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Contents

Abstract	4
Non-technical summary	5
1 Introduction	6
2 Selected abstracts	7
2.1 Stablecoins – overview and regulatory developments	7
2.1.1 Just another crypto boom? Mind the blind spots	7
2.1.2 Electronic money tokens in Europe: the changing landscape of US dollar-denominated and euro-denominated stablecoins in the EU	8
2.1.3 Stablecoin multi-issuance schemes with issuers in the EU and third countries	9
2.1.4 The interplay between the Markets in Crypto-Assets Regulation and the revised Payment Services Directive	10
2.2 Stablecoins and central bank digital currencies	11
2.2.1 Potential complementarity of the digital euro and euro money tokens issued in the private sector	11
2.2.2 Central bank money as a catalyst for fungibility: the case of stablecoins	12
2.2.3 Foreign exchange implications of central bank digital currencies and their integration via bridge coins	13
2.3 How stable are stablecoins' values relative to reference assets?	14
2.3.1 Making or breaking the peg? Predicting stablecoins' Betelgeuse moment	14
2.3.2 Are stablecoins stable or is their stability just a flip of the coin?	15
2.4 Crypto-asset insights from survey data	16
2.4.1 Crypto-asset ownership in the euro area: a comparison of different retail surveys	16
2.4.2 Who holds and pays with crypto-assets? Global trends and Slovak evidence	17
2.4.3 Distributed ledger technology-related activities among significant institutions of the Single Supervisory Mechanism	18

2.5	Regulatory reporting under the Markets in Crypto-Assets Regulation and institutional initiatives to close data gaps	19
2.5.1	MIDAS: the case for EU-level market surveillance of crypto-assets	19
2.6	Towards reliable crypto-asset data – terminology, classification and other issues	20
2.6.1	Digital money and finance: a critical review of terminology	20
2.6.2	Crypto-asset data collection – experience and challenges	21
2.6.3	Investigating the reliability of crypto data	22
2.7	Investigating shocks, stress and scams in crypto-assets	23
2.7.1	What if Ether goes to zero? How market risk becomes infrastructure risk in crypto	23
2.7.2	Digital asset integration in the financial system: evidence from Austria	24
2.7.3	What can we learn from a major crypto-asset scam? A Slovak case study from 2025	25
2.7.4	Private money and public debt: stablecoins and the global safe asset channel	26
2.8	Interlinkages	27
2.8.1	Interconnections between financial markets and crypto-asset markets	27
2.8.2	Crypto-assets and macroeconomic conditions: a reassessment	28
2.9	Tokenisation	29
2.9.1	The fully tokenised bank’s balance sheet	29
2.9.2	Distributed ledger technology-based bonds – level of adoption and business models	30
2.9.3	Use of permissioned vs permissionless and public vs private distributed ledger technology platforms in the financial sector	31
2.9.4	Reinventing custody services to address the tokenisation revolution	32
2.9.5	Evolving secret sharing for crypto-asset custody and regulatory compliance	33
2.10	Issues related to decentralised identity and privacy	34

2.10.1	Decentralised identity with selective disclosure	34
2.10.2	Privacy-enhancing mechanisms	35
2.10.3	Balancing privacy and regulation in the design of future digital payment systems	36
3	Way forward	37

Abstract

This paper provides an overview of analytical work¹ conducted largely in 2025, under their own aegis, by experts from various European central banks and authorities in the field of crypto-asset monitoring and presented at the Crypto-Asset Monitoring Expert Group (CAMEG) 2025 Conference. Currently, risks stemming from crypto-assets and the potential implications for central banking and relevant authorities' domains remain limited and/or manageable, also given the existing regulatory and oversight frameworks. Nevertheless, the importance of monitoring developments in crypto-assets, raising awareness of the potential risks and fostering analytical preparedness cannot be overstated.

This paper offers a brief background of the 2025 activities of CAMEG, which brings together experts from the European System of Central Banks and the European Banking Authority. It also provides abstracts from various CAMEG and non-CAMEG papers and other analytical works presented at the conference held on 30 and 31 October 2025. The conference aimed to take stock of analytical work and data issues in the area of crypto-assets, while fostering European collaboration and monitoring in this field.

Finally, this paper outlines the prospective way forward for CAMEG, focusing on gaining greater insight into data and deepening analytical work on interlinkages, crypto-asset adoption and the latest trends.

Keywords: crypto-assets, monitoring, crypto-asset risks, crypto-asset data.

JEL codes: E42, G21, G23, O33

¹ It should be noted that although the analytical