cash equivalents", with over 80% of this category consisting of US Treasury Bills.[6]

According to Tether's website, roughly 20% of Tether's assets fall in the "relatively risky" category. And while Tether's liabilities fall short of its assets, its capital buffer is only just above 3%.

COUNTERPARTY RISK

What Tether's balance sheet does not reveal is its exposure to counterparty risk. Because Tether is not classified as a US person, it cannot hold US Treasury securities directly. Instead, it must employ the services of a custodian, in this case, Cantor Fitzgerald. And while it is tempting to assume that Tether's large holdings of US Treasury securities and its custodial relationship with Cantor Fitzgerald – an established primary dealer – offer robust protection against a run, such assumptions misunderstand the nature of financial panics.

6 See https://tether.to/en/transparency/?tab=reports

First, liquidity is not the same as immediacy. While short-term Treasuries are highly liquid in normal times, they may not be liquid in the volumes and speed required during mass redemptions. Markets can become one-sided, and even high-quality collateral may need to be sold at a discount if too many sellers appear at once. This dynamic was evident during the March 2020 dash for cash, when even Treasury markets briefly showed signs of strain.

Second, Cantor Fitzgerald's primary dealer status means it can participate in Federal Reserve open market operations – but only on its own behalf. Tether, as a client, has no direct access to the Fed's Standing Repo Facility or discount window. If Tether faces sudden redemption pressure, it must rely on Cantor or other intermediaries to convert assets to cash. These intermediaries, however, are not obligated to do so at par or on demand. In a crisis, they may prioritise their own liquidity needs.

Third, even if the assets are fundamentally sound, what matters in a run is belief. If market participants lose confidence that USDT tokens can be redeemed for full dollar value in a timely manner, they may rush to exit. The resulting surge in redemptions can overwhelm operational capacity, degrade liquidity in key markets, and cause a temporary break in the peg – even without any fundamental insolvency.

Finally, the interconnectedness of Tether with global crypto markets makes any disruption a source of systemic risk. Stablecoin arbitrage, DeFi collateral, cross-border payments, and centralised exchange settlements all rely on the assumption that USDT will hold its peg. A loss of confidence can therefore cascade through multiple layers of crypto-financial infrastructure, triggering broader instability.

In sum, Tether's assets may be high quality and its custodians reputable, but financial history shows that panic is often about coordination, not fundamentals. As with money market funds and shadow banking institutions before it, the key vulnerability lies in the mismatch between the liquidity of the liabilities (redeemable on short notice) and the liquidity of the assets (convertible, but not on short notice). No combination of balance sheet strength and brand-name custodianship can fully eliminate this risk.

POLICY IMPLICATIONS AND RECOMMENDATIONS

Why should US regulators care about Tether and Tether-like arrangements? From a financial stability perspective, the concern is the systemic risk these entities potentially present as they continue to grow. Large-scale redemption events that require an extraordinarily large liquidation of assets would almost surely disrupt US money markets and the commercial enterprises that depend on them.

Although Tether is incorporated offshore and operates outside the direct reach of US financial regulators, it nonetheless depends heavily on US financial infrastructure – most notably, through its use of Cantor Fitzgerald as custodian. This dependency offers a possible point of leverage. US regulators could pursue a policy path that uses Cantor

Fitzgerald's regulatory status and access to the Federal Reserve system to impose indirect discipline on Tether's operations. Several options exist, each with its own legal, institutional, and political complexities.

First, regulators could encourage or require Cantor Fitzgerald to act not only as a custodian but also as a fiduciary or trustee for Tether's reserves. This would impose a higher standard of care, potentially extending Cantor's obligations beyond Tether Ltd. to the token holders who rely on the integrity and liquidity of those reserves. In such a role, Cantor could be required to ensure that all assets are held in instruments fully under US jurisdiction – such as interest-bearing balances at the Federal Reserve.

Second, regulators might leverage Cantor's master account at the Fed. Tether's reserves, now reportedly held primarily in US Treasuries, could be converted into central bank liabilities via Cantor's balance sheet – either as overnight reverse repos or Fed account balances. This would effectively back Tether with central bank money, without granting Tether direct access to a master account. The structure would resemble that used by US government money market funds. While operationally straightforward, such a move may raise concerns about regulatory arbitrage or the perception that Tether is implicitly backstopped by the US government.

Third, to the extent that Cantor plays an active role in executing redemptions or managing flows, it may already be subject to obligations under existing financial laws, including the Bank Secrecy Act and associated AML/KYC requirements. The Treasury's Financial Crimes Enforcement Network (FinCEN) or the Securities and Exchange Commission (SEC) could use this legal basis to impose reporting, disclosure, and compliance standards. One possible step would be to designate custodians of large offshore stablecoins as systemically important financial institutions under Dodd-Frank, triggering enhanced oversight.

Finally, the Federal Reserve Bank of New York could exercise its authority over primary dealers like Cantor. Participation in open market operations and access to the Standing Repo Facility could be made conditional on adherence to reserve management or disclosure standards for custodial services provided to stablecoin issuers. This form of gatekeeping could be used to impose de facto regulatory constraints on Tether through its US-based intermediaries.

In short, while Tether remains outside the direct scope of US financial regulation, its reliance on US market infrastructure – particularly its custodian – creates a policy opportunity. By strengthening the role of Cantor Fitzgerald as a fiduciary and requiring reserves to be held in the form of central bank liabilities, regulators could tie an offshore dollar substitute more closely to the institutional framework of the US monetary system. This would not eliminate run risk, but it would substantially reduce it, without requiring Congress to act or the Federal Reserve to extend master accounts to foreign issuers.

REFERENCES

Aldasoro, I, M Aquilina, U Lewrick and S H Lim (2025), "Stablecoin growth – policy challenges and approaches", BIS Bulletin No. 108 (https://www.bis.org/publ/bisbull108.pdf).

Andolfatto, D (2024), "Technological Change and Central Banking", *Federal Reserve Bank of St. Louis Review* 106(1): 1-9 (https://www.stlouisfed.org/-/media/project/frbstl/stlouisfed/publications/review/pdfs/2024/01/05/technological-change-and-central-banking.pdf?sc_lang=en&hash=781F23450ADA811FC030EA2647357046).

Diamond, D W and P H Dybvig (1983), "Bank Runs, Deposit Insurance, and Liquidity", *Journal of Political Economy* 91(3): 401-419.

President's Working Group on Financial Markets, Federal Deposit Insurance Corporation and Office of the Comptroller of the Currency (2021), *Report on Stablecoins* (https://home.treasury.gov/system/files/136/StableCoinReport_Nov1_508.pdf).

ABOUT THE AUTHOR

David Andolfatto received his PhD in Economics in 1994 from the University of Western Ontario, London, Canada. A native of Vancouver, British Columbia, he began his academic career in Canada as a professor of economics. In 2009, he was awarded the Bank of Canada Fellowship Award for his contributions in the theory of money, banking, and monetary policy. In that same year, David left Canada to become Vice President, and then Senior Vice President, in the Research Division of the Federal Reserve Bank of St. Louis, where he served as a senior policy advisor for James Bullard, CEO and president of the Bank. He left the Fed in 2022 to become Chair of the Economics Department at the University of Miami Patti and Allan Herbert Business School.

CHAPTER 12

Multi-issuer stablecoins: A threat to financial stability

Richard Portes[1]
London Business School and CEPR

The multi-issuer model for stablecoins poses significant financial stability risks and regulatory challenges for the European Union. In such a model, an electronic money token (EMT) – a stablecoin – is jointly issued by both an EU-regulated institution and one or more third-country entities. This arrangement was not foreseen and not explicitly regulated under the EU legislation of 2023, Markets in Crypto-Assets Regulation (MiCAR), applicable from mid-2024. There are thus substantial ambiguities, which issuers can exploit. These stablecoins – deemed fungible across jurisdictions – facilitate regulatory arbitrage, fragment reserve management, and potentially expose EU issuers and their banking partners to systemic stress, redemption runs, and contagion. Hence, regulatory reforms are needed urgently. The urgency is heightened by the passage of the American stablecoin-enabling GENIUS Act in July 2025.

This chapter provide a framework for understanding and mitigating the multi-issuer stablecoin loophole – a gap which, if left unaddressed, could have far-reaching consequences for EU financial stability and investor protection. It advocates prompt legal and supervisory adaptation to ensure MiCAR meets the realities of a globalised crypto-finance landscape. It first explains the model and the regulatory background, then provide a technical and legal risk assessment. It highlights the need for a robust EU-level regulatory and supervisory response, bespoke prudential standards, explicit cross-border arrangements, and greater harmonisation at the global level.

THE MULTI-ISSUER MODEL AND ITS RISKS

Stablecoins are crypto-assets designed to maintain a stable value by reference to an official currency or a basket of assets. The design is not entirely robust: there are multiple instances in which key stablecoins have 'broken' their pegs under stress; and there is significant everyday volatility for the major stablecoins, USDT (not an EMT under MiCAR) and USDC, around the 1 US dollar peg. In the European Union, the regulation

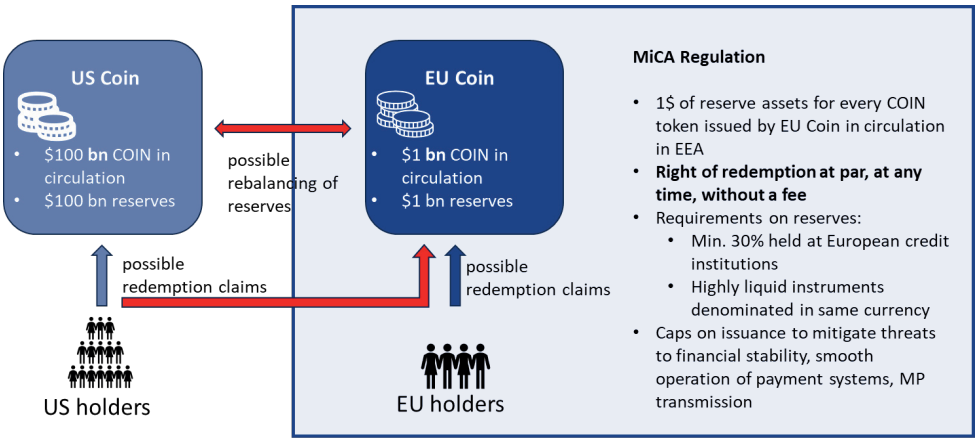
1 The author is Co-Chair of European Systemic Risk Board Crypto Asset Task Force. Views expressed here are personal and not those of the Task Force, which will report soon. I am grateful for exchanges with Yvan Dubravica, Adam Glogowski, Steffen Kern, and Elisabeth Noble on these issues. This essay extends the analysis in "The stablecoin loophole that could expose the EU", Financial Times, 24 July 2025.

of stablecoins (asset-referenced tokens (ARTs) and EMTs) – is governed primarily by MiCAR, recently introduced as a comprehensive regime to ensure investor protection, market integrity, and financial stability.

A multi-issuer arrangement arises when an EMT or ART is issued in multiple jurisdictions by different legal entities with the same controlling interest – for example, a European subsidiary and a US parent or affiliate issuing 'the same' token. These tokens are treated by the issuer and the holders as interchangeable (fungible), regardless of the regulatory framework.

For intra-EU issuance, joint liability is clear and fully subject to rules under MiCAR. In a cross-border framework, with issuance in the European Union and a third country, the fungibility of tokens muddles accountability, as EU entities may be held responsible for redemptions originally undertaken by non-EU affiliates, over which they have neither legal nor operational control (see Figure 1).

FIGURE 1 ILLUSTRATIVE EXAMPLE OF EU AND THIRD COUNTRY STABLECOIN MULTI-ISSUER APPLIED TO EU AND US



Note: The diagram conceptualises the flow of reserves and redemption claims between an EU and a US stablecoin issuer. It highlights how tokens can move and be redeemed in either jurisdiction, while underlying reserves remain subject to two regulatory and supervisory silos, increasing the risk of misalignment in crises.

Source: ESRB Crypto Asset Task Force Report, forthcoming.

MiCAR sets specific obligations for ARTs and EMTs jointly issued only by EU-established entities, such as a single reserve (Art. 36(5)), joint custody (Art. 37(2)), and coordinated redemption, recovery, and resolution plans. But there is no explicit provision in MiCAR for third-country cross-border co-issuance, although issuers market multi-issuer stablecoin (MISC) tokens as fully fungible, regardless of the original jurisdiction.

This model poses significant prudential and regulatory issues. First, the reserves backing the stablecoin are fragmented. When the same stablecoin is issued by both EU and non-EU entities, reserve assets are split and managed under different regulatory regimes, with no guarantee the reserves held in the third country will be available for

attempted redemptions in the European Union in stress episodes. EU law requires prompt, cost-free redemption at par by EU issuers. But the third-country issuer may apply fees or delays. And in a crisis, the third-country authorities might 'ringfence' (withhold) locally held reserves, jeopardising redemptions in the European Union. This national ringfencing of liquidity was observed within the European Union itself during the crises of autumn 2008 and spring 2020, despite the supposedly ironclad legal prohibition of capital flow barriers within the EU.

The MISC model therefore raises major macroprudential issues. First, there would be clear incentives to run in a stress episode. Regulatory arbitrage enables stablecoin holders to redeem preferentially in the jurisdiction offering the most favourable terms, in this case the European Union. This increases the likelihood of a run, especially if holders (correctly) perceive the inadequacy of EU-held reserves to meet redemptions. Second, there might be contagion to and across banks. If a run on an EU stablecoin issuer occurs, and the issuer is a credit institution, direct contagion may affect the bank. For e-money institutions, large reserves requirements (e.g., 30% or 60% deposited with EU banks for non/significant issuers) mean that redemptions could strain the liquidity positions of associated banks, especially those with concentrated exposure to crypto-asset players. The risk is heightened by the likely development of 'crypto-friendly' banks: with no overall cap on the aggregate stablecoin-related liability any one bank can have, the rise of banks heavily reliant on crypto sector funding is likely, amplifying systemic risk. The fragility of this funding and the consequent systemic risk were observed in the US mini-crisis of March 2023 (Silicon Valley Bank, Signature Bank, Silvergate Bank), which required major intervention by the federal authorities (Admati and Portes 2023).

There is a significant likelihood of circumvention of EU safeguards and regulatory arbitrage. Foreign-issued tokens under a multi-issuer arrangement may exploit favourable EU rules (e.g., par redemption, absence of fees, market prominence), while not being subject to EU-level reserves, risk management, or supervisory scrutiny. The risk is exacerbated by the difficulty of tracking the effective volumes of tokens in circulation within the European Union and abroad, especially for those held in off-chain wallets. Thus, requirements designed to mitigate financial stability and policy risks (e.g., issuance caps for foreign currency EMTs, enhanced oversight at critical thresholds) become difficult to uphold. Note that there is an incentive to hold stablecoins in the United States: although the GENIUS Act prohibits paying interest on stablecoins, there is a way around this via crypto-asset service providers, which can hold the stablecoins and pay interest to the owner.

The MISC scheme does not provide the necessary investor protection, one of the main objectives of MiCAR. Investors may be led to believe an 'EU-branded' stablecoin carries full EU protections when part of the token stock is issued outside the European Union and not subject to MiCAR. Moreover, supervisory reach is limited, especially because

EU supervisors lack control over third-country assets or operations yet may have to take actions with respect to redemptions from holders who have acquired tokens from third-country issuers. This is a sharp deviation from standards in classical banking regulation.

EU regulators have no control over the marketing practices of third-country issuers, which might misrepresent redemption arrangements and links to the EU-based issuer. That then poses reputational risks for the EU authorities. The model sets a precedent for non-EU issuers to access the EU Single Market while evading regulatory obligations, making the EU vulnerable to international regulatory arbitrage. While EU supervisors cannot oversee non-EU risk management, they would de facto be tasked with maintaining the solvency and liquidity of all tokens, a legal and prudential stretch never tolerated in the traditional cross-border banking world.

We can elaborate on reserve allocation and the operational hurdles to running a MISC scheme.

First, the rebalancing mechanism. For the system to work, reserve assets must be transferable in both directions between the EU and non-EU issuers to fulfil redemptions as they arise. This is only as effective as the underlying legal and operational frameworks and the ability to move funds promptly – often unreliable, especially under stress or intervention. Where reserves are invested in third-country money market funds, as permitted under the GENIUS Act, redemption can be frozen by local authorities, further weakening the reliability of cross-border pools. The most acute risk, therefore, is having a liquidity shortfall locally due to operational, legal, or market blockages in moving assets cross-border.

Second, we lack reliable data on where tokens are held, due to the prevalence of self-hosted wallets (44% for Circle USDC as of February 2025) and limited reporting from non-EU crypto providers. This leads to large judgement calls in stress testing and risk modelling for EU supervisors. The actual exposure of the EU issuer is unknown; estimates of 'EU-circulating' supply are only lower bounds, reducing confidence in reserve adequacy and crisis planning. Limited knowledge of self- or omnibus wallet holders means redemption behaviour is unpredictable, raising the risk of unanticipated runs. Arbitrage opportunities would arise if the coin were trading below par in one jurisdiction and could be redeemed at par and for free in the European Union, inviting profit-seeking redemptions during even minor price declines – a classic 'run' scenario. The MiCAR ban on redemption fees amplifies this incentive.

Third, there are custody risks. Inadequate business continuity protocols and fragmented custodial arrangements increase operational shortcomings.

LEGAL AND SUPERVISORY CONSIDERATIONS

MiCAR grants national competent authorities latitude under Article 35 (own funds requirements), Article 45(4) (liquidity enhancements post-stress testing), and Article 94(1)v (broad preventive powers), enabling strengthened buffers for at-risk institutions. For cross-border multi-issuer schemes, increases to own funds requirements would have legal precedent – for example, a 20% uplift for non-significant issuers and a 20–40% increase for significant ones, based on stress test findings, risk outlook, and redemption guarantees.

The European Banking Authority (EBA) can take into account considerations relating to multi-issuance in the context of significance assessments – significant EMTs/ARTs being subject to EU-level oversight, which facilitates cross-border coordination and a level playing field. But classification is hindered by incomplete or contested data about token distribution and reporting inadequacies by crypto-asset service providers (CASPs). Still, supervisors may revoke authorisations, impose redemption fees, or limit redemptions in emergency, provided they meet the MiCAR flexibility requirements.

POLICY OPTIONS AND RECOMMENDATIONS

There is a wide range of policy options available to the EU authorities for dealing with the specific risks posed by MISCs. The first would simply be to ban them. Against this, there has been considerable lobbying pressure in Brussels from well-funded issuers. But some key members of the European Parliament have resisted and have written to Commissioner Albuquerque setting out their concerns. And President Lagarde of the ECB has forcefully expressed her opposition to MISCs.2 At the time of writing, the European Commission had not set out its final position.

If the Commission deems that under existing legislation, MISCs are permissible, then they could propose amendments to MiCAR to cover multi-issuer schemes explicitly and lay out a framework for cross-jurisdiction equivalence, reciprocity, and asset ringfencing protections.

Meanwhile, macroprudential authorities should intensify scrutiny and systemic risk analysis of multi-issuer schemes. The authorities could require EU stablecoin issuers engaged in multi-issuer arrangements to set high minimum denomination amounts, or limit issuance if the ECB identifies payment systems or monetary policy risks. They could impose higher own-funds or stricter liquidity requirements based on stress-testing outcomes whenever reserve sufficiency is in doubt.

Enhanced disclosure obligations for issuers would be desirable, with the European Securities Markets Authority (ESMA) providing whitepaper disclosure templates detailing the structure, risks, and reserve-management specifics of any multi-issuer

2 See https://www.ecb.europa.eu/press/key/date/2025/html/ecb.sp250903~10647505c7.en.html

token. These should be strengthened, with harmonised reporting standards for CASPs and issuers, both inside and outside the European Union, to map accurate token distribution and calibrate policy.

Ideally, the authorities should develop enforceable global regulatory standards in coordination with Financial Stability Board (FSB) guidance and robust cooperation agreements to ensure liquidity flows and consistent application of prudential rules, even during crises. And within the European Union, national competent authorities (NCAs) should coordinate, but not in a decentralised way – an EU-level approach is judicially and practically more robust. Decentralised equivalence assessments (by each NCA) create the risk of fragmentation, a practice the European Commission would not tolerate in other areas of financial regulation. The EBA or ESMA should lead here.

The multi-issuer model introduces critical vulnerabilities into the EU financial system, undermines MiCAR's Single Market protections, and exposes EU issuers to liabilities and operational risks beyond their control. Systemic risks include investor runs, bank contagion, loss of monetary policy sovereignty, and undermined regulatory credibility. Immediate regulatory action at both EU and global levels is necessary, with legal clarification of multi-issuance, harmonised prudential tools, robust cooperation arrangements, and enhanced crisis management protocols.

REFERENCES

Admati, H and R Portes (2023), "When will they ever learn? The US banking crisis of 2023", VoxEU.org, 18 May (https://cepr.org/voxeu/columns/when-will-they-ever-learn-us-banking-crisis-2023).

ABOUT THE AUTHOR

Richard Portes, Professor of Economics at London Business School, is Founder and Honorary President of the Centre for Economic Policy Research (CEPR) and Co-Founder of Economic Policy. He is an elected Fellow of the Econometric Society and the British Academy. He has been Chair of the European Systemic Risk Board Advisory Scientific Committee, remains a member, and is Co-Chair of both the ESRB Joint Expert Group on Non-bank Financial Intermediation and the ESRB Crypto Assets Task Force. He is a founder member of the Bellagio Group on the International Economy and the Euro50 Group. He is Academic Director of the AQR Asset Management Institute at LBS. Professor Portes was a Rhodes Scholar and Official Fellow of Balliol College, Oxford (now an Honorary Fellow). He has taught at Princeton and Birkbeck College (University of London). He was the inaugural holder of the Tommaso Padoa-Schioppa Chair at the European University Institute (2014–17) and Distinguished Global Visiting Professor at Haas Business School, UC Berkeley, and Joel Stern Visiting Professor at Columbia

Business School. He holds three honorary doctorates. He has written extensively on sovereign borrowing, European monetary issues, financial markets, macroprudential regulation, and international capital flows.

CHAPTER 13

Stablecoins, central bank digital currencies, and policy

Harald Uhlig
University of Chicago and CEPR

The European Central Bank is pushing forward with establishing a central bank digital currency (CBDC) – a form of digital money issued by the central bank and available to everyone who wishes to hold it. One may view this as one step in keeping up with technological developments, complementing the ancient and traditional form of money as paper with an up-to-date digital version. It may allow competition with electronic payment systems such as the US-based Visa and Mastercard, as well as providing 'financial inclusion' for people currently excluded from the banking system and the world of digital payments. The United States has embarked on a different path, ruling out issuing a CBDC and encouraging the development of stablecoins instead. The GENIUS Act became law on 18 July 2025, setting up a regulatory framework for issuing and maintaining a stablecoin. The different approach in the United States may be due to a greater trust in markets in providing stable digital currencies, if so desired by the public, and a greater concern over the potential privacy hazards arising out of a government entity such as the central bank being directly involved in the payment system. In Uhlig et al. (2023), my co-authors and I discuss the tricky trade-offs arising here and for digital currencies in general. Many other central banks are actively pursuing one, or both, of the two approaches; this is not the place to review these developments.

While there are many differences in the detail, and while the technical issues can be daunting, there are also key common challenges. Both the United States and the euro area have in common that a CBDC or a stablecoin should not be allowed to pay interest. While CBDCs are directly a liability of the central bank and while the asset side of stablecoin issuers is trickier, one should not be surprised to see the latter ultimately be backed by the central bank itself. From a financial system and a macroeconomic perspective, then, there are more similarities than differences. What are the implications for monetary policy? What are the implications for financial stability? And what are the implications for international relations? My aim here is to shed light on these common issues arising. In my discussion, I will focus more on stablecoins than on CBDCs due to the additional challenges arising there, but much can be seen as applying directly to CBDCs as well. For my discussion, I will be drawing on insights provided in various publications, starting with Schilling and Uhlig (2019) as far as my own contributions are concerned. In Uhlig (2024), I provide a survey and introduction.

STABLECOINS AND NARROW BANKING

A stablecoin can be thought of as akin to a narrow bank with additional functionality of its deposit accounts. This has profound implications. A narrow bank is a bank that only holds liquid and safe government liabilities as assets. Properly supervised narrow banks should, in principle, be attractive additions to the financial landscape, as their deposits are safe and as traditional bank runs, where the conversion of deposits into cash is called into question, can no longer happen. The safest form of government assets are central bank reserves. Thus, a particularly safe and particularly narrow bank is one that backs its deposit base one-for-one with reserves at the central bank. Reserve holdings by banks at the central bank are remunerated with the interest on reserves, which is a key tool of central bank policy. A narrow bank could therefore pay interest on its deposits at nearly the same rate, with the difference helping to finance operational expenditures. Healthy competition between narrow banks should lead to this outcome, since narrow banks that do not pay interest on deposits will lose out against competitors that do.

Regardless of whether narrow banks pay interest or not, the business model itself – i.e. the ability of a financial institution to deposit reserves at the central bank and receive interest – rests on the Federal Reserve granting it a master account. This has been tried by an institution that was properly called The Narrow Bank (TNB). In February 2024, the Federal Reserve denied The Narrow Bank's application for a master account six years after it applied, stating that it would "*pose undue risk to the stability of the US financial system and would adversely affect [the Fed's] ability to implement monetary policy*".[1] This happened despite the excellent arguments and ringing endorsement in 2018 by John Cochrane (Cochrane, 2018). It is possible that the denial was based on technical details such as proper regulation or deposit insurance – matters which should be easy to fix. More likely, the Federal Reserve did not like the business model per se, seeing it as just a means of arbitraging between interest-free cash and interest-bearing reserves, fearing it may erode and disrupt traditional banking or that households would then in practice be able to earn interest on reserves, which is meant for financial institutions only rather than cash-like instruments, or fearing the resulting constraints on monetary policy.

Whatever the reasons, this is a conundrum for the development of stablecoins. If one wants genuinely stable stablecoins, a construction akin to that of The Narrow Bank is ideal: they should be fully backed by reserves, be granted a Federal Reserve master account, and should be able to pay interest. As with The Narrow Bank, the Federal Reserve will be concerned about the implications listed above. If so, we ask that these concerns be spelled out more clearly. Unfortunately, the GENIUS Act has not gone down this route and instead asks stablecoin issuers to generally hold highly liquid and secure

1 "Fed denies TNB master account after 6 years", BankingDive, 27 February 2024 (https://www.bankingdive.com/news/fed-denies-tnb-master-account-after-six-years/708648/)

assets. A master account will not be easily granted. While stablecoins issued by banks with such a master account may hold balances at Federal Reserve banks, stablecoin issuers generally will hold physical US dollars, short-term US government debt such as Treasury bills, notes, or bonds with a maturity of 93 days or less as well as overnight repurchase and reverse repurchase agreements collateralised by US government securities. They may also hold shares in registered government money market funds that invest in these types of assets or demand deposits at institutions insured by the Federal Deposit Insurance Corporation (FDIC). The crash of Silicon Valley Bank in March 2023 and the resulting temporary de-pegging of the USDC stablecoin due to its issuer Circle holding about 8% of its reserves at SVB should give anyone pause in thinking that the latter will be a robust construction.[2] The money market mayhem in September 2008, when the Reserve Primary Fund 'broke the buck', implies that holding shares in money market funds will not be a robust stable solution either.

The resistance against stablecoins holding master accounts and backing up their liabilities with reserves at the central bank means that it is the legislation itself that will make stablecoins "fragile by design" (Calomiris-Haber 2014). This strikes me as genuinely paradoxical. If stablecoins are meant to thrive, then the most stable arrangements should be applauded and supported, not met with additional regulatory roadblocks. This needs resolution. Most optimistically, perhaps competition between stablecoins will lead to the surviving stablecoins being those issued by banks with master accounts and backed by reserves at the central bank, though it is hard to see why competition should lead to such an outcome. At least, algorithmic stablecoins such as the Terra-Luna system have been ruled out.[3]

INTEREST ON STABLECOINS AND CBDCS

The reasoning above applies too to the matter of paying interest on stablecoins, which healthy competition between stablecoins should achieve, but which is ruled out by the GENIUS Act. The debate in the US parallels the debate on paying interest on central bank digital currency in the European Monetary Union, which also rules out paying interest on retail CBDC. Nonetheless, both the Federal Reserve and the ECB will happily continue to pay interest on CBDCs held by banks, i.e. on bank reserves held at the central banks. This is a remarkable imbalance which will likely be politicised in the future, possibly with bad repercussions for banks and the central bank. But how did we get here?

Policymakers have largely concluded that they want central bank digital currency to be nothing but a digital version of cash. Since cash does not pay interest, goes the reasoning, central bank digital currency should not either. This is likely to avoid direct competition with traditional banking and the pressure of the banking lobby. For the

2 See Arfaoui and Uhlig (2025) for an analysis of the SVB bank run.
3 The crash of the Terra-Luna system in 2022 is analysed in Uhlig (2022).

same reason, there will be limits on the amounts anyone can hold, both of stablecoins as well as CBDCs. Privately issued stablecoins with master accounts at the central bank would undermine that, since they are as good as or even better than central bank digital currency, will pay interest, given healthy competition, and will ultimately be hard to constrain in terms of private balances held. Policymakers will therefore likely resist that outcome. But that strikes me as strange. Why should taxpayers pay interest on reserves held by banks but be excluded from earning interest on reserves that they hold themselves? Why should digital money be handicapped to make it just a digital version of physical money, an old technology, rather than allowing for the possibilities of a new technology? Why should traditional banks be safeguarded against the forces of creative destruction? Without clear answers, I argue that it should be possible to pay interest on stablecoins as well as on central bank digital currency, and that the interest should be close to the interest on reserves, modulo considerations for operating expenses, just as healthy competition would imply.

With the introduction of stablecoins and CBDCs, a substantial step towards a world of competing currencies as envisioned in Hayek (1990) and analysed in Fernández-Villaverde and Daniel Sanches (2019) will have been taken, and further developments will surely follow.

IMPLICATIONS FOR FINANCIAL STABILITY AND MONETARY POLICY

Privately issued stablecoins are likely to have additional advantages compared to central bank digital currencies, allowing for features such as setting up recurrent payments, smart contracts, or tokenisation of other assets. The competitive landscape may result in a range of solutions and ongoing developments, to be sorted out by discerning customers. As a result, and together with the interest they can pay, they may indeed become attractive alternatives to deposits and conventional banking not only at home, but also abroad or for international payments. Not only would this disrupt conventional banking, it may also have implications beyond the currency area of its denomination. In Benigno et al. (2022), my authors and I argue that the existence of an internationally circulating stablecoin, which is a perfect substitute for local currencies for the purpose of making payments, will lead to 'crypto-enforced monetary policy synchronisation' (CEMPS), upending the independence of central banks from US monetary policy, lest they risk their currency ceasing to be used as a means of payment. In Uhlig and Xie (2020), the challenges arising to monetary policy when a parallel digital currency becomes a unit of account for pricing a segment of the goods are analysed. It is therefore likely that the vigorous development of dollar-based stablecoins in the United States will lead to strains in international relations that would need to be addressed in a thoughtful manner. We believe this can be done, but it may end up giving the dollar an even more prominent role as international reserve currency.

Finally, the absence of traditional bank runs in a world where only fully reserve-backed stablecoins or, similarly, only central bank digital currencies rather than traditional bank deposit accounts exist does not imply the absence of 'runs' understood more broadly. As Brunnermeier and Niepelt (2019) have pointed out, the various monetary systems emerging in the future may be equivalent fundamentally to the traditional system. Thus, the tension arising from maturity transformation will not disappear when deposit accounts are replaced with stablecoins and central bank digital currencies – it may just move elsewhere. A traditional bank run is a run away from something the bank has, or can easily issue ('deposits'), to something that the bank does not have or cannot easily generate ('cash'). Likewise, a run on a system of reserve-backed stable coins or, equivalently, a run on central bank digital currencies would not be a run away from these assets to something that the central bank can easily produce ('cash'), but rather to something that the central bank cannot produce (i.e., real resources). Such runs are familiar from hyperinflations, where trust in the means of payment erodes, or from stockouts during the 2020 pandemic. Schilling et al. (2024) study such runs and argue that they put a central bank in a trilemma: "*it can only achieve two of three objectives: a socially efficient allocation, financial stability (i.e., absence of runs), and price stability*" (taken from the abstract to their paper). Their scenario may envision a world far in the future, where stablecoins and central bank digital currencies have become remarkably successful. But even if that point is never reached, their analysis is a useful reminder that stablecoins and central bank digital currencies represent technological progress, but not a solution to the fundamental tension between maturity transformation and the need for liquidity.

These warnings must be kept in mind.

CONCLUSIONS

Stablecoins in the United States and a central bank digital currency in the euro area will form part of our future. These will lead to disruptions and challenges for the financial system and monetary policy – small at first, but with the potential to become large if stablecoins and CBDCs become as successful as I hope they will be. While challenges will arise and need to be addressed, as discussed here and elsewhere, these changes should be welcomed and embraced. As Schumpeter (1942, p. 83) pointed out, creative destruction moves us forward and is the source of our wealth. This is no different.

REFERENCES

Arfaoui, J and H Uhlig (2025), "Maturity Risks and Bank Runs", Becker Friedman Institute for Economics Working Paper No. 2025-86.

Benigno, P, L Schilling and H Uhlig (2022), "Cryptocurrencies, currency competition, and the impossible trinity", *Journal of International Economics* 136(C).

Brunnermeier, M K and D Niepelt (2019), "On the equivalence of private and public money", *Journal of Monetary Economics* 106(C): 27-41.

Calomiris, C W and S H Haber (2014), *Fragile by Design: The Political Origins of Banking Crises and Scarce Credit*, Princeton University Press.

Cochrane, J (2018), "The Safest Bank the Fed Won't Sanction", *Chicago Booth Review*, 30 November.

Fernández-Villaverde, J and D Sanches (2019), "Can Currency Competition Work?", *Journal of Monetary Economics* 106: 1-15.

Hayek, F A (1990), *Denationalisation of Money: The Argument Refined: An Analysis of the Theory and Practice of Concurrent Currencies*, Vol. 70, Institute of Economic Affairs.

Schilling, L and H Uhlig (2019), "Some simple bitcoin economics", *Journal of Monetary Economics* 106: 16-26.

Schilling, L, J Fernández-Villaverde and H Uhlig (2024), "Central bank digital currency: When price and bank stability collide", *Journal of Monetary Economics* 145(C).

Schumpeter, J A (1942), *Capitalism, Socialism, and Democracy*, Harper Torchbooks.

Uhlig, H (2022), "A Luna-tic Stablecoin Crash", CEPR Discussion Paper No. 17465.

Uhlig, H (2024), "On Digital Currencies", *Atlantic Economic Journal* 52(1): 1-14.

Uhlig, H, M Alonso and J Frost (2023), "Privacy in Digital Payments—Escaping the Panopticon", *Georgetown Journal of International Affairs* 24(2): 174-180.

Uhlig, H. and T. Xie (2020), "Parallel Digital Currencies and Sticky Prices", CEPR Discussion Paper No. 15619.

ABOUT THE AUTHOR

Harald Uhlig is the Bruce Allen and Barbara Ritzenthaler Professor in Economics and the College in the Kenneth C. Griffin Department of Economics at the University of Chicago. Uhlig has been a member of the Economics department since 2007 and was the department chairman from 2009 to 2012. Previously, he held positions at Princeton University, Tilburg University, and Humboldt-Universität zu Berlin. Professor Uhlig's research interests are in macroeconomics, financial markets, and Bayesian econometrics, particularly at the intersection of these three. Uhlig served as co-editor of Econometrica from 2006 to 2010 and as managing editor of the Journal of Political Economy from 2013 to 2021. Uhlig chaired the CEPR European Business Cycle Dating Committee from 2005 to 2012. He is a Research Fellow of CEPR and a Research Associate of the National Bureau of Economic Research. He received his PhD in Economics from the University of Minnesota in 1990.

PART III
MONETARY SINGLENESS

CHAPTER 14

Singleness of money: Towards a nuanced debate

Rhys Bidder[1]
King's College London

> *Under this [singleness] principle, all different forms of money - whether we hold them in bank accounts, notes, or coins etc- must be exchangeable with each other at par value. In other words, the value of a pound in an individual's bank account must equal the pound coin in another individual's pocket.... Singleness is crucial to monetary and financial stability for a number of reasons: First, households and businesses can be assured that all money in the economy has the same value at all times. This underpins trust and confidence in money. Second, there is an unambiguous unit of account that underpins all economic transactions in society.*
> Bank of England (2024)

INTRODUCTION

With the advent of blockchain and the emergence of novel forms of money (central bank digital currencies, cryptocurrencies, stablecoins, deposit tokens, etc.), many fundamental questions about monetary systems are being asked anew. In this chapter, I discuss a concept that has come to be known as the 'singleness of money' – the idea that moneys circulating within a currency area should always be at, or close to, par with the unit of account, which is typically taken to be defined by central bank money (cash and reserves).[2] 'Singleness' has become something of a rallying cry among those opposed to stablecoins. However, even proponents have expressed concerns over deviations from their pegs.

My central argument is that a more nuanced debate is required. It is far from obvious that the small, noisy deviations from singleness so far observed in 'normal times' are as concerning as various central banks and regulatory authorities have claimed. It is also plausible that the magnitude of these deviations will decline in the future. However, the large deviations seen in times of stress are far more troubling and more difficult to solve.

1 An expanded version of this chapter is available to download at https://sites.google.com/view/rhysbidder/commentary.
2 This analysis will focus almost exclusively on fiat-collateralised stablecoins, which are typically issued by a single company and hold reserves of assets like cash, high-quality liquid assets (HQLA), and bank deposits. My focus is on coins akin to USDC and USDT, which are currently the two dominant stablecoins circulating globally.

Given the potentially devastating effects of large de-pegs, it is difficult to argue that stablecoins can reliably operate as effective money at a systemic scale until this risk is dramatically reduced. If stablecoins operate with a narrow balance sheet, however, there appears to be scope for this outcome, particularly if global lender of last resort (LOLR) safeguards are developed. This will, however, require a level of regulatory and policy coordination that has so far not been forthcoming.

SINGLENESS IN THE TRADITIONAL TWO-TIER SYSTEM

Under the existing two-tier monetary system, a central bank issues reserves and cash, while fractionally backed commercial banks create money in the form of deposits. These depository institutions are heavily regulated due to their fractional backing and systemic role in the economy. A critical piece of public infrastructure in this system is the central bank's operation of real-time gross settlement (RTGS) systems, which enable interbank settlement in a credit- and liquidity-risk-free money (reserves).

Transactions between depositors at different banks are technically settled through transactions between the banks themselves in reserves. Traditionally, as retail customers transact during the day, a clearing system tracks and nets the various exposures that arise among banks. Towards the end of the day, banks must have sufficient reserves to make good on these positions, at which point the full settlement process is complete.[3]

In systems with deferred final settlement, there is a theoretical risk that a bank may not have adequate reserves to settle its obligations at the end of the day. This could result from poor liquidity management, systemic liquidity stresses, or simply bad luck, such as a surprisingly large depositor outflow late in the day. When a bank cannot borrow adequate reserves privately, it may resort to liquidity from the central bank. Central banks provide various forms of support to promote both the *liquidity* and *solvency* of money issuers. They offer a suite of liquidity facilities within RTGS systems – intraday, overnight, and nonstandard/emergency – to ensure that a solvent bank with adequate collateral will 'always' be able to settle its payments (Arseneau et al. 2025).[4]

The implications of this are powerful. Consider traditional retail payments with bank deposits. No bank need tell its merchants to discount the moneys of other banks when selling their goods, as it knows that when it credits the merchant's balance in its money, it will by end of day receive the corresponding amount of reserves from the customer's bank. And the customer's bank will debit the customer's balance in *its* money. Note that

3 Note that in recent years, as instant payment systems have become more prevalent, an increasing fraction of retail payments are settled immediately, transaction-by-transaction, in RTGS systems.

4 This emergency liquidity is typically secured and provided on somewhat punitive terms to incentivise market participants to manage their own liquidity competently, a principle dating back to Bagehot (1873).

three moneys are involved (customer bank's money, merchant bank's money, reserves), recorded on three ledgers (customer bank's database, merchant bank's database, central bank's ledger), which collectively enable one overarching payment *process*.[5]

This process essentially hardwires singleness of money – one of the great strengths of the 'traditional' financial system (and one that would be inherited in the case of deposit tokens). As a result (this is not a primitive), various auxiliary systems in the payments stack can safely impose singleness at the point of retail interactions. For example, point-of-sale (PoS) systems and payment processors typically don't even provide the option to discount different banks' moneys. This technical manifestation of '*no questions asked*' (Holmstrom 2015) would break down if settlement between solvent banks were not ensured. This is why the huge amount of public infrastructure and policy support provided to banks (including liquidity support in RTGS systems) are key to maintaining singleness in the current system.

STABLECOINS AND THE CHALLENGE TO SINGLENESS

As bearer assets, where settlement is identified with the exchange of the asset itself, payment with stablecoins is very different from the process in the two-tier system. If a customer has USDC and a merchant is prepared to accept it, payment can occur through a simple transfer call on the USDC smart contract. Economically, this is much like a closed-loop 'on us' settlement between depositors at the same bank.

Now consider a merchant who does not accept USDC but does accept USDT. A single atomic transaction can be constructed that combines a call to an automated market maker (AMM) – like Uniswap or Curve – to exchange the customer's USDC for USDT and then transfer that USDT to the merchant. This exchange involving multiple issuers' stablecoins does not use an RTGS system for secondary market settlement, which has important implications for both singleness and the potential for efficient cross-border payments that avoid the correspondent banking system.

AMMs are decentralised exchanges where one sends a token to a smart contract and receives another in return. The exchange rate is determined by a mathematical formula, typically dependent on the relative amounts of the two tokens locked within the smart contract by 'liquidity providers'. This design means that the implicit price can deviate from par. For instance, the balances of the coins might be such that one has a price above one dollar while the other has a price below. Even if the balance implies a par price for infinitesimal trades, a large trade will result in an execution price that deviates from par.

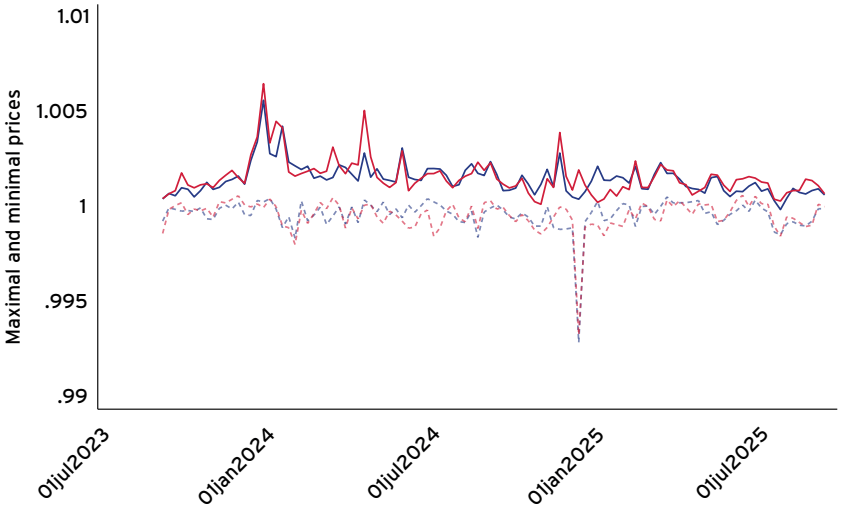
5 In the case of instant payment systems, the availability of intraday credit allows banks to economize on how much (low yielding) liquidity it holds as buffer to allow payments to settle reliably with acceptably high probability.

A simplistic arbitrage argument suggests that this common price 'should' be $1, assuming coins can be issued and redeemed at par with a credible issuer. We 'should' attain singleness. But this is very different from the hardwiring of singleness in the traditional system. In fact, stablecoins do not offer the singleness to which we are accustomed. Garratt and Shin (2023) express this well:

The fact that tokens circulate as transferable issuer liabilities render them financial assets with a prevailing market price. In general, any asset that can be traded will have an exchange rate and this exchange rate can fluctuate away from par for various reasons.

Accordingly, Figure 1 shows the weekly maximum and minimum prices for USDC and USDT over a two-year period. During this relatively calm period, we observe continual, albeit extremely small, deviations from par in both coins.

FIGURE 1 WEEKLY MAXIMUM AND MINIMUM OF MINUTE-BY-MINUTE USDT AND USDC PRICES RECORDED IN DUNE.COM'S PRICES.MINUTE TABLE.



Note: Solid lines = maximum; dashed lines =minimum; blue = USDC; red = USDT.
Source: Draws on CoinPaprika pricing data for 2 September 2023 to 2 September 2025

ARE THESE DEVIATIONS FROM SINGLENESS PROBLEMATIC?

The existence of these small price fluctuations begs a critical question: are they truly a problem? It is very hard to argue that small amounts of noise – say, fluctuations between $0.999 and $1.001 – are per se likely to cause substantial losses or disastrously hinder commerce, certainly when compared to the various other frictions and costs in traditional payment systems. The exchange rate variation known to be an obstacle to international trade is orders of magnitude larger.

Furthermore, it is likely that business models will emerge to insulate retail users from these high-frequency fluctuations. For example, a card company using stablecoin rails is not going to let a $100 transaction fail because the user's 100 USDC momentarily drops in value to $99.999. This could promote the emergence of a 'no questions asked' property for a broad class of users. For sophisticated agents like corporate treasurers, minor price variation can be handled using derivatives or self-insurance.

Nevertheless, one must ask whether all deviations from par should be considered equal. There could be various drivers of fluctuations around the stablecoin peg. In Morris and Shin (2012), there is underlying uncertainty – or, more specifically, incomplete information – that opens the door to adverse selection and even a collapse in a market due to extreme dynamics in market participants' beliefs about what other participants' may know about a certain asset. Garratt and Shin (2023) heavily emphasise the thrust of Morris and Shin (2012) in their paean to tokenised deposits:

> *Even a small seed of doubt (whether justified or unjustified) has the potential to reverberate through monetary exchange and could undermine the role of money as a medium of exchange.*

However, if incomplete information is so problematic, perhaps regulators could mandate rigorous transparency standards for stablecoin backing assets to ensure common knowledge and shut down these disruptive implications. Unlike opaque bank balance sheets, stablecoins backed by short-maturity treasuries or the like can make their balance sheets effectively completely transparent. As innovations like proof of reserve spread, it is plausible that stablecoins may come to be perceived as substantially safer than bank deposits and not worth monitoring closely (making them informationally insensitive liabilities).

Moreover, interesting new research from Chiu and Monnet (2025) suggests that some key benefits of novel monies, like programmability, could even be in tension with singleness. In an admittedly stylised model, the authors examine a context where there is a trade-off between programmability that enables a degree of commitment (to a particular path of spending) and the uniform purchasing power of money. In this context, imposing par may not be welfare-optimal, providing a theoretical counterpoint to the almost lexicographic preference for singleness often expressed by central banks.

As Ma et al. (2025) have noted, the precise details of redemption agreements vary across stablecoins and can be rather complex – possibly involving fees, minimum redemption thresholds and a closed set of approved counterparties and market makers. Their work suggests there may be delicate trade-offs between promoting efficient redemption in normal times (aiding singleness) and increasing the risks of run-like behaviour in times of stress (undermining singleness).

Hemingway (2025) also provides nuanced insights on these issues in building on Doepke and Schneider's (2017) analysis of the emergence of a dominant unit of account within a currency area. This (preliminary) work allows money issuers to choose the unit of

account for their liabilities, and whether they can be used as a medium of exchange. Exchange rate risk in the presence of multiple units of account can undermine broader efficiency – emphasising that dramatic deviations from singleness are to be avoided – but small deviations from singleness nevertheless can be consistent with efficiency.

It is also important to note that the degree of price variation observed so far has occurred while stablecoins and their underlying blockchain infrastructure have been in an embryonic form and in the absence of clear regulation. There are many reasons to expect the already small deviations from par in normal times to shrink further in the future:

- Issuers have learned from past difficulties. For example, the excessive reliance by Circle on a small set of commercial banks was revealed as a vulnerability during the Silicon Valley Bank (SVB) crisis. Research by Lyons and Viswanath-Natraj (2023) argues that reforms to Tether's operations and DAI's stabilisation mechanisms reduced their deviations from par by economically significant margins. Furthermore, there are strong market incentives for stablecoins to offer a high degree of stability to attract institutional flows (see Allen and Winters 2020 for instructive evidence from floating NAV money market funds). Academic understanding of AMMs is gradually improving, leading to better designs for price discovery, and the professionalism of other DeFi protocols (notably DeFi lending) continues to advance (Huang et al. 2024, Barnon and Ranaldo 2024, Alexander et al. 2025).

- The costs and risks of executing arbitrage strategies are key limitations to maintaining a stable peg. It is well known that blockchains have faced a trilemma – a trade-off between decentralisation, security, and scalability. However, significant progress has been made in enhancing the performance of blockchains through Layer 2 solutions and upgrades to underlying Layer 1s, which should drive down arbitrage costs. Additionally, sophisticated cross-chain interoperability protocols like Chainlink and LayerZero are emerging to address the thorny challenge of fragmented liquidity across multiple blockchains.

- Research by Gorton et al. (2022) provides a thorough examination of deviations from singleness and finds that technological enhancements to blockchain infrastructure are important. In terms of stablecoin design, they find that coins with smart contracts that allow upgrades and other 'good governance' features – such as the functionality to pause activity or blacklist addresses – exhibit improved price stability. As such best practice spreads, one may well see enhancements in singleness.

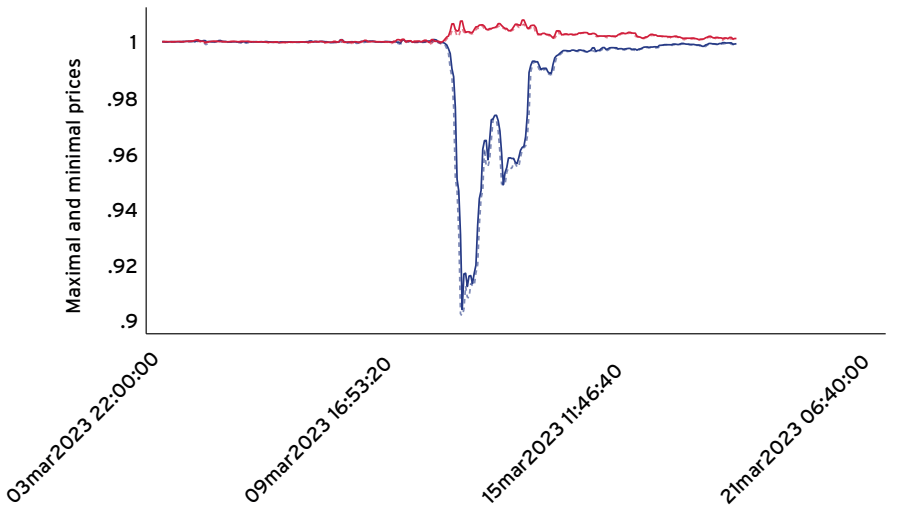
Overall, it seems likely that market frictions will decline and, with them, deviations from par in normal times. All else equal, the flood of liquidity from institutional investors that appears likely as tokenisation expands, will act as a tailwind to this process. However, we are not always in 'normal times'.

THE REAL THREAT: BIG DE-PEGS AND RUNS

It is reasonable to argue that the large de-pegs during times of stress could disqualify stablecoins as effective money for large value settlement and systemic markets. The de-peg of USDC during the SVB crisis in March 2023 provides a stark illustration of deviations that should be unacceptable in a mature monetary system.

As shown in Figure 2, a severe negative de-peg of USDC occurred at the height of the crisis, while USDT experienced de-pegs in the opposite direction (Watsky et al. 2024). During this period, questions were being asked about the fundamental health of Circle/USDC, due to ambiguity over the recoverability of its uninsured deposits at SVB. This was exacerbated by trading frictions in both the traditional finance system (banks were closed on weekends, for example) and the DeFi system (limited liquidity in AMMs). As such, standard arbitrage arguments for why the peg should hold no longer applied, and large de-pegs were observed. Many USDC holders ran to USDT, causing large imbalances in AMM pools.

FIGURE 2 HOURLY MAXIMUM AND MINIMUM OF MINUTE-BY-MINUTE USDT AND USDC PRICES RECORDED IN DUNE.COM'S PRICES.MINUTE TABLE.

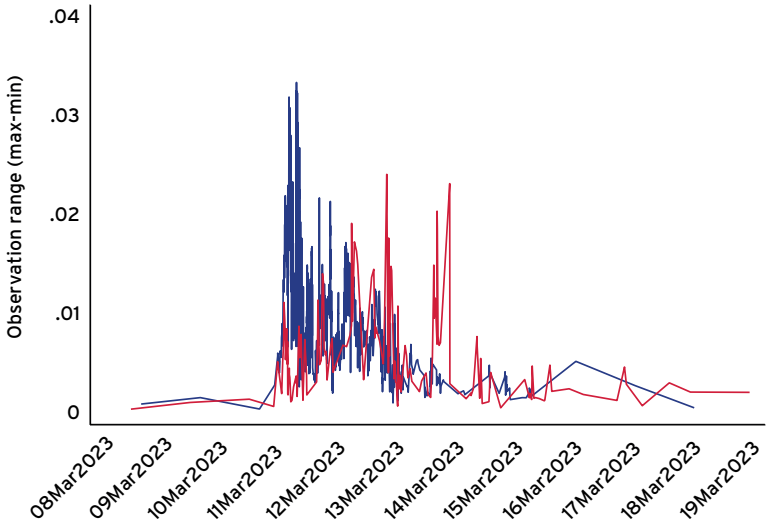


Note: Solid lines = maximum; dashed lines =minimum; blue = USDC; red = USDT.
Source: Draws on CoinPaprika pricing data for 4 to 17 March 2023.

Aside from undermining stablecoins' claim to be effective money, large de-pegs also bring the risk of financial market spillovers. In March 2023, the USDC de-peg spilled over to other stablecoins like DAI and to decentralised lending protocols like AAVE where USDC was used as collateral. Given the public nature of stablecoin prices, there are also concerns that herding/panic behaviour may set in, worsening the situation in a vicious cycle.

Adding to the impression of 'questions being asked', we note that during this period prominent oracle services, such as Chainlink Price feeds, exhibit spikes in dispersion among the price estimates contributed by members of decentralised oracle networks (DONs), from which the overall oracle price feed value is obtained as a median.[6] Figure 3 depicts the difference between the maximum and minimum values proposed by DON members during the March 2023 episode on the Optimism blockchain. While not enormous, we see notable increases in dispersion during the crisis. This increased 'disagreement' among expert data providers emphasises that not only had prices moved to unusual levels, but that uncertainty around these levels may also have increased. Both, of course, are highly problematic for an asset purporting to be an effective money – and represent troubling deviations from singleness.

FIGURE 3 DISPERSION BETWEEN HIGHEST AND LOWEST SUBMITTED PRICE FROM CHAINLINK DON MEMBERS FOR USDC/USD AND USDT/USD PRICE FEEDS ON OPTIMISM BLOCKCHAIN.



Note: USDC= blue; USDT = red.

USING LIQUIDITY FACILITIES TO PROMOTE SINGLENESS

Theoretical models emphasise that confidence in collateral quality is key to making money issuers robust to runs. However, even narrow backing in 'safe' assets like treasuries is not a panacea. After episodes like the 2020 'dash for cash', one might worry that even narrow stablecoins are subject to runs because of the possibility of mass redemptions triggering a fire sale of treasuries (with knock on implications for safe asset prices; see Ahmed and Aldasaro (2025). This is particularly the case in the absence

6 For more details on price feeds, see https://docs.chain.link/data-feeds/price-feeds; for the USDC/USD price feed on Ethereum mainnet, see https://data.chain.link/feeds/ethereum/mainnet/usdc-usd.

of any form of explicit deposit insurance or emergency liquidity facilities. It is notable that policymakers emphasise the importance of these for singleness, yet there has been almost no discussion of extending them to stablecoins.

Since at least Bagehot, consensus has been that if a solvent money issuer is suffering from liquidity difficulties and has good collateral, a lender of last resort should provide emergency liquidity. The aim is to avoid the issuer being forced to sell assets at fire-sale prices, which could erode capital and lead to self-reinforcing redemption dynamics.

Is it then obvious that central banks should provide emergency liquidity to stablecoin issuers? In fact, it is not entirely obvious, for several reasons. First, central banks are likely to remain reluctant to broaden access to such facilities. Nevertheless, the Bank of England recently established the Contingent Non-bank Financial Institution Repo Facility (CNRF), setting a precedent for providing liquidity to non-banks in periods of stress, against high quality collateral.

Second, and more importantly, stablecoins are often global in nature. Their backing assets may be held in multiple jurisdictions, making it extremely problematic for standard liquidity facilities to be extended. A single central bank may not have any duty or interest in providing liquidity for foreign holders of the stablecoin. There is no single LOLR that can span the reach of a global stablecoin, nor is there any collaborative infrastructure for a collective of central banks to coordinate quickly on a bailout.

This gap in LOLR infrastructure seems a pressing priority for research and policy discussions and a natural focus for supranational authorities like the Bank for International Settlements and the Financial Stability Board. Note that providing an LOLR framework does not necessarily imply that stablecoins need to become a form of deposit token, with secondary market settlement operating through RTGS systems day in and day out. Instead, one could envision them having contingent access to liquidity, which would be used rarely in times of stress, while their bearer nature – important for efficient cross-border transactions – could be retained.

CONCLUSIONS

If a money is backed by high-quality liquid assets and provided with emergency liquidity, it should be possible to make it as safe as commercial bank money, and likely safer. From the perspective of singleness, it should be possible for it to remain vanishingly close to par, essentially always and everywhere, including in secondary markets and in times of stress. By moving beyond exaggerated concerns over singleness in normal times and putting measures in place to preserve it during stress, the debate can focus on other important costs and benefits of different types of money – discussions around credit creation, market power, and financial accessibility that have been abstracted from in this chapter.

REFERENCES

Ahmed, R and I Aldasoro (2025), "Stablecoins and safe asset prices", BIS Working Paper 1270 (https://www.bis.org/publ/work1270.htm).

Alexander, C, X Chen, J Deng and Q Fu (2025), "Price Discovery and Efficiency in Uniswap Liquidity Pools", *The Journal of Futures Markets* 45(8): 1023-1048 (https://onlinelibrary.wiley.com/doi/10.1002/fut.22593?af=R).

Allen, K D and D B Winters (2020), "Crisis regulations: The unexpected consequences of floating NAV for money market funds", *Journal of Banking & Finance* 117, 105851 (https://doi.org/10.1016/j.jbankfin.2020.105851).

Arseneau, D, M Carlson, K Chen (2025), "Central bank liquidity facilities around the world", FEDS Notes, 26 February (https://www.federalreserve.gov/econres/notes/feds-notes/central-bank-liquidity-facilities-around-the-world-20250226.html).

Bagehot, W (1873), *Lombard Street: A Description of the Money Market*, Henry S. King & Co.

Bank of England (2024), "The Bank of England's approach to innovation in money and payments", Bank of England Discussion Paper (https://www.bankofengland.co.uk/paper/2024/dp/the-boes-approach-to-innovation-in-money-and-payments).

Barbon, A and A Ranaldo (2024), "On The Quality Of Cryptocurrency Markets: Centralized Versus Decentralized Exchanges", Swiss Finance Institute Research Paper No. 22-38 (https://ssrn.com/abstract=3984897).

Chiu, J and C Monnet (2025), "On the Programmability and Uniformity of Digital Currencies", Bank of Canda Staff Working Paper 2025-18 (https://www.bankofcanada.ca/2025/06/staff-working-paper-2025-18/).

Doepke, M and M Schneider (2017), "Money as a Unit of Account", *Econometrica* 85: 1537-1574 (https://doi.org/10.3982/ECTA11963).

Garratt, R and H S Shin (2023), "Stablecoins versus tokenised deposits: implications for the singleness of money", BIS Bulletin 73 (https://www.bis.org/publ/bisbull73.pdf).

Gorton, G B, C P Ross and S Y Ross (2022), "Making money", NBER Working Paper No. 29710 (https://www.nber.org/papers/w29710).

Hemingway, B (2025), "A Model of Monetary Singleness", working paper (https://benhemingway.github.io/assets/papers/Hemingway_money_singleness.pdf).

Holmstrom, B (2015), "Understanding the role of debt in the financial system", BIS Working Paper No. 479 (https://www.bis.org/publ/work479.pdf).

Huang, W, N Rostova, and Z Song (2024), 'Decentralized Exchanges for Near-Money Assets", working paper (https://warwick.ac.uk/fac/soc/wbs/subjects/finance/gillmore/annualconference2024agenda/huang_dexs_for_near_money_assets.pdf).

Lyons, R K and G Viswanath-Natraj (2023), "What keeps stablecoins stable?", *Journal of International Money and Finance* 131, 102777 (https://doi.org/10.1016/j.jimonfin.2022.102777).

Ma, Y, Y Zeng and A L Zhang (2025), "Stablecoin Runs and the Centralization of Arbitrage", NBER Working Paper No. 33882 (https://www.nber.org/papers/w33882).

Morris, S and H S Shin (2012), "Contagious Adverse Selection", *American Economic Journal: Macroeconomics* 4(1): 1–21 (https://www.bis.org/publ/AEA_Morris_Shin_2012_Contagious_adverse_selection.pdf).

Watsky, C, J Allen, H Daud et al. (2024), "Primary and Secondary Markets for Stablecoins", FEDS Notes, 23 February (https://www.federalreserve.gov/econres/notes/feds-notes/primary-and-secondary-markets-for-stablecoins-20240223.html).

ABOUT THE AUTHOR

Rhys Bidder is a senior lecturer at King's Business School. Rhys received his PhD from NYU and, for several years, worked for the Federal Reserve Bank of San Francisco. He is also currently a research affiliate at the Central Bank of Ireland and an Advisor to Chainlink Labs.

CHAPTER 15

Programmability and uniformity: Rethinking the trade-off in digital currency design

Jonathan Chiu and Cyril Monnet
Bank of Canada; University of Bern and Study Center Gerzensee

In recent policy discussions, central banks have raised concerns that programmable digital currencies could undermine the 'singleness' of money – that is, the principle that all units of a currency should have the same value and purchasing power. However, programmability also opens new possibilities for solving long-standing economic frictions, particularly commitment problems (e.g. Lee et al. 2024). In this chapter, we present the key ideas and findings from Chiu and Monnet (forthcoming), where we develop a formal model to examine the trade-offs involved.

Precisely, we ask whether programmable money can improve efficiency despite compromising uniformity. Also, when is it optimal to allow or restrict programmability? And under what conditions does adherence to the classical principle of monetary singleness actually compromise welfare maximisation?[1]

THE ECONOMIC ROLE OF PROGRAMMABLE MONEY

Programmable money refers to digital tokens whose usage can be restricted or conditioned via embedded software rules. Unlike traditional money, which is fully fungible, programmable tokens may differ in their transferability across time and states, counterparties, or transaction types. For example, investors can restrict the way funds are used in early-stage financing, or users can impose controls on their own spending.

These programmed features are increasingly implemented through smart contracts on blockchain platforms. Smart contracts are self-executing digital agreements with contract terms directly written into code and deployed on a blockchain network. These programmable contracts automatically enforce and execute predetermined conditions without requiring intermediaries, as the contract logic is immutably stored on the distributed ledger and executed by the network's consensus mechanism. Embedding smart contracts in money has the potential to automate commitments and constrain future behaviour in ways that ordinary money, be it cash or bank deposits, cannot.

1 This question is particularly relevant for stablecoins, as differently programmed and designed stablecoins aim to maintain the same stable exchange value, despite operating under varying governance structures and reserve compositions.

In our model, programmability arises endogenously to mitigate a commitment problem: some agents would like to commit *not* to spend in certain future states, but without programmable tokens, that commitment is not credible. Then these agents are interested in tokens that cannot be transferred in those states where they face the commitment problem.

At the same time, programmability leads to differentiation among tokens. If some tokens are less transferable or more restricted, they may have lower market value. When such differentiation becomes widespread, the economy may lose monetary singleness – a term we use to describe the uniformity of purchasing power across money balances.

The trade-off between the commitment benefits of programmed tokens and the uniformity costs that they imply is at the heart of our analysis. Using a stylised but useful example, we show that, under perfect information, singleness is neither necessary nor sufficient for reaching the efficient allocation. Whether programmability is desirable depends on the severity of information and commitment frictions.

A MODEL OF PROGRAMMABLE MONEY

To formalise the issues, we need a model of exchange where people cannot commit, even towards their own selves. To model exchange, we introduce buyers and sellers who can trade early (on food) or late (on alcohol).

Buyers are heterogeneous. Some are 'L-types', who are more likely to consume food and derive very little (albeit positive) utility from drinking alcohol. Others are 'H-types', who are more balanced in their consumption preferences. The key friction is that L-type buyers cannot credibly commit not to drink alcohol, even when doing so is socially inefficient.

Also, sellers do not trust buyers and information frictions prevent the use of credit. Therefore, buyers need a means to pay that they can acquire from banks, before markets open, in the form of tokens, that bankers can redeem after the market for alcohol. Importantly, bankers can issue two kinds of tokens: standard tokens that are always transferable; and *programmed* tokens that cannot be transferred late: they cannot be spent on alcohol. In equilibrium, buyers choose portfolios of tokens depending on their type, and sellers accept tokens (or not) in exchange for consumption goods.

Importantly, sellers who sold food early on may want to buy alcohol later. Therefore, they may apply a discount on programmed tokens used to buy food relative to unprogrammed token, because the earlier cannot be used to purchase alcohol, while the latter can.

We define *programmability* as the share of balances that are restricted, and singleness as the share of early market transactions in which all tokens are treated as fully fungible with the same value.

PROGRAMMABILITY HELPS COMMITMENT, AT THE COST OF SINGLENESS

When sellers can perfectly recognise the type of token (i.e. perfect recognisability), prices adjust to reflect the difference in transferability. Sellers apply a discount to programmed tokens relative to standard tokens, because they are less useful in later transactions. Singleness is lost, but the allocation is efficient.

In this setting, L-type buyers choose to hold only programmed tokens, as these are cheaper and better aligned with their consumption needs because they derive very little utility from drinking alcohol. H-type buyers, in contrast, hold only standard tokens that can be spent indifferently on food or alcohol. The price of each token reflects its expected redemption, and sellers differentiate accordingly. Because tokens are priced according to their value, buyers self-select into portfolios that support the socially efficient allocation.

We show that in this case, *prohibiting programmability reduces welfare*. It forces L-buyers to use standard tokens that are unnecessarily liquid and more costly to acquire because they can be redeemed, thereby depressing their food consumption. The loss of commitment outweighs the gain in singleness. In fact, the efficient allocation coincides with a complete loss of singleness – each type of token trades at a different price.

This is our first key insight: **singleness is neither necessary nor sufficient for efficiency**.

INFORMATION FRICTIONS CHANGE THE PICTURE

We then consider the case of *imperfect recognisability*, where some sellers cannot distinguish between token types. These uninformed sellers price tokens based on the average composition of tokens in circulation. As a result, standard tokens 'subsidise' programmed ones in anonymous transactions. This introduces adverse selection.

For small levels of imperfection, the previous separating equilibrium prevalent under perfect information persists: L-buyers use programmed tokens, H-buyers use standard ones, and prices adjust accordingly. But when information frictions are more severe, H-buyers start acquiring programmed tokens – not to constrain their behaviour, but to exploit pooled pricing. This behaviour resembles *Gresham's Law*, where 'bad' money (here, the more illiquid programmed tokens) drives out 'good' money.

In this *mixing equilibrium*, too many programmed tokens are created. H-buyers over-acquire them to extract value in early transactions from uninformed sellers selling food, which leads to inefficiencies in later markets (where tokens can no longer be used). L-buyers, in turn, consume too much food, anticipating higher purchasing power. As these distortions grow, the welfare gains from programmability disappear. In some cases where the distortions remain contained however, banning programmability altogether leads to better outcomes.

This leads to our second main insight: **whether programmability is desirable depends on the severity of information and commitment frictions**. When tokens are easily recognised and commitment problems are strong, programmability improves welfare. When tokens are hard to distinguish and commitment problems are weak, singleness becomes more important.

RETHINKING HISTORICAL LESSONS

Our analysis challenges the conventional wisdom – often based on the US historical experience of free banking when banks holding sufficient species could issue their own banknotes – that non-uniform money necessarily leads to inefficiency. In our example, differentiation in tokens is not a failure, but it can be a feature of the optimal allocation, even in the presence of frictions.

While the US free banking era was plagued by discounting and loss of parity across banknotes, the conditions that created those problems – lack of backing, inconsistent redemption, and poor information – need not apply in a digital setting. Indeed, with programmable money, backing can be automated, redemption is guaranteed by smart contracts, and information about token properties can be encoded on-chain. As such, historical analogies should be applied with caution.

OPEN QUESTIONS FOR FUTURE RESEARCH

Our paper takes a first step in modelling the economic trade-off between programmability and uniformity. However, it leaves several important questions open for further exploration.

Endogenous recognisability

In our example, recognisability is exogenous: sellers either can or cannot tell tokens apart. It is, however, of interest to endogenise information acquisition as, in reality, both buyers and sellers may have some control over recognisability. For instance, bankers could design tokens to be more or less distinguishable (e.g. via metadata or cryptographic proofs), and sellers might invest effort in verifying token features. A more general model would endogenize these choices to analyse whether a laissez-faire equilibrium can lead to optimal recognition, or whether it would generate too much or too little differentiation.

Optimal regulation

Our analysis compares two polar cases: allowing all forms of programmability versus banning it entirely. A natural extension is to explore intermediate regulatory tools. For example, a Pigouvian tax on programmed tokens could induce H-buyers to internalise the externality they impose on uninformed sellers. Alternatively, subsidies for token

transparency or penalties for excessive programmability could improve outcomes. Understanding the optimal form of regulation – outright bans versus price-based instruments – remains an important policy question.

Token design space

Our example uses a primitive form of programmability – a binary restriction on whether a token can be transferred in one future period – because this is sufficient for us to make the point that programmability is neither necessary nor sufficient for optimality. But in practice, programmability can be far more nuanced. Tokens can be conditional on the identity of recipient, on location, on purpose of spending, or on time. They can allow a limited number of uses or dynamic rules. What constitutes the optimal design of programmable money, given the frictions in the economy? Can smart contracts be tailored to match buyer types in richer ways, and what are the trade-offs involved?

These extensions are not only theoretically interesting but practically relevant as digital money systems evolve.

CONCLUSION

In sum, our analysis highlights that the interaction between programmability and uniformity is subtle and depends on the frictions hindering trades. Programmable money can enhance welfare by solving commitment problems, but only when the monetary system can adequately price or inform recipients about the nature of each token. When information frictions grow, these same features can backfire, leading to inefficient allocation and over-creation of programmed tokens.

We conclude that policymakers should move beyond binary debates over whether programmable money is 'good' or 'bad'. Instead, the key is to understand the specific frictions in the environment and to design token systems – and regulatory frameworks – that align incentives accordingly. Rather than assuming uniformity is always and everywhere desirable, it may be more productive to ask: How can we design a monetary system that allows the right degree of monetary fragmentation, without undermining trust or efficiency?

REFERENCES

Chiu, J and C Monnet (forthcoming), "On the Programmability and Uniformity of Digital Currencies", *American Economic Review: Insights*.

Lee, M J, A Martin, and R M Townsend (2024), "Zero settlement risk token systems", Federal Reserve Bank of New York Staff Report No. 1120.

ABOUT THE AUTHORS

Jonathan Chiu is a Senior Research Advisor of the Banking and Payments Department at the Bank of Canada. His main research interests concern monetary theory, banking, payments and financial infrastructures. His current research focuses on digital currencies, international monetary systems and tokenization. He also teaches monetary theory at Queen's University. Jonathan holds a PhD in Economics from the University of Western Ontario.

Cyril Monnet is a Professor of Economics at the University of Bern and at the Study Center Gerzensee. He has previously been an Economic Advisor at the Federal Reserve Bank of Philadelphia, and a Senior Economist at the European Central Bank. Cyril's research focuses on monetary theory and the design of financial markets. He holds a PhD in Economics from the University of Minnesota.

PART IV
TOKENISATION, PLATFORMS, CREDIT, AND DECENTRALISED FINANCE

CHAPTER 16

Tokenisation: The promise and the perils

Jon Frost,[a] Leonardo Gambacorta,[ab] Anneke Kosse[a] and Peter Wierts[a1]
[a]Bank for International Settlements; [b]CEPR

INTRODUCTION

Out of today's fever pitch of digital innovation, new technological capabilities are emerging that could have an important impact on the monetary and financial system. Among these, a particularly important advance is tokenisation. Tokenisation is the process of generating and recording a digital representation of traditional financial or real assets that exist on a traditional ledger on a programmable platform (BIS 2023, 2025, BIS and CPMI 2024). By enabling contingent execution of transactions – "if, then, else" – tokenisation unlocks a range of new functionalities that could improve existing financial services and open up new contracting possibilities (BIS 2025). With the right steps by public and private sector actors, tokenisation could help to reshape the monetary and financial system.

A possible first step would be to tokenise money. This could involve central bank money, which sits at the core of the monetary system, in the form of reserves that commercial banks (and some non-banks) hold at the central bank. It could also involve new tokenised forms of bank deposits and e-money (El Dimachki et al. 2025). It remains to be seen what role new private alternatives, such as stablecoins, may play.[2]

Beyond this, tokenisation could reshape capital markets and other financial services, including lending, insurance, and asset management. Tokenising real-world assets, such as securities (e.g. stocks and bonds), lending contracts (e.g. trade finance), and real estate, could enable the automation of transactions and unlock efficiency gains. Here, initial experiments show promise, but there is much more work to be done.

1 The views expressed here are those of the authors and do not necessarily reflect those of the Bank for International Settlements (BIS), its Committee on Payments and Market Infrastructures (CPMI) or its member central banks. We thank Gaston Gelos, Dan Rees and Takeshi Shirakami for helpful comments, and Giulio Cornelli and Ilaria Mattei for data support. All errors are our own.

2 Stablecoins are cryptoassets that are designed to maintain a stable value relative to a reference asset, such as fiat currencies.

This chapter assesses tokenisation of money and other financial assets – assessing the promise and the perils, and highlighting findings from current applied research. The next section discusses approaches to tokenising money. The subsequent section looks at other financial assets. We then discuss risks and challenges, and conclude in the final section.

APPROACHES TO TOKENISING MONEY

The term tokenisation emerged in the crypto sector, as it was exploring how Ethereum and other public blockchains, combined with smart contract functionalities, could help process financial transactions in a decentralised and disintermediated way. But public (permissionless) blockchains face inherent limitations around scalability and fragmentation (Boissay et al. 2022). Due to their pseudonymous nature, they are also susceptible to financial integrity issues.

The monetary instruments used for settlement in these settings currently are primarily stablecoins. Stablecoins are often used as a stable monetary unit, and as on-ramps and off-ramps to the crypto-ecosystem. They have been much more successful than (unbacked) cryptoassets at maintaining a stable value and purchasing power. Yet they fall notably short when set against the three key tests of singleness (i.e. settlement at par), elasticity (providing settlement liquidity), and integrity (protecting the monetary system against illicit activities) (BIS 2025).

A better way forward is to build on the two-tier monetary system, with central bank money at the core for systemically important payments, and money for less systemic day-to-day use being provided by commercial banks and other regulated (non-bank) private intermediaries. Tokenisation with programmable platforms built on central bank money would ensure the crucial stability and trust in money while allowing for new functionalities. It would also address constraints often associated with legacy payment systems (e.g. limited operating hours and cross-border access).

In a tokenised two-tier monetary system, central bank money is the first tier. Tokenised central bank reserves serve a similar role as central bank reserves today, but with added functionalities enabled by tokenisation. For example, through programmability and composability, tokenised reserves could provide for atomic settlement (e.g. delivery versus payment) of wholesale transactions between banks, central banks and other financial institutions. This, in turn, could promote automation and straight-through processing, and allow for risk reduction and cost efficiency, among other opportunities (BIS and CPMI 2024). For day-to-day payments by individuals, digital cash – issued by the central bank and made available through regulated commercial banks or other payment services providers – could include some of these functionalities, too.

Central banks are already working on related initiatives, both in advanced economies and emerging market and developing economies (EMDEs). As reported in Illes et al. (2025), more than half of central banks are working on tokenised wholesale central

bank money. Preserving the role of central bank money as a settlement asset for transactions involving tokenised assets is a key motivation for this work. While various central banks are running experiments (advanced economies: 79%; EMDEs: 35%) or pilots (advanced economies: 38%; EMDEs: 16%), some others are already developing a live version (advanced economies: 17%). And at the retail level, many central banks are experimenting with (48%) or piloting (19%) digital cash solutions, with some having issued or preparing for live issuance (3%) (Illes et al. 2025).

As the second tier, tokenised commercial bank deposits can introduce new functionalities for end users (Garratt and Shin 2023). Examples include programmability, 24/7 transactions, and lower costs for cross-border payments. Commercial banks in about one in three jurisdictions are currently exploring tokenised deposits. A couple of commercial banks have already issued tokenised deposit services, mainly to their own corporate clients (Illes et al. 2025).

TOKENISATION OF FINANCIAL ASSETS

Beyond money, tokenisation offers substantial potential to enhance the efficiency, liquidity, and accessibility of financial markets. By creating and recording digital representations of assets on a programmable platform, tokenisation can streamline transactions, reduce costs, and open new investment avenues, extending beyond traditionally tradable assets.

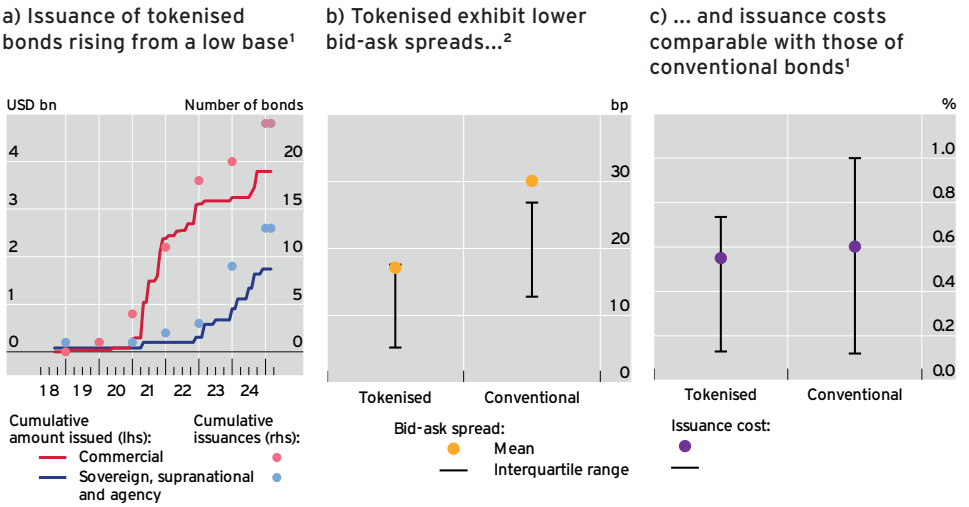
A particularly promising area for tokenisation is bonds. Indeed, Illes et al. (2025) show that by the end of 2024, most financial asset tokenisation initiatives involved bonds. Government bonds in particular play a central role in the financial system. The global government bond market is valued at approximately US$80 trillion, and government bonds are crucial for securities markets and serve as the backbone for monetary policy and collateral management. As Aldasoro et al. (2025) highlight, tokenising government bonds could generate significant efficiency gains, potentially improving financial market functioning and having a broad impact on the global economy.

While still in its early stages, the tokenisation of government bonds has gained momentum in recent years (Figure 1a). More than 20 sovereigns, supranationals, and agencies (SSAs) have issued tokenised bonds, totalling over $4 billion in nine different currencies. While most issuances have used private, permissioned distributed ledger technology (DLT), some have experimented with other technologies.

Initial findings suggest that tokenised bonds have comparable market liquidity and issuance costs to conventional bonds, with some indications of improved market liquidity. For instance, tokenised bonds show tighter bid-ask spreads, with a 17 basis point spread compared to 30 basis points for traditional bonds (Figure 1b). There is no significant difference in issuance costs (Figure 1c), suggesting that tokenisation does

not impose additional financial burdens (see Aldasoro et al. 2025).[3] However, legal and regulatory uncertainties remain, along with limited market experience, which could present challenges. These issues can likely be addressed through legislation for robust legal framework and regulatory reforms, and their impact may diminish as the market matures.

FIGURE 1 GOVERNMENT BOND MARKETS ARE A GROWING FOCUS OF TOKENISATION INITIATIVES



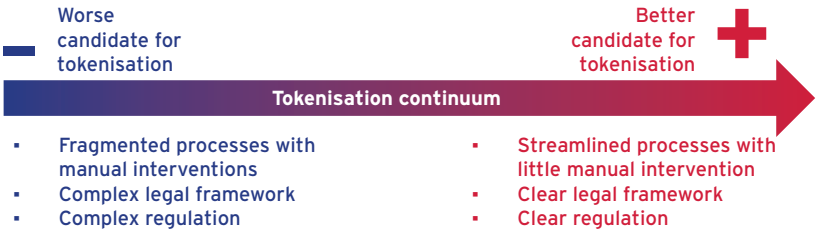
Note: 1 Based on the subset of tokenised bonds with an available ISIN. 2 Based on a matched sample of conventional bonds with same issuer, currency of denomination and coupon type of the tokenised bonds. 3 Data as of 26 March 2025. Measured as the difference between the initial price offered to the public and the price paid by the underwriter to the bond issuer.

Sources: Leung et al. (2023); LSEG Workspace; Aldasoro et al. (2025).

The potential to tokenise other asset classes is substantial. Beyond government bonds, assets such as commercial bonds, stocks, real estate, and trade finance claims could benefit from tokenisation. However, the ease of tokenisation varies across asset classes, with some options presenting greater challenges than others. For example, while tokenising bonds and stocks is relatively easy (because they are already standardised and securitised), tokenising more complex assets like real estate and trade finance involves more significant hurdles (Figure 2). As Aldasoro et al. (2023) suggest, overcoming these challenges could unlock substantial benefits, but would require substantial investment in technology, standardisation, and infrastructure.

3 Leung et al. (2023) find lower yields and bid-ask spreads, and comparable issuance costs, for tokenised bonds against a matched sample of conventional bonds.

FIGURE 2 THE TOKENISATION CONTINUUM



Source: Aldasoro et al. (2023).

RISKS AND CHALLENGES

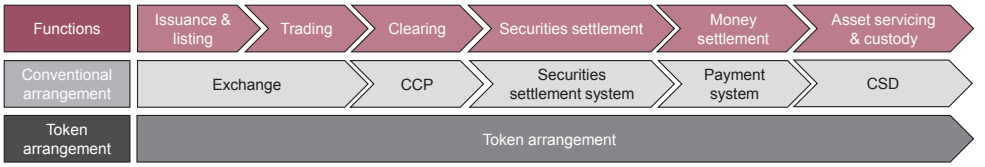
As in conventional financial market infrastructures, the safeguarding of assets, execution and settlement of trades are key concerns in transactions involving tokenisation. Generally, the same risks can arise as in existing infrastructures, such as those related to legal uncertainty, settlement risk, concentration risk, operational risk (including cyber risk), and custody risk (BIS and CPMI 2024). But risks may materialise in a different manner – for example, due to a mismatch between the token and its underlying assets and the risk of a 'fork' in the case of decentral governance (BCBS 2024).

Risks that are specific to tokenisation may also emerge. Currently, functions performed through the life cycle of a financial transaction – such as issuance, trading, clearing, and settlement – are often performed by separate entities that use their own platforms and that each have their own participants. Tokenisation, however, may allow for the combination of functions in one single platform (Figure 3). While this may lead to efficiency gains, it may exacerbate concentration risks and introduce risks related to conflict of interests.

Programmable platforms are characterised by a separation between the operator of the platform and the issuers and transferers of the assets (Budau and Tourpe 2024, BIS and CPMI 2024).[4] While, again, this may lead to efficiency gains (see previous sections), it leads to governance challenges in managing the operation of a shared technical environment.

4 In the context of money and funds transfers, in a conventional payment system design, each issuer of a settlement asset typically operates its own closed system in which its settlement assets are issued/redeemed, stored and transferred (van Hee et al. 2025). This leads to potential frictions due to the need for reconciliation between disparate systems when settlement assets are transferred across systems. At the same time, it simplifies governance, since each issuer controls its own technical environment.

FIGURE 3 TOKENISATION: A FUNCTIONAL PERSPECTIVE



Note: CCP=central counterparty; CS=central securities depository.
Source: BIS and CPMI (2024).

Different governance solutions bring their own challenges. When there is a single operator of the platform, the operator may have an incentive to achieve network effects and to discourage links with other platforms, which would lead to market fragmentation and lack of competition. By contrast, in a decentralised setting and in which functions are performed based on smart contracts (i.e. without human interaction), large losses may arise in times of stress. This could come particularly from problems associated with 'incomplete contracts' that do not anticipate all potential contingencies, and the lack of clearly established direct lines of responsibility and timely human intervention (CPMI and IOSCO 2022). A public sector operator, or a public-private partnership as platform operator, could help to mitigate some of these issues, as a platform can be operated as a utility in the public interest.

Finally, a particular challenge relates to overcoming the impediments to further market development. Potential impediments include the presence of strong network effects and the need for a 'critical mass' of users, inefficiencies when interacting with legacy systems and legal uncertainty. There are also impediments from investment costs, the need for central bank money as a settlement asset, a current lack of interoperability between platforms, and the need for industry standards (OECD 2025, FSB 2024). A concerted effort of private and public sector stakeholders is needed to overcome these barriers.

CONCLUSION

Tokenisation of money and other financial assets brings many possibilities for the financial and monetary system, but there are also key risks and challenges to be overcome. It offers opportunities in terms of risk reduction and cost efficiency, due to built-in programmability and composability of transactions. At the same time, for tokenisation to improve the safety and efficiency of financial transactions, it would require sound risk management. Both the public and private sector have their role to play in unlocking the full potential of tokenisation without compromising on safety and efficiency of the financial and monetary system.

Going forward, research can assess concrete experiences to date and shed light on the added value and business cases of tokenisation. It may also consider the comparison between permissioned DLT and public permissionless variants, and other technologies, in terms of their ability to overcome network effects and achieve large-scale adoption, as well as their implications for the safety and efficiency of payment ecosystems, monetary

policy, and financial stability. It may also explore how tokenised central bank money, commercial bank money, and non-bank money will interact with each other. Finally, it can look into the experience with specific policy measures in promoting the sustainable growth of a tokenised financial system.

REFERENCES

Aldasoro, I, S Doerr, L Gambacorta, P Koo-Wilkens and R Garratt (2023), "The tokenisation continuum", BIS Bulletin No. 72, April (https://www.bis.org/publ/bisbull72.htm).

Aldasoro, I, G Cornelli, J Frost, P Koo Wilkens, U Lewrick and V Shreeti (2025), "Tokenisation of government bonds: assessment and roadmap", BIS Bulletin No. 107, July (https://www.bis.org/publ/bisbull107.htm).

BCBS – Basel Committee on Banking Supervision (2024), "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", BCBS Working Paper (https://www.bis.org/bcbs/publ/wp44.htm).

Budau, V and H Tourpe (2024), "ASAP: A conceptual model for digital asset platforms", IMF Working Paper No. 24/19 (https://www.imf.org/en/Publications/WP/Issues/2024/02/02/ASAP-A-Conceptual-Model-for-Digital-Asset-Platforms-544387).

BIS – Bank for International Settlements (2023), "Blueprint for the future monetary system: improving the old, enabling the new", Chapter III in *Annual Economic Report*, June.

BIS (2025), "The next-generation monetary and financial system", Chapter III in *Annual Economic Report*, June.

BIS and CPMI - Bank for International Settlements and Committee on Payments and Market Infrastructures (2024), "Tokenisation in the context of money and other assets: concepts and implications for central banks", CPMI paper, October (https://www.bis.org/cpmi/publ/d225.htm).

Boissay, F, G Cornelli, S Doerr and J Frost (2022), "Blockchain scalability and the fragmentation of crypto", BIS Bulletin No. 56, June (https://www.bis.org/publ/arpdf/ar2025e3.htm).

CPMI and IOSCO – Committee on Payments and Market Infrastructures and International Organization of Securities Commissions (2022), "Application of the Principles for Financial Market Infrastructures to stablecoin arrangements", CPMI Paper (https://www.bis.org/cpmi/publ/d206.pdf).

El Dimachki, M, F Klinger and A Maechler (2025), "Blockchain: hype, success or potential", CEPR eBook chapter, August.

FSB – Financial Stability Board (2024), "The Financial Stability Implications of Tokenisation", October (https://www.fsb.org/2024/10/the-financial-stability-implications-of-tokenisation/).

Garratt, R and H S Shin (2023), "Stablecoins versus tokenised deposits: implications for the singleness of money", BIS Bulletin No. 73, April.

Illes, A, A Kosse and P Wierts (2025), "Advancing in tandem - results of the 2024 BIS survey on central bank digital currencies and crypto", BIS Paper No 159, August (https://www.bis.org/publ/bppdf/bispap159.pdf).

Leung, V, J Wong, A Ying and W Wan (2023), "An assessment on the benefits of bond tokenisation", Hong Kong Institute for Monetary and Financial Research (HKIMR) Research Paper, no 17.

OECD – Organisation for Economic Cooperation and Development (2025), "Tokenisation of assets and distributed ledger technologies", OECD Business and Finance Policy Paper.

van Hee, K, A Kosse, P Wierts and J Wijngaard (2025), "Let's speak the same language: a formally defined model to describe and compare payment systems architectures", *Journal of Financial Market Infrastructures* 12(3) (https://www.risk.net/node/7961795).

ABOUT THE AUTHORS

Jon Frost is Head of Innovation and the Digital Economy in the BIS. He has published research on fintech, big tech in finance, digital currencies, stablecoins, capital flows and technology and inequality. Previously, Jon was Head of Economics for the Americas in the BIS Americas Office in Mexico City. He also worked at the Financial Stability Board (FSB) Secretariat, the Dutch central bank, VU University Amsterdam and in the private sector in Germany. Jon holds a PhD in Economics from the University of Groningen. He is a Research Affiliate of the Cambridge Centre for Alternative Finance.

Leonardo Gambacorta is Head of the Emerging Markets unit at the BIS. He previously served as Head of Innovation and Digital Economy (2019-24), Research Adviser (2014-18) and Head of Monetary Policy (2010-12). Before joining the BIS, he worked at the Bank of Italy, and was a visiting scholar at the National Bureau of Economic Research. Leonardo holds an MSc in Economics from the University of Warwick and a PhD in Economics from the University of Pavia. His research interests include monetary transmission, macroprudential policies and the effects of technological innovation. He is a research fellow of the Centre for Economic Policy Research.

Anneke Kosse is a Senior Economist at the Secretariat of the BIS Committee on Payments and Market Infrastructures (CPMI). She conducts research and supports the CPMI's policy and analytical work in the field of digital innovation in payments, covering topics such digital currencies, stablecoins and tokenisation. Previously, Anneke worked at the Bank of Canada and the Dutch central bank. Anneke's payments research

appeared in various peer reviewed journals. Anneke holds a PhD in Business and Economics from Tilburg University and is a Deputy Editor of the *Journal of Financial Market Infrastructures*.

Peter Wierts is Senior Economist at the Bank for International Settlements. He studied monetary economics at the University of Groningen and holds a PhD from the University of Reading. Before joining the BIS, he was Senior Economist at the Dutch central bank (2005–23) and Associate Professor of Finance at VU University Amsterdam (2014–23). He also worked for the European Commission (DG ECFIN, 2002–05) and the Dutch Ministry of Finance (1996–2002). His research interests include innovation in payments, macroprudential policy and fiscal policy.

CHAPTER 17

The rise of tokenised money: Building the digital future of financial infrastructure

Emre Ozdenoren and Kathy Yuan
London Business School; London School of Economics and Political Science

INTRODUCTION

The rise of digital currencies, particularly programmable or tokenised money issued by platforms and central banks, is fundamentally reshaping financial markets. This chapter examines how tokenised money secures financial transactions, automates financial contracts in primary and secondary markets, reduces information frictions, and significantly enhances funding and market liquidity. These advancements carry profound implications for monetary policy and financial stability.

WHAT IS TOKENISED MONEY?

Tokenised money refers to digital currencies issued or guaranteed by central banks or private platforms. Examples include central bank digital currencies (CBDCs), stablecoins, tokenised deposits, and regulated private digital currencies such as Uber Cash and WeChat Money. Unlike traditional digital payments, tokenized money can incorporate rules via smart contracts, automating financial transactions and enforcing contractual terms without intermediaries (Ozdenoren, Tian and Yuan 2025). Platforms like Amazon and Alibaba integrate tokenised money into economic activities, generating valuable data that help address information frictions between commercial and financial counterparties.

Private enterprises and individuals also issue unregulated tokenised payment instruments, such as cryptocurrencies, which possess similar technological capabilities like programmability and interoperability but carry risks when used as a medium of exchange for consumption goods.

DUAL ECONOMIC FUNCTION OF TOKENISED MONEY

Tokenised money simultaneously fulfils two critical roles: it acts as a payment method for commercial transactions and it serves as security for financial contracts. This dual capability is achieved at significantly reduced costs through its programmability.

Like traditional money, tokenised money acts as a medium of exchange in commercial transactions to help overcome the limited commitment problem of buyers and sellers of consumption goods, creating trust and realising gains from trade. However, tokenised money provides superior automation and efficiency in both digital and face-to-face transactions by lowering custodian costs, providing atomic settlement, and hence reducing settlement risk. This automation minimises human error, significantly reduces the potential for fraud, and ensures compliance with regulatory standards, such as anti-money laundering (AML) and combating the financing of terrorism (CFT).

Due to its programmability and tradability, tokenised money can also perform functions akin to securities and can be automated into financial contracts that previously required trusted third-party intermediaries. Consequently, it cuts down the cost to arrange financial contracts and makes more financial transactions economically viable to a larger population.

Therefore, tokenised money can be used as a medium of exchange for both commercial and financial transactions. The former are mostly spot transactions while the latter are future (contingent) payments. For instance, tokenised money can integrate payments for goods and services with conditional buy-now-pay-later features, blurring the line between payments and financial transactions and creating incentives for regulatory arbitrage. This convergence introduces new challenges for payment and financial service regulators. The multiple uses of tokenised money also present potential risks to monetary authorities regarding price stability.

Leading examples include WeChat Pay and Alipay, which integrate payment (e.g. train or flight tickets) and financial services (e.g. travel insurance) within their ecosystems, and decentralised finance (DeFi) platforms like Aave, which use tokenised assets to automate collateral management. CBDC projects by various central banks, such as the Bank of England and the Federal Reserve, also explore programmability to improve financial stability and efficiency.

TOKENISED MONEY AS CUSTODIED COLLATERAL

Custodied collateral is a necessary component in financial transactions. Unlike commercial transactions, which are mostly spot exchanges,, financial transactions involve future obligations and settlements, necessitating secure arrangements through custodians or collateral. Tokenised money efficiently provides both roles. Its digital and programmable nature significantly reduces custodial costs and eliminates settlement risks through instant transfer capabilities.

Moreover, tokenised money's traceability and programmability make it an effective new collateral source, embedding conditions directly into contracts and automating collateral enforcement, including automatic liquidation triggers upon default without reliance on third-party custodians or lengthy judicial processes.

High custodial costs and collateral scarcity often limit financial service accessibility, especially for underserved populations. Provisions of financial services have been suboptimal in the existing financial system due to collateral shortages, leading to some productive activities being left unfunded and risk-sharing and consumption-smoothing possibilities limited. Tokenised money addresses these barriers through technological advantages by making collateral management affordable and financial services inclusive.

For example, in a standard risk-sharing arrangement, a risk-averse agent purchases insurance from a risk-neutral agent, where the latter promises future insurance payouts. The risk-neutral agent needs collateral to make this promise credible. However, optimal outcomes cannot be achieved when insurance providers have limited collateral inventory. Tokenised money potentially alleviates this issue by increasing collateral supply.

Ozdenoren, Yuan and Zhang (2025) demonstrate that even risky tokenised money, such as cryptocurrencies, can effectively support financial lending services typically managed by intermediaries collecting information. Contrary to popular belief, DeFi is not inherently fragile due to cryptocurrency volatility; rather, fragility arises from decentralised governance structures with rigid, costly contract updates. When DeFI lending contract terms can adjust to market conditions, the equilibrium is unique, sustaining lending despite underlying asset volatility. However, DeFi platforms have rigid contractual arrangements due to algorithm-based, decentralised governance, creating vulnerabilities that are difficult to resolve without giving up some degree of automation/decentralisation.

TOKENISED MONEY AS SAFE ASSET AND COLLATERAL MULTIPLIER

Most collateral assets backing financial contracts face information frictions due to uncertain or volatile values. Borrowers often pledge collateral that they value more than lenders, leaving lenders exposed to the risk of adverse selection. To overcome these information frictions, counterparties in financial transactions have to agree to complicated contracts, and in some cases only certain securities (e.g. debt) are acceptable by both counterparties.

Tokenised money, particularly when issued or guaranteed by central banks, addresses this by serving as transparent and safe collateral. It mitigates information frictions, allowing better collateralisation of risky assets and enhancing borrowing capabilities (Ozdenoren Tian and Yuan 2025).

Ozdenoren Tian and Yuan (2025) show that when enough safe tokenised money is combined with risky assets in a collateral portfolio, the collateral portfolio becomes less information-sensitive and hence lowers the severity of adverse selection. Consequently, the pledgeability of risky collateral goes up. Effectively, tokenised money acts as a collateral multiplier, increasing the supply of collateral assets in the economy, enabling

greater financial transaction volumes, and promoting enhanced risk-sharing and financing of productive economic activities. This collateral multiplier effect further raises the value of tokenised money, sustaining more consumption and forming a positive feedback loop.

Tokenised money possesses qualities that distinguish it from traditional safe assets like reserves and sovereign bonds. Unlike central bank reserves, which are exclusive to financial institutions, or sovereign bonds, which face price volatility and settlement frictions, tokenised money is both universally accessible and settlement-final. These features make it a more inclusive and flexible class of safe assets. In extreme stress episodes, such as the March 2020 'dash for cash', tokenised money could serve as a liquidity backstop, enabling margin payments without requiring asset liquidation or costly interbank transfers.

Finally, by offering a safe and broadly accessible asset, tokenised money may reduce systemic dependence on sovereign bonds within the financial sector for safe assets and help mitigate the sovereign-financial sector 'doom loop' – a key vulnerability during the European sovereign debt crisis of 2009-2010. By decoupling safe asset provision from sovereign debt issuance, tokenised money can enhance financial system resilience.

TOKENISED MONEY AS TRADABLE COLLATERAL

Tokenisation makes it technically feasible and economically viable to create secondary markets for tokenised assets, including money. Traditional money transfers require credit facilities arranged by payment service providers (eg. banks) or central bank settlements, whereas tokenised money ownership can be sold and exchanged between counterparties (across or within borders) in marketplaces without intermediary credit facilities. This closely integrates funding and market liquidity within tokenised financial systems, meaning that financial transactions can be market-based instead of in the existing bank-dominated financial system.

Tokenised money holders can access liquidity more flexibly than ever. They can pledge tokenised money as collateral or exchange it for other liquid assets issued by central banks or private entities. For instance, to access other forms of liquidity, tokenised bank deposit receipts can be pledged as collateral for a loan or sold in a marketplace (eg. centralised or over-the-counter exchanges). Currently, the only option for bank depositors to obtain liquidity is to withdraw/redeem their deposit receipts from their banks.

In a study of 'liquid staking' where agents are allowed to sell tokenised ownership of an illiquid claim in a DeFi staking service (that pays an interest payment similar to a bank deposit account) to satisfy a liquidity need, Lehar et al. (2025) establish that the liquid secondary market for tokenised deposits has two effects: it allows agents to redeem illiquid assets and thus reduces run risk on the staking/deposit protocol, but it also conveys information and can act as a coordination mechanism and increase a

market sell-off. Consequently, financial institution fragility in the tokenisation era is more likely triggered by market shocks rather than sunspots in traditional depositor-driven runs as in Diamond and Dybvig (1983). The broader literature has focused on potential financial disintermediation with the introduction of tokenised money, but this focus overlooks the liquidity benefits that tokenisation offers and the new sources of fragility it introduces.

TOKENISED MONEY AS PLATFORM MONEY

Digital platforms that issue their own programmable money benefit substantially from seigniorage – the profits derived from issuing money at virtually no cost while receiving interest or economic benefits from its circulation. Traditional marketplaces using fiat money cannot capture seigniorage because monetary issuance and inflation are controlled by central banks.

By issuing programmable money, digital platforms generate substantial seigniorage income, which can be strategically utilised to attract users and stimulate network effects. Platforms such as WeChat Pay and Alipay have leveraged their proprietary payment systems to quickly expand user bases through incentives such as cashback offers, loyalty rewards, and subsidies on transactions. These financial incentives reduce the cost for buyers and sellers to transact on the platform, making it increasingly attractive compared to traditional markets that charge fees without the advantage of seigniorage.

As more buyers are attracted to the platform due to lower costs, sellers also flock to the platform to access the larger buyer base. This dynamic creates a self-reinforcing feedback loop – commonly known as network effects – which further consolidates the platforms' market position. Over time, the increased market participation not only enhances the platforms' ability to generate additional seigniorage income but also solidifies user loyalty and platform dependency. Ozdenoren, Tian and Yuan (2025) find that when a platform has the same matching technology as other marketplaces, the equilibrium with platform money is socially inefficient both in terms of resulting seller/buyer ratios and the number of traders on the platform. When the platform has superior matching technology, introducing platform money can move the equilibrium outcome closer to the social optimum relative to the alternative when the platform can only charge a fee in fiat money.

The study by Ozdenoren, Tian and Yuan (2025) raises a critical policy question regarding the social welfare consequences of allowing platforms to maintain private payment systems. Currently, regulated financial institutions, regarded as trustworthy third parties, dominate payment systems. However, digital platforms are increasingly equipped with advanced data processing and machine learning capabilities that not only improve buyer-seller matching but also secure transactions. With the growing

prevalence of platform-based economies, it is essential to examine whether these digital marketplaces, through their intrinsic economic synergy with payment systems, should be entitled to the seigniorage income traditionally captured by financial institutions.

FINANCIAL STABILITY

The dual economic function of tokenised money creates a reinforcing feedback loop: higher collateral quality boosts asset prices and borrowing capacities, further enhancing tokenised money's reliability and value, and thus promoting more gains from trade and generating greater value-added for the society. This dynamic can stabilise financial markets during economic shocks, acting as a buffer against systemic risks when more safe assets are used as collateral. Tokenised money complements existing safe assets like reserves and sovereign bonds in this stabilising dynamic (Ozdenoren, Tian and Yuan 2025).

However, tokenised money introduces risks such as cybersecurity threats and new market risks to financial intermediation. Effective policy frameworks are essential to manage these risks while maximising economic benefits. Policymakers must balance innovation with regulatory oversight, ensuring the benefits of tokenised money are realised without jeopardising financial stability.

CONCLUSION

Tokenised money represents a transformative innovation in financial infrastructure, offering unique capabilities that extend beyond conventional monetary instruments. Through its programmability, tokenised money enables automated contract execution, enhances market transparency, and provides novel mechanisms for financial stability. Its dual functionality – serving simultaneously as payment medium and collateral asset – creates economic efficiencies unattainable with traditional money forms.

The emergence of tokenised money heralds a financial architecture that transcends the traditional dichotomy between market-based and bank-based systems. This convergence promises a more inclusive financial landscape, characterised by enhanced competition and operational efficiency. But realising this potential requires careful navigation of technological, regulatory, and economic challenges.

As tokenised money moves from experimental deployments to mainstream adoption, its multifaceted economic functions demand rigorous analysis from multiple perspectives. Policymakers must develop frameworks that balance innovation with systemic stability; financial institutions need strategies to integrate these instruments into existing operations; and market participants require deeper understanding of the opportunities and risks inherent in programmable money. The trajectory of digital finance will be shaped by how effectively these stakeholders address the fundamental questions surrounding the role of tokenised money in the evolving financial ecosystem.

REFERENCES

Diamond, D W and P H Dybvig, (1983), "Bank Runs, Deposit Insurance, and Liquidity", *Journal of Political Economy* 91(3): 401-419.

Lehar, A, C Parlour and K Yuan (2025), "Liquid staking", Working Paper.

Ozdenoren, E, K Yuan and S Zhang (2023), "Money as Collateral Multiplier", Working Paper.

Ozdenoren, E, Y Tian and K Yuan (2025), "Platform Money", CEPR Discussion Paper 20436.

Ozdenoren, E, K Yuan and S Zhang (2025), "On the Fragility of DeFi Lending", CEPR Discussion Paper 20434.

ABOUT THE AUTHORS

Emre Ozdenoren is a Professor of Economics at London Business School. He works on microeconomics, decision making under uncertainty, behavioural economics, game theory and auction theory. More recently, he has focused his research on various topics in financial economics such as feedback effects between financial markets and the real economy, security design and money. Before joining London Business School, he was an Associate Professor of Economics at University of Michigan. He is also a Research Fellow at the CEPR. His research has been published in leading economics journals across the world including the Review of Economic Studies, Journal of Finance, RAND Journal of Economics and the Journal of Economic Theory.

Kathy Yuan is a Professor of Finance at the London School of Economics and Political Science. She received her PhD in Economics from MIT and previously worked on J.P. Morgan's Emerging Markets Trading Desk. Her research develops macro-finance and asset pricing theories with liquidity implications under market frictions, examining crisis transmission, market liquidity, and the role of benchmark securities. Currently, she studies liquidity and financial stability in banks and non-banks sector, the macro effects of digital payments, and applied theories of digital money and public liquidity. She has been a Houblon-Norman Fellow at the Bank of England, a research fellow at the IMF and BIS, and is affiliated with FMG and CEPR.

CHAPTER 18

BigTechs, credit, and digital money

Markus K. Brunnermeier and Jonathan Payne
Princeton University and CEPR; Princeton University

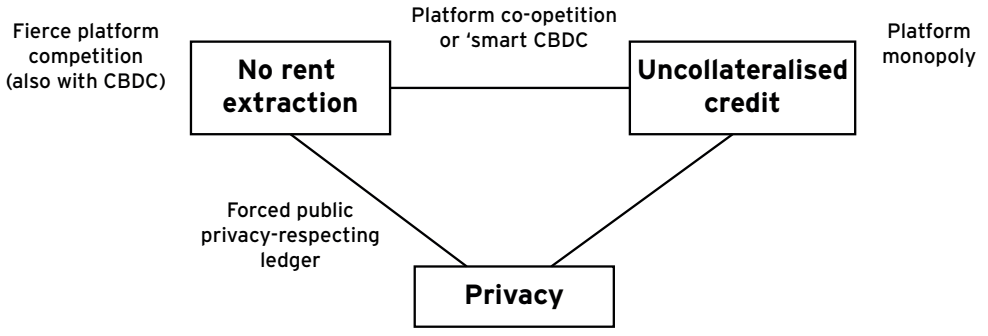
1 INTRODUCTION

Digital technologies promise to relax long-standing frictions that restrict access to credit. The fintech toolbox – machine learning, large-scale behavioural data, and programmable ledgers – aims to improve both screening and enforcement. In principle, moving payments, information collection, and contracting onto a shared digital ledger can automate settlement and transform future revenue into 'digital collateral', expanding uncollateralised credit for borrowers without traditional assets or credit histories.

Technology alone, however, cannot deliver scale without supportive institutions. Practical obstacles – off-ledger *side-trading* via cash or anonymous channels, identity verification, coordination of ledger adoption, and the standardisation and processing of data – shape incentives and can undermine enforcement. Addressing these frictions requires platform design, regulation, and, in some cases, public infrastructure that together determine whether ledgers yield inclusive and resilient credit markets.

In Brunnermeier and Payne (2025), we show these tensions crystallise in a policy trilemma: no institutional arrangement can simultaneously ensure robust enforcement of uncollateralised credit, limit rent extraction by intermediaries, and preserve user privacy. As highlighted in Figure 1, a monopolistic BigTech platform can enforce repayment but risks privacy loss and markups; privacy-preserving public options protect users yet weaken enforcement by enabling side trades; and platform co-opetition or programmable public ledgers can discipline rents while sustaining enforcement, but only by compromising privacy.

FIGURE 1 POLICY TRILEMMA



2 FINTECH VISION FOR LENDING AND PAYMENTS

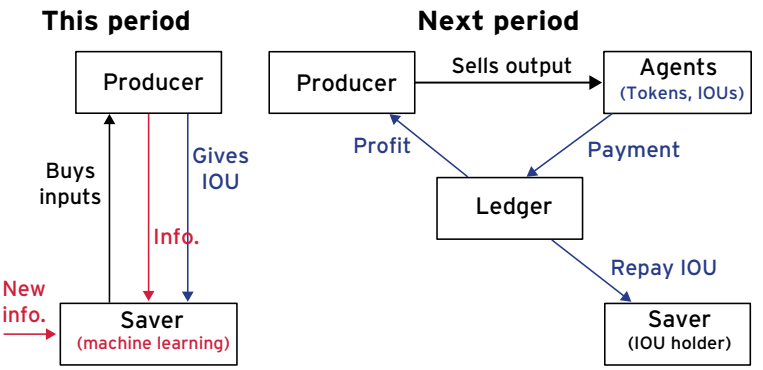
Firms often require external credit to finance investments, purchase inputs, and begin production. At a high level, the lending process involves the following steps:

1. savers assess the likelihood that the business will repay, based on its expected future revenue and assets;
2. savers decide which loans to fund;
3. businesses use the funds to produce goods;
4. businesses sell output and generate revenue; and
5. loans are settled, either through repayment or default.

To make this process work at scale, savers must be able to screen out low-quality borrowers and enforce repayment from viable ones. Historically, in small communities, this was achieved informally through local knowledge and reputational enforcement. But at scale, personal monitoring breaks down. This led to a financial system centred on collateralised lending, where standardised assets simplify screening and enable enforcement by allowing lenders to seize pledged assets in default – while excluding many worthy borrowers with intangible or illiquid assets.

The *fintech vision* seeks to address this by improving both screening and enforcement using new technologies. On the information side, fintech firms gather large-scale behavioural datasets ('soft' information) and use machine learning to identify creditworthy borrowers. On the contracting side, fintechs propose using shared digital ledgers that can automatically settle payments and enforce repayment. If most transactions are processed through such a ledger, loans can be repaid before the borrower has the chance to default. This vision is illustrated in Figure 2.

FIGURE 2 THE FINTECH VISION



Note: Black depicts the flow of goods; blue depicts the flow of financial contracts; red depicts the flow of information

Despite these advances, technology alone has not been sufficient to transform credit provision. Institutional arrangements must also ensure that agents face the right incentives to make the system work. A key fragility is off-ledger side trading: borrowers can transact using cash or anonymised channels, spend the proceeds, and avoid automatic repayment – while still remaining active in the economy. In effect, side trades replicate liquidity outside the ledger, short-circuiting enforcement and destabilising uncollateralised lending unless institutions restrict such leakages.

In addition, there are other hurdles the fintech vision must overcome. Ledger operators must verify user identities, build and coordinate ledger adoption, standardise data collection, and address cognitive or legal limits on information processing. They must also support efficient risk-sharing arrangements and guard against new forms of systemic risk.

This chapter analyses two institutional responses to these challenges: BigTech platform finance and the public provision of a common ledger.

1 RESPONSE I: BIGTECH PLATFORMS

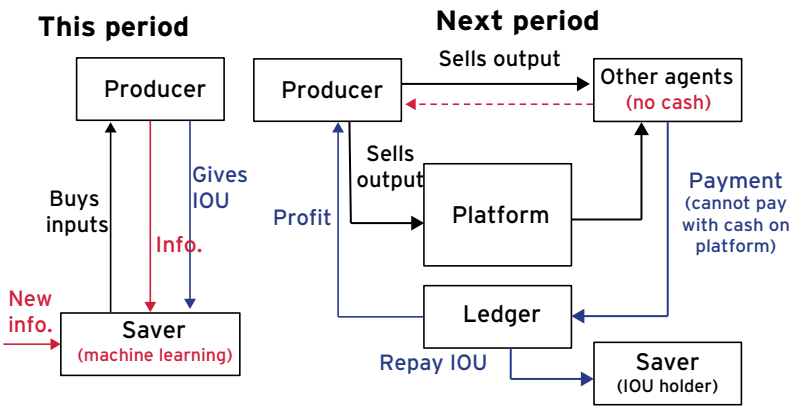
BigTech platforms have the opportunity to bundle the provision of trading and payment technologies. On the trading side, BigTech platforms offer improved matching between buyers and sellers. On the payment side, they can set up their own ledger for settling financial transactions, creating currency tokens, and executing automatic contracts. As a real-world example, this can be thought of as Amazon or Alibaba offering a programmable ledger in the style of Ethereum. There are many potential synergies between the provision of these services.

One synergy arises because BigTech platforms can exploit 'unconventional' information that banks, investment funds, and FinTech startup are unable to access and/or process. These platforms observe a large share of goods trade, enabling them to infer market characteristics such as customer product demand and supplier pricing power. They also collect granular data on individual purchasing habits, website activity, social media usage, and payment behaviour. Unless other financial institutions contract with the platforms, they cannot access this information. This gives BigTech platforms the opportunity to exploit machine-learning tools and use unconventional information to predict loan default. This is sometimes referred to as making 'soft' information sufficiently 'hard' to be used for providing financial services. A growing academic literature supports the value of such information – for example, Berg et al. (2020) shows that digital footprints can predict default risk as accurately as credit scores, and improve predictions when used alongside them.

Another synergy is that BigTech platforms can steer users towards their payment systems and discourage the use of cash. Platforms can require users to conduct transactions using their internal ledgers and tokens. In doing so, they create a 'walled garden' that restricts off-platform payments. This makes it is hard for producers to sell goods

anonymously using cash, default on their loan obligations, and then bring the cash back into the platform to make future purchases. By undermining the universal liquidity of cash, platforms reduce the incentive to hold it. Consequently, savers no longer hold the assets needed to facilitate private side trades, and all transactions are channelled through the platform's ledger, where loan repayments can be enforced automatically. This mechanism is depicted in Figure 3. Importantly, full market coverage is not necessary: since agents must choose their portfolio (cash versus tokens) before knowing where they will trade, the platform can deter cash holding even when only a fraction of transactions go through the platform.

FIGURE 3 LENDING WITH A PLATFORM



Note: Black lines show the flow of goods; red lines show information flow; blue lines show the flow of financial assets.

These insights yield three conceptual takeaways about digital payment ledgers:

1. **BigTech platforms can 'back' ledger use**. Ledger technologies are only effective if agents actually use them. Thus, platforms that control trade in the economy must also support ledger use by mandating it for participants. In this sense, BigTech platforms are natural providers of currency ledgers.

2. **BigTech platforms need to destroy the universal liquidity of cash**. Many credit-enforcement problems arise when agents can use cash for side trades. Platforms can close off these opportunities by making cash impractical to use, thereby enhancing contract enforceability.

3. **The payment technology can collateralise sales revenue**. The method of payment affects whether future sales revenue can be treated as collateral. Transactions conducted on a common ledger can be diverted to repay loans, functioning like 'digital collateral'. Off-ledger trades, by contrast, require costly coordination to monitor and exclude defaulters. Platforms can control how effectively future revenue becomes collateral by shaping where transactions occur.

The expansion of BigTech into finance introduces new challenges as well as new opportunities. One issue is the presence of natural monopolies in ledger-based services. For contract enforcement, platforms with greater market share can better enforce repayment, since more trades are routed through the ledger. For information collection, different institutions specialise in different types of data – BigTechs typically excel in trade-related data, while banks specialise in collateral evaluation. Without mechanisms for sharing information, this specialisation leads institutions to target borrowers based on the characteristics they observe best, rather than efficiently allocating credit. These dynamics lead to monopoly BigTech platforms can allocate credit efficiently but also use their market power to extract significant rents.

The inverse challenge is that platforms require some degree of market power in order to be willing to set up the platform. Their revenues come from charging markups on transactions. But these markups also affect incentives: platforms enforce repayment by discouraging cash usage, and excessive markups reduce the attractiveness of using the platform payment system and/or tokens. There is thus a trade-off: higher markups generate revenue but undermine enforcement by incentivising cash use. A platform that controls a large share of trade can charge a positive markup while still discouraging default. In contrast, a smaller platform may need to subsidise users (i.e. charge negative markups) to enforce repayment, making ledger provision unprofitable. In this case, it prefers to not set up the common ledger.

In short, the extent of platform dominance – measured by the share of trade it intermediates – determines whether the economy suffers from monopoly rent extraction or credit fragility. These observations are reflected in the policy trilemma introduced in Figure 1 in the introduction. Without any regulation, the economy is likely to end up in the top right corner where a BigTech monopoly provides uncollateralised credit but also extracts large rents. Without any market power, the economy is likely to end up in the top-left corner where competition brings down rents but also discourages platforms from setting up the ledger. In principle, a regulator with perfect information could finely tune restrictions on platform markups to achieve both uncollateralised credit provision and low rents. However, doing so would require detailed knowledge of costs and demand. In the following sections, we consider alternative strategies: public provision of a payment ledger and regulated competition between large platforms.

2 RESPONSE II: PUBLIC OPTION

The arguments in Section 3 suggest that payment ledger provision exhibits characteristics of a natural monopoly, and that directly regulating private ledger providers is complex. An alternative policy response is for the government to introduce a public payment ledger that competes with or substitutes for commercial payment technologies.

Governments face several key design decisions in setting up a public ledger. First, should the system be a pure payment infrastructure, or should it also involve the issuance of central bank liabilities? Second, should the government offer a user-facing interface, or just provide backend infrastructure for financial institutions? Third, should access be limited to the banking sector, or extended to other intermediaries? Fourth, should end-users be able to write programmable contracts onto the ledger?

We have seen many different forms of public ledgers (broadly defined to include all payment and settlement systems) that reflect different design choices:

- **FedNow** is a real-time payment and settlement system in the US accessible only to banks. It does not involve the issuance of currency and functions as backend infrastructure alongside the Automated Clearing House (ACH) network.
- **Pix** is a real-time payment system in Brazil open to both banks and non-bank intermediaries. Unlike FedNow, it includes a public-facing interface.
- **Central bank reserves** are digital liabilities of the central bank, accessible only to banks.
- **Wholesale central bank digital currency** (**CBDC**) is a central bank digital currency not accessible to the general public but potentially used by non-bank financial institutions.
- **Retail CBDC** is a digital central bank liability that can be held by the public.
- **'Smart' CBDC** is a programmable version of retail CBDC, operated on a centralised blockchain, where users can write and execute contracts (a public analogue to platforms like Ethereum).

A public ledger can play multiple roles in the system described in Section 3. First, it offers a superior outside option to physical cash – especially for publicly accessible systems like Pix. On the positive side, this disciplines markup-setting by BigTech platforms and banks, substituting for direct price regulation. However, it also provides an alternative means of payment that can facilitate side trades, potentially weakening enforcement. As we discuss later in Section 6, this creates a policy trade-off between improving contract enforcement and protecting privacy.

Second, a public ledger can act as a fallback in emergencies. In the event of a cyberattack, financial intermediaries could shift settlement operations to the public ledger. Likewise, during financial crises, if private settlement systems fail, the public ledger could maintain basic payment functionality.

Third, the government could offer a public ledger as the exclusive infrastructure for payment and contracting. A universal, programmable CBDC would phase out cash and require settlement on a public ledger; all transactions would clear on that infrastructure,

enabling automatic diversion of revenues to satisfy obligations and making enforcement economy-wide. Platforms could still compete on services atop this base layer, but settlement and contract execution would be centralised.

Across all these roles, policymakers must balance the benefits of system- wide coordination on current technology with the need for continued innovation. Offering a universal public ledger may enhance enforcement and payment efficiency, but it also risks entrenching a government monopoly that could deter technological progress. In recent years, private competition has driven substantial innovation in payment and settlement technologies. Replacing this with a centralised system – no matter how well-designed – may suppress the next wave of advances.

5 BIGTECH PLATFORMS CO-OPETITION REGULATION

In Section 4 we discussed how the government can offer a public digital payment system alternative with the objective to limit the rent extraction of the BigTech platform and provide a fallback option (e.g. in case of a cyberattack). An alternative regulatory approach is to encourage the entrance of at least two competing BigTech platforms.

To do so, regulators have several potential tools at their disposal. More specifically, the government can: (i) limit markup charges for trading on the platform, (ii) regulate exchange rates between platform ledger tokens and other currencies, and (iii) set rules for information collection and sharing. All these tools interact and involve 'co-opetition' – fostering competition in some dimensions and encouraging cooperation in other dimensions.

Regulation can foster competition across platforms by eliminating lock- in and walled-garden effects. Information and interoperability regulation can have large implications for platform competition. For example, if customers 'own' the information and can carry it across platforms, lock-in effects are reduced. This is analogous to 'open banking' in finance, which grants agents the right to decide whether to pass on their information to other platform ledgers.

A second form of regulation concerns the exchange-rate fees platforms charge when agents want to transfer tokens of one platform to tokens of a competing platform. Requiring interoperability across digital ledgers and the ability to swap tokens easily increases competition across platforms.

Regulation should also enhance cooperation across competing BigTech ledger operators to ensure efficient credit extension, especially information-sharing rules. A regulatory environment that focuses exclusively on fostering competition leads to settings where BigTech ledgers offer agents an option to default on loans registered on competing ledgers. As in the fintech vision of Section 2, agents would be encouraged to default on

one ledger and side-trade on another; the uncollateralised credit market would never get off the ground. In addition, platforms should earn sufficient rent to make the ledger worth offering.

Hence, competing BigTech ledgers have to coordinate to exclude financial intermediaries that allow clients to store wealth with them after the client defaulted on other intermediaries using the other platform ledger. This requires information sharing. In Brunnermeier and Payne (2025), we examine a setting in which platforms commit ex ante, when setting up the ledgers, to exclude financial intermediaries who allow their depositors to default on contracts on the other ledger. When both competing platforms are sufficiently efficient in matching agents, both platforms set up individual ledger tokens. If one platform has strictly superior matching technology, the superior platform sets up a monopoly ledger (with its token) and the less efficient platform pays a fee for its clients to use the ledger services. Ultimately, the only viable ledger operators are those that also possess platform trading technology – implying a natural bundling between offering ledger and trading services. A standalone institution with no trading technology would not provide the ledger in equilibrium.

Overall, while minimising rent extraction asks for fierce competition to minimise trading markups, exchange-rate fees, and information ownership, a functioning credit market requires coordination in credit enforcement, particularly information sharing across lenders. Agents that default on one platform should not be allowed to transact and make payments on a competing platform. In other words, the welfare-optimising solution requires *co-opetition*. The analogy to traditional lending is instructive: competition among banks should be fierce, but coordination via credit bureaus is desirable to ensure a functioning credit market.

6 PRIVACY CONSIDERATIONS

We now add a third objective – privacy – which the government must balance against effective credit enforcement and limiting private-sector rent extraction. Historically, physical cash has allowed for private transactions, whereas digital money has generally lacked this feature. Commercial banks – and, indirectly, the government – can monitor bank accounts and other forms of digital bank money. Central banks track who holds reserves. Transactions on blockchains like Bitcoin are publicly recorded and permanently stored, making them non-private by design.

However, recent technical developments have made it possible to create private digital currencies. One approach relies on cryptographic techniques that enable users to send coins without revealing the recipient or transaction amount. Notable examples include zero-knowledge proofs and Pedersen commitments. In the cryptocurrency space, these methods have been implemented by Zerocash, which provides a privacy-preserving digital token.

Deciding whether to offer a private or non-private digital token is one of the most important design choices for a central bank digital currency (CBDC). On one hand, surveys show that many individuals and businesses value privacy. On the other hand, enabling private transactions makes it difficult to meet other government objectives, including:

- **anti-money laundering** (AML): prohibiting the use of financial trans- actions to conceal the origins of criminal proceeds;
- **countering the financing of terrorism** (CFT): prohibiting the use of financial transactions to fund terrorist activity;
- **know your customer** (KYC): requiring financial institutions to verify the identities of their clients; and
- **anti-evasion** (AE): prohibiting structuring or other efforts to circum- vent reporting requirements.

For example, if the government issued a CBDC in the form of a USD eToken using zero-knowledge proofs to ensure privacy, it would not satisfy AML, CFT, KYC, or AE requirements – much like physical cash does not. Conversely, if the government were to allow anyone to hold an account at the Federal Reserve provided they supply a Social Security number, it would satisfy all of these regulatory requirements but would not preserve user privacy.

The introduction of BigTech platform ledgers provides another reason why privacy poses challenges. A privacy-respecting public payment ledger effectively creates a universally liquid payment technology that does not require agents to hold endowment goods in advance. As a result, agents can always engage in side trades and default on their obligations. By contrast, if the government abandons privacy protections and uses the CBDC ledger to enforce contracts, it can expand access to uncollateralised credit directly. This creates another trade-off: while a public payment ledger that respects privacy can improve the functioning of the payment system, it may also undermine the ability to enforce contracts efficiently.

These observations bring us back to the trade-offs illustrated in Figure 1. A universal programmable CBDC can achieve two outcomes at the top of the triangle: low rents and uncollateralised credit. A CBDC that respects privacy can deliver the outcomes on the left side of the triangle: low rents and privacy. However, no public ledger can simultaneously maximise uncollateralised credit expansion, minimise rent extraction, and protect privacy. Instead, the government must decide which objectives to prioritise.

Many proposals have been put forward to create hybrid systems that incorporate some form of privacy protection while balancing the trade-offs in the policy trilemma:

- **Regulating the interaction with the financial system**. This proposal envisions a CBDC eToken that uses zero-knowledge proofs to preserve privacy. Agents would be allowed to trade USD eTokens privately with one another. However, AML, CFT, KYC, and AE regulations would apply when agents move CBDCs into the broader financial system (e.g. to purchase financial assets). This approach effectively mirrors how cash is treated in the current system.
- **Anonymity vouchers** (2019 ECB proposal). Users provide their identity to the central bank (or an intermediary implementing the CBDC) and receive a pseudonymous identity, which serves as their CBDC net- work address. They are also granted limited, non-transferable 'anonymity vouchers', which allow them to transfer a specific amount of CBDC within a given timeframe without regulatory oversight of transaction data.
- **Third-party authentication**. Users obtain wallet addresses after undergoing an electronic KYC assessment conducted by an approved third-party authenticator. End-users are not anonymous if a homomorphically encrypted AML process triggers compliance flags, or if a court order requires disclosure of information. In addition, wallet balances are subject to upper limits.
- **Asymmetric privacy**. In this CBDC design, the privacy of consumers (senders of money) is maximally protected, while the privacy of merchants (receivers of money) is less protected (Tinn 2024).

7 CONCLUSION

The emergence of digital payment ledgers presents a transformative opportunity to expand access to uncollateralised credit, but it also introduces deep trade-offs at the heart of modern financial design. No institutional arrangement can simultaneously achieve efficient enforcement, limit rent extraction, and safeguard user privacy. Whether ledgers are operated by monopolistic

BigTech platforms, public central banks, or co-opetitive ecosystems, each approach resolves some dimensions of the trilemma in Figure 1 while compromising others. These tensions are further heightened by geopolitical considerations, as global platforms and foreign CBDCs threaten national monetary sovereignty. Navigating these challenges requires a careful balancing of objectives and a strategic blend of regulation, innovation, and institutional design.

REFERENCES

Berg, T, V Burg, A Gombović and M Puri (2020), "On the rise of fintechs: Credit scoring using digital footprints", *The Review of Financial Studies* 33(7): 2845–2897.

Brunnermeier, M and J Payne (2025), "Strategic money and credit ledgers", Princeton Working Paper.

Tinn, K (2024), "A theory model of digital currency with asymmetric privacy", available at SSRN 4891933.

ABOUT THE AUTHORS

Markus K. Brunnermeier is the Edwards S. Sanford Professor in the Economics Department at Princeton University, Director of Princeton's Bendheim Center for Finance, and a CEPR Research His research focuses on resilience, international financial markets and the macroeconomy with special emphasis on bubbles, liquidity, financial and monetary price stability, and digital money. Brunnermeier was president of the American Finance Association, is nonresident senior fellow at the Peterson Institute, a research associate at the National Bureau of Economic Research, the Centre for Economic Policy Research, CESifo, ABFER, and a member of the Bellagio Group on the International Economy. He is a Sloan Research Fellow, fellow of the Econometric Society, Guggenheim Fellow, and the recipient of the Bernácer Prize granted for outstanding contributions in the fields of macroeconomics and finance. He is a member of several advisory groups, including to the US Congressional Budget Office, the Bank for International Settlements, Bank of Japan, and the Bundesbank as well as previously to the International Monetary Fund, the Federal Reserve of New York, the European Systemic Risk Board.

Jonathan Payne is an Assistant Professor of Economics in Princeton's Department of Economics. His research studies questions in finance, banking, macroeconomics, economic history, computational economics and econometrics. He earned his Ph.D. from New York University and he joined the Princeton faculty in 2020 after spending a year as a Pyewacket Fellow at the Bendheim Center for Finance.

CHAPTER 19

Trading and lending in decentralised finance

Wenqian Huang[1]
Bank for International Settlements

Decentralised finance (DeFi) is a recent development that facilitates transactions without relying on traditional intermediaries. The underlying market infrastructure – order matching, custody, and margin management – is executed by smart contracts on public blockchains. Among the many building blocks that have emerged, two deserve particular attention: decentralised exchanges (DEXs) and decentralised lending protocols. Both dispense with conventional intermediaries, and both are now spilling over into the tokenisation of real-world assets such as property.

This chapter brings together the economics from three recent studies: Huang et al. (2025a) on credit cycles in tokenised real estate markets; Huang et al. (2025b) on DEXs for stablecoins; and Heimbach and Huang (2024) on leverage in DeFi lending. In what follows, we first explain how DEXs differ from order-book exchanges, then show how DeFi lending mimics collateralised finance, and finally discuss how both mechanisms combine to reshape markets for tokenised assets.

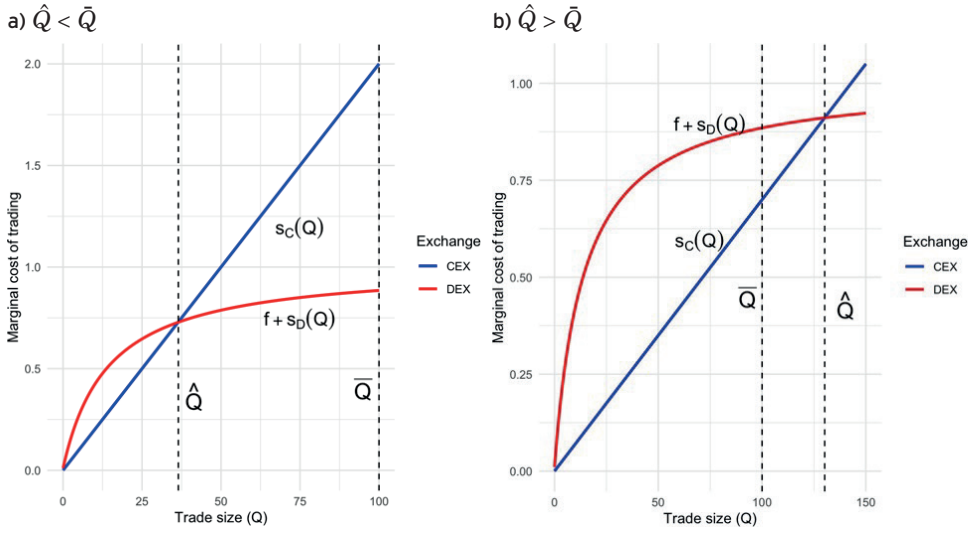
WHAT ARE DEXs?

A decentralised exchange is a smart contract – a programme living on a blockchain – that allows anyone to swap one crypto-asset for another. Instead of maintaining a limit-order book, a DEX pools the two assets in an 'automated market-maker' (AMM) and computes prices from a pre-set curve. The earliest and still most famous formula is the constant-product rule, $x \times y = C$, of Uniswap: the product of the token reserves must stay constant, so any trade that withdraws one token must deposit enough of the other token to keep C unchanged.[2]

We focus on Curve, a DEX specialised in trading stablecoins – tokens whose face value is pegged to fiat currencies. Because a stablecoin should trade near parity, the constant-product curve is too steep: a large order quickly empties the pool on one side and forces a big price dislocation ('slippage'). Curve therefore blends the constant-product with a constant-sum term, controlled by a curvature parameter, A. The higher A is, the flatter the curve around the 1:1 equilibrium.

1 The views are mine and not necessarily those of the Bank for International Settlements.
2 See detailed analysis in Lehar and Parlour (2025) and Capponi and Jia (2025).

FIGURE 1 MARGINAL COST OF TRADING ON THE CEX (IN BLUE) AND THE DEX (IN RED) AS A FUNCTION OF TRADE SIZE *Q*.



Note: Panel (a) shows the case where ρ = 0.1, while Panel (b) illustrates the case where ρ = 0.035. Other parameters are fixed at: $N_C = 5$, $A = 0.3$, $f = 0.01$, $X_D = 10$, and $\bar{Q} = 100$.

Figure 1 visualises the economics. The blue line is the marginal cost of executing a trade on a centralised exchange (CEX), where dealers charge a linear inventory cost. The red line is the marginal cost on the DEX, which is low for small imbalances but rises non-linearly once the pool tilts. The intersection gives a threshold order size $\hat{Q}$. Trades below $\hat{Q}$ stay on the CEX; large block trades migrate to the DEX, because one aggregated pool is cheaper than 'walking' a shallow order book. Two implications follow:

- First, liquidity on DEXs is complementary: if more liquidity providers top up the pool, slippage falls for everyone, encouraging yet more liquidity provision.
- Second, a flatter curve (larger A) or a narrower fee shifts $\hat{Q}$ leftwards, expanding the set of traders that prefer the DEX.

Empirically, we show that the average USDC-USDT trade on Binance (a CEX) is a mere $3,000, while on Curve it exceeds $575,000. When Curve was launched on 6 September 2020, intra-day price volatility of the three major stablecoins on Binance dropped by 5 basis points and mean absolute price deviations by 27 basis points relative to BUSD, a control coin not yet listed on Curve. Finally, governance votes that change A or the pool fee move not only on-chain liquidity but also average trade size on Binance in the predicted direction.

In short, a DEX can be understood as a crowd-funded dealer: it flattens price impact for large, uninformed stablecoin trades, but at the expense of the so-called 'impermanent loss' when fundamentals move and arbitrageurs rebalance the pool. The design parameter A must therefore strike a balance between attracting volume and protecting liquidity providers.

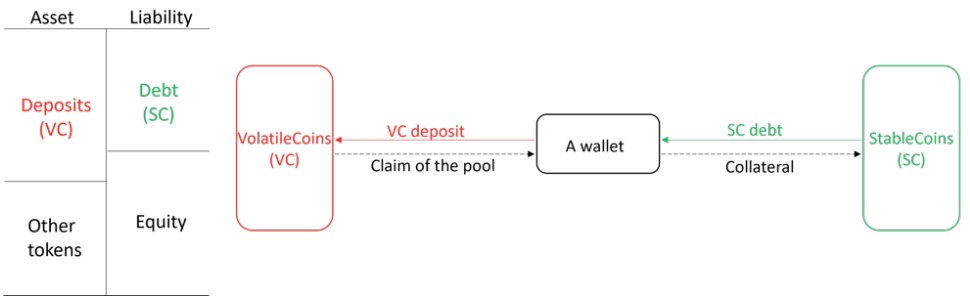
WHAT IS DEFI LENDING?

If a DEX replaces a dealer, a DeFi lending protocol replaces a repo desk. Users deposit crypto-assets, receive tokenised deposit receipts, and can immediately pledge those same receipts as collateral to borrow other assets. Interest rates and loan-to-value (LTV) ratios are set algorithmically and enforced by smart contracts. Should collateral value drop or debt rise, anyone can liquidate the position for a bounty – a brutally efficient margin call.

We analyse wallet-level data from Aave v1 & v2 and Compound v2 – which together account for 80% of Ethereum-based lending – over January 2021 to March 2023. Two leverage concepts are key. First, the implied leverage from the LTV ratio requirement is $Leverage^I = 1/(1 - LTV)$, i.e., the maximum a protocol allows. Second, the actual leverage is $Leverage = assets/equity$, which is what users choose.

Platforms advertise hefty limits (LeverageI between 3.3× and 6.9× for the main coins) but users in practice borrow far less. Figure 2 illustrates the mechanics: a wallet deposits volatile coins (e.g. ETH), borrows a dollar-stablecoin (e.g. USDC) and thus creates a leveraged long position on crypto prices.

FIGURE 2 MECHANICS OF DEFI LENDING

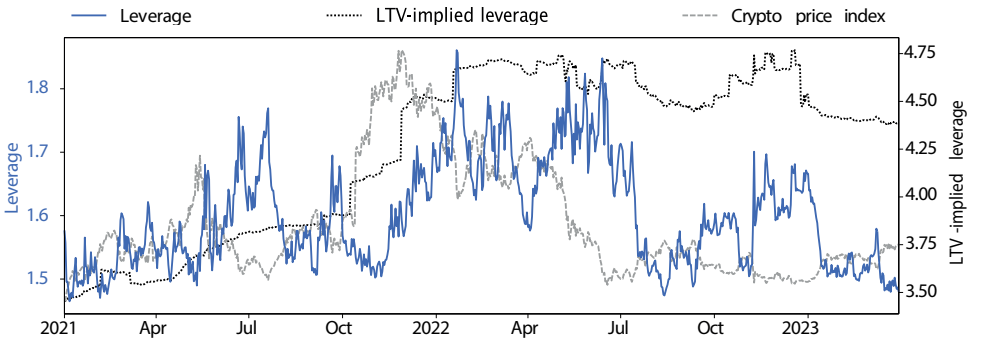


Note: This figure shows the balance sheet of a user that borrows stablecoins (SC) using volatile coins (VC) as collateral.

Figure 3 tracks the average leverage across all wallets: it hovers between 1.4× and 1.9×, well below the theoretical ceiling and closely shadows crypto price cycles with a three-month lag.

Why so conservative? Automatic liquidations are costly: collateral is sold at a discount, plus gas fees. Rational users therefore keep a buffer. Wallet-day regressions confirm that higher implied leverage (looser haircuts), lower net borrowing costs and bullish market sentiment all raise actual leverage, but even the largest and most active users typically stop at around 2×.

FIGURE 3 LEVERAGE VS LTV-IMPLIED LEVERAGE



Note: The figure plots the time series of average daily leverage (blue solid line) and implied leverage (black dashed line) across all wallets with outstanding debts. The grey dotted line in the background indicates the market-wide price movements of crypto assets.

Does leverage endanger the system? We compute the value-at-risk (VaR) of each lending pool – i.e. the share of debt whose health factor is within 10% of the liquidation threshold. Pool-day regressions show that a one standard deviation increase in average borrower leverage raises VaR by roughly 0.9 percentage points on Aave and 1.2 percentage points on Compound, a sizeable jump relative to a baseline of 3-5%. Actual liquidations, however, remain episodic, clustering around external shocks such as the Terra-USD collapse or the FTX bankruptcy. Finally, when borrowers are on the brink, some (but not all) switch collateral into more volatile coins in the hope of a rebound, and the propensity to 'gamble for resurrection' rises with leverage.

In sum, DeFi lending automates repo, but user behaviour looks surprisingly prudent. Nonetheless, leverage amplifies downside risk via VaR concentrations and strategic collateral shifts.

HOW DOES DEFI AFFECT TOKENISED-ASSET MARKETS?

Tokenisation promises to bring real-world assets (RWAs) – real estate, invoices, art, etc. – on-chain, where they can piggy-back on the deep liquidity and 24/7 settlement of DeFi. Yet, the same Lego blocks that improve efficiency could also import procyclical behaviours.

We use data from the RealT ecosystem, which includes over 700 US rental properties tokenised as ERC-20 tokens. The institutional set-up is as follows. First, a property is placed in an LLC and its equity is tokenised and sold for dollars. Second, tokens earn pro-rata rental income and can be deposited as collateral on the RMM lending market to borrow the stablecoin wxDAI at variable rates. In addition, secondary trading happens either in a DEX or, since February 2023, on a peer-to-peer offer book called YAM (standing for "**Y**ou **A**nd **M**e").

We merge the complete blockchain histories of borrowing and trading, and compare trades by wallets that borrowed earlier the same day with trades by non-borrowers.

On both the DEX and the YAM markets, borrower wallets trade more tokens per trade and pay higher prices, with a higher immediate price impact. In addition, a positive appraisal shock that lifts collateral value triggers new borrowing in large-borrower wallets, confirming a collateral-feedback loop akin to mortgage markets.

These results dovetail neatly with the mechanisms already seen for pure-crypto assets. On the one hand, DEX pricing means that big, leverage-fuelled buys move prices non-linearly. On the other hand, borrowing decisions respond to collateral valuations, reinforcing up-swings.

Importantly, we also find that average price dislocations remain 'bounded'. DeFi's ruthless margin calls and transparent order flow may impose a self-discipline absent in opaque mortgage securitisation. Still, the evidence warns regulators that tokenised RWAs are not insulated from procyclicality – they merely replay them at blockchain speed.

CONCLUSION

Decentralised exchanges and lending protocols are not just curiosities of the crypto world; they are laboratories for new market designs. DEXs show that a single liquidity pool with a smart pricing curve can outcompete traditional order books for near-par instruments. DeFi lending platforms demonstrate that fully automated collateral management can scale to billions without a single credit officer – though prudence ultimately rests on users' incentives. Real estate tokenisation reveals how these primitives can migrate to real assets, bringing both efficiency and the risk of leverage.

For regulators and economists, the message is subtle. Yes, code can embed robust constraints (slippage curves, health factors), but these same rules create cliff effects. Yes, DeFi is global and borderless, yet its valuations respond sharply to national policy because ramps to fiat and real assets remain jurisdictional. And yes, transparency is unprecedented, but so is the speed at which leverage and prices can spiral.

The agenda ahead, therefore, is twofold: continue studying the micro-economics of DeFi designs (the curvature of DEXs, the game theory of liquidators, the optimal haircut schedule) and, in parallel, craft supervisory hooks that respect decentralisation (if any) while containing systemic risk. In the end, DeFi may well earn its place alongside traditional institutions – not by replacing them, but by forcing all of us to rethink what good market design looks like in a programmable world.

REFERENCES

Capponi, A and R Jia (2025), "Liquidity provision on blockchain-based decentralized exchanges", *Review of Financial Studies*.

Heimbach, L and W Huang (2024), "Defi leverage", BIS Working Paper No. 1171.

Huang, W, V Laturnus, and D Ruf (2025a), "Tokenised real estate markets", BIS Working Paper (forthcoming).

Huang, W, N Rostova, and Z Song (2025b), "Decentralized exchanges for stablecoins", BIS Working Paper (forthcoming).

Lehar, A and C Parlour (2025), "Decentralized exchange: The Uniswap automated market maker", *The Journal of Finance* 80(1): 321–374.

ABOUT THE AUTHOR

Wenqian Huang is a Senior Economist at the Bank for International Settlements. Her research focuses on financial market infrastructures, systemic risk, and financial innovation, with a particular emphasis on decentralised finance (DeFi). Her work has been published in leading academic journals, including the *Journal of Financial Economics* and *Management Science*, and has been featured in major media outlets such as the *Financial Times* and Bloomberg.

CHAPTER 20

Retail trading in the era of digital finance: Risks, opportunities, and the need for policy innovation

Claudio Tebaldi[1]
Bocconi University

The global financial landscape is undergoing a profound transformation. A recent World Economic Forum insight report on retail trading highlights the rapid growth of financial retail participation, fuelled by accelerated digital adoption, rising affluence, and the expanding influence of the G20 consumer base (World Economic Forum 2025). This new cohort of investors – diverse in age, geography, gender, and income – demonstrates an earlier and more pronounced engagement with capital markets, a readiness to integrate technology into their investment journeys, and an openness to a broader array of financial products. While the democratisation of access offers the potential to extend market participation to traditionally underserved populations, this expansion also carries significant risks and challenges.

For example, India's securities regulator, the Security Exchange Board of India (SEBI) has documented a severe disconnect between market access and financial literacy. A SEBI study revealed that a staggering nine out of ten individual traders lose money in this segment, with total annual losses skyrocketing from $4.7 billion to $12.2 billion by March 2024 (SEBI 2024). This demonstrates that while technology has granted access to complex products, the inherent risks of leveraged trading are not being adequately understood or managed by a new generation of traders.

Consider, for example, the expansion of so-called decentralised finance opportunities emerging within the blockchain ecosystems. These have exploded over the past few years, creating a myriad of asset digital types, and a completely new taxonomy has emerged. The new jargon lends itself to marketing narratives and serves the purpose of capturing the attention of financial consumers. Financial innovation is notoriously harmed by these dynamics. Biais et al. (2012) analyse the implications of moral hazard in the early phases of new product development. Uncertainty makes it difficult to monitor managers and ensure they exert the effort necessary to reduce default risk. Initial successes spur optimism and growth, but increasingly confident managers end up requesting large rents. If these become too high, investors give up on incentives giving rise to endogenous crises. Bolton et al. (2016) propose a model in which investors

1 The author acknowledges financial and organisational support of the M.U.S.A. PNRR project, MUR- Prin 2022- Prot. 20227TCX5W, NextGenerationEU.

may choose to acquire costly information that identifies good assets and purchase these assets in opaque markets. They show that the equilibrium acquisition of information is generically inefficient. Informed investors don't just get access to the best assets, they also benefit from the cream-skimming activities of other informed dealers which helps them extract better terms from the asset sellers. Hence, uninformed investors access an asset pool that has been cream-skimmed by informed ones.

While the above considerations make a clear case for regulatory intervention, the current institutional landscape remains fragmented, marked by a patchwork of regional approaches and volatile institutional architectures influenced by political narratives. De facto, digital innovation brings with itself technology-driven deregulation, and finding the right balance between fostering innovation and protecting retail investors is difficult.

I contribute to the ongoing debate by proposing a new scheme to articulate the regulatory challenge. This framework draws inspiration from the so-called blockchain trilemma that emerges in the design of blockchain protocols.[2] This states that it is impossible to simultaneously achieve the following:

- **Security**: the system is resistant to attacks and ensures that transactions are valid and cannot be tampered with.
- **Scalability**: the system can handle a large number of transactions quickly and efficiently, even as more users join.
- **Decentralisation**: the system is not controlled by a single person or small group; instead, many participants (nodes) around the world help maintain it.

Different designs inevitably prioritise certain objectives over others, targeting a specific trade-off among these three goals. Similarly, regulation in digital financial markets must strike a balance between the following three, hard-to-reconcile, characteristics:

- **Protection of financial consumer rights**: ensuring transparency, fairness, and safeguards against fraud or abuse.
- **Large-scale participation**: enabling broad and efficient market access without compromising stability.
- **Inclusive stakeholder governance**: giving diverse participants a meaningful role in shaping market rules and oversight.

2 A blockchain protocol is the set of rules and procedures that defines how a blockchain network operates. It governs how transactions are validated, nodes reach consensus so that blocks are added, and participants interact securely and fairly.

In the traditional approach, *protection of financial consumer rights* is enforced by consumer protection laws, financial regulations (e.g. Markets in Financial Instruments Directive (MiFID) II in the EU; Dodd-Frank in the United States), codes of conduct from regulators or financial institutions, and international guidelines (e.g. OECD; World Bank "Good Practices"). They can be articulated as follows:

- **Right to information**: consumers must receive clear, accurate, and timely information about financial products, including fees, risks, and terms and contractual obligations.
- **Right to choose**: consumers should have access to a variety of financial products and providers, allowing them to compare and select the most suitable option without coercion or unfair bundling.
- **Right to financial education**: consumers have a right to education and resources to help them make informed decisions and understand their rights and obligations.
- **Right to privacy**: consumers have the right to the protection of their financial data, which must not be shared or used without consent, except where legally required.
- **Right to redress**: consumers should have access to affordable and effective mechanisms to resolve disputes, such as ombudsman services, mediation, or legal remedies.

While these principles are not controversial, their enforcement is particularly difficult when financial services are offered through digital platforms. A clear example of regulation-heavy implementation is the European approach. MiFID rests on key pillars such as mandatory suitability and appropriateness tests, which product providers must perform before offering investments to different client categories. It also promotes fair competition across trading venues and enforces robust conduct standards for financial firms – all aimed at fostering efficient, integrated, and trustworthy markets. For instance, business models such as payment-for-order-flow arrangements are prohibited under this jurisdiction. The second pillar of EU consumer protection is the General Data Protection Regulation (GDPR), enacted in May 2018. This establishes a robust legal framework that gives individuals greater control over their personal data, while imposing strict obligations on organisations that collect, process, or store such data – both within and outside the EU. Many digital finance platforms rely on data collection for algorithmic analysis (e.g. for credit scoring or robo-investing). GDPR limits profiling and requires transparency and human oversight, especially when decisions have legal or significant effects on users.

It is fair to say that, among other factors, this regulatory approach is not fostering *large-scale participation* and poses strict limitation to digital economies of scale. In fact, these strict requirements are a well-known source of *increased compliance costs*. Platforms must invest in dedicated data protection officers and internal systems to

manage data requests. Failure to comply risks hefty fines. Not unexpectedly, retail trading in the European region is lagging, with recent survey-based evidence[3] showing that retail trading volume amounts to less than 10% of the total, with a significant lag with respect to to US, UK, Chinese, or Indian capital markets, where the fraction of retail trades generally exceeds 20-25%.

This regulation-heavy approach is also criticised for being distortionary. A common example is the effort to strengthen consumer protection by restricting retail investors' direct access to high-risk investments.[4] Such access is often seen as incompatible with broader concerns about the complexity of certain financial products that may expose consumers to unnecessary or unmanageable risks (Ghent et al. 2019). While portfolio-level risk diversification is undoubtedly desirable, the choice of an individual risk profile is ultimately a matter of personal preference. Limiting access to securities with high embedded leverage reduces the scope for risk-taking and has drawn strong criticisms from the advocates of the democratisation of markets.

Indeed, the most striking trend in modern retail trading is the explosive growth of derivatives, particularly options and futures. The global futures market has seen record-breaking volumes for six consecutive years, with 137 billion contracts traded in 2023, representing a 64% increase over 2022. This boom is attributed to the inherent features of these instruments, including the ability to leverage positions and implement event-driven strategies around news announcements and earnings reports. The 'Tesla complex' offers a well-known example of the structural changes brought to the capital market by the retail demand for options. Tesla's options market is uniquely large – often exceeding $200 billion in daily notional value and surpassing the rest of the S&P 500 single-stock options combined. This makes the stock highly responsive to derivatives flow rather than financial performance or other fundamentals. This implies that retail option positions have become mechanically influential in driving the stock's price through gamma hedging, where market makers are forced to buy shares in response to massive retail demand for short-dated call options. This dynamic creates powerful, self-reinforcing price surges largely disconnected from fundamentals, making Tesla behave more like a momentum-driven financial instrument than a traditional equity. As a result, Tesla has become 'too big to short', reshaped volatility signals across markets, and evolved into a highly reflexive, narrative-driven asset at the heart of a global options ecosystem.

The burden of ensuring informed participation and financial education at scale is increasingly shifting to the design of the platforms themselves (Arner et al. 2017). In this context, AI-powered tools – especially scalable robo-advisory systems – can play a pivotal role in operationalising the right to financial education and advice, which is central to modern consumer protection regimes. For traditional financial

3 Data source: Household Finance Consumption Network statistics
4 India's markets regulator is advocating 'structural reforms' for the country's derivatives market, following measures to limit retail participation

intermediaries, such investments may be not only strategic but existential, allowing them to remain competitive while contributing to a more inclusive and transparent digital finance ecosystem. By embedding personalised real-time guidance into user interfaces, robo-advisory technologies can reduce information asymmetries, mitigate behavioural biases, and promote more responsible risk-taking – key elements in aligning retail investor outcomes with public policy objectives (OECD 2023, Sironi 2016).

Paradoxically, while Europe is underperforming in traditional and derivative retail investment, it has emerged as a strong participant in crypto markets, showing that 'gamification' of digital financial investment and an increased risk appetite is a global trend among younger demographics. Segmentation between regulation-heavy compliant institutions and the 'Wild West' of crypto investing is clearly suboptimal, and regulators are rapidly expanding their action to crypto-assets. The Markets in Crypto-Assets Regulation (MiCAR), the EU's comprehensive legal framework for crypto-assets, was adopted in 2023 and has entered into force gradually starting mid-2024. These regulatory efforts have so far overlooked the critical challenge of ensuring that new investment opportunities are supported by *inclusive stakeholder governance* – the third pillar of the digital market trilemma.

While crypto-space narratives emphasise the role of blockchain and distributed ledger technologies as a way to decentralise and disintermediate control of financial resources, the emergent landscape has shown that those solutions that offer consumers greater control over their private data and contents are struggling. Their development is lagging relative to the centralised counterparts they are trying to replace. There is emerging consensus around the fact that it is difficult to undo the entrenched network effects of the leading centralised digital platforms. Pure algorithmic decentralisation may be overly expensive and, without legal enforcement, most of the decentralised platforms are actually controlled by a small number of agents, or even a single agent, that effectively act as intermediaries.[5]

In other words, the heterogeneity of organisational configurations enabled by the adoption of blockchain and distributed ledger technologies, particularly the emergence of decentralised autonomous organisations (DAOs), highlights the urgent need for a new regulatory framework capable of enforcing the core principles of governance.[6] Such a regulatory framework would ensure that crypto-asset issuers are governed according to core principles of transparency, accountability, and stakeholder alignment. To preserve market integrity and investor trust, the hybrid organisational forms emerging as token issuers – the capital demand side of the crypto-asset ecosystem – should meet governance standards comparable to those long applied to corporations accessing public markets.

5 There is a growing consensus on the limits of decentralization (e.g. Budish 2025, Bakos and Halaburda 2022, Cong et al. 2025).
6 For a related discussion about the regulation of decentralized organization, see also Tebaldi (2024).

REFERENCES

Arner, D W, J Barberis and R P Buckley (2017), "FinTech, RegTech, and the Reconceptualization of Financial Regulation", *Northwestern Journal of International Law & Business* 37(3): 371–413.

Bakos, Y and H Halaburda (2022), "Will blockchains disintermediate platforms? the problem of credible decentralization in DAOs", available at SSRN.

Biais, B, J-C Rochet and P Woolley (2012), "Innovations, rents and risk", De Nederlandsche Bank Working Paper No. 356.

Bolton, P, T Santos, and J A Scheinkman (2016), "Cream-skimming in financial markets", *The Journal of Finance* 71(2): 709-736.

Budish, E (2025), "Trust at scale: The economic limits of cryptocurrencies and blockchains", *The Quarterly Journal of Economics* 140(1): 1-62.

Cong, L W, D Rabetti, C C Wang and Y Yan (2025), "Centralized governance in decentralized organizations", available at SSRN.

Ghent, A C, W Torous and R Valkanov (2019), "Complexity in Structured Finance", *The Review of Economic Studies* 86(2): 694–722.

OECD – Organisation for Economic Co-operation and Development (2023), *The Role of Digital Financial Advice in Strengthening Consumer Protection*.

SEBI – Security Exchange Board of India (2024), "Analysis of Profits & Losses in the Equity Derivatives Segment (FY22-FY24)" (https://www.sebi.gov.in/reports-and-statistics/research/sep-2024/study-analysis-of-profits-and-losses-in-the-equity-derivatives-segment-fy22-fy24-_86905.html)

Sironi, P (2016), *FinTech Innovation: From Robo-Advisors to Goal-Based Investing and Gamification*, Wiley.

Tebaldi, C (2024), "A new model of sustainable digital development for european business network", in F Decarolis et al., *Rules that Empower Institute for Economic Policy*, Bocconi University.

World Economic Forum (2025), *2024 Global Retail Investor Outlook*.

ABOUT THE AUTHOR

Claudio Tebaldi is an Associate Professor of Quantitative Methods for Economics, Finance, and Insurance at Bocconi University since 2011. He serves as Managing Editor of *Quantitative Finance* and Scientific Director of the Bocconi Fintech Lab. He is a member of PhD in Economics and Finance Executive Council. His research, published on top tier journals and teaching activities are focused asset pricing, derivatives valuation, interest rate theory, and risk management. In 2025 he visited the European

Central Bank. He received the Best Paper Award at the North American Finance Association (2019) and at the Swiss Econometrics and Finance Society (2007). Previous visiting appointments include UCLA Anderson (2004) and the Niels Bohr Institute, Copenhagen (1998).

CENTRE FOR ECONOMIC POLICY RESEARCH

Digital innovation is transforming money and redrawing the global financial landscape. From instant payments to stablecoins, CBDC, and tokenised assets, new technologies are redefining how value is created, stored, and exchanged – reshaping the roles of banks, central banks, and markets. Yet this transformation is far from uniform: while some economies are leaping ahead, others lag behind, and divergent views on the state's role in money are creating tensions over sovereignty, control, and interoperability.

Bringing together leading researchers and policymakers, this volume offers a panoramic view of the forces reshaping the financial architecture. It examines regional trajectories – from India and Brazil to sub-Saharan Africa, the United States, and the euro area; the development of and regulatory response to stablecoins; the challenge of maintaining monetary 'singleness' amid the growing variety of digital money; and the implications of tokenisation and decentralised finance for credit, financial inclusion, and stability.

187 boulevard Saint-Germain | 75007 Paris | France
2 Coldbath Square | LONDON EC1R 5HL | UK
TEL: +44 (0)20 7183 8801 | EMAIL: CEPR@CEPR.ORG
WWW.CEPR.ORG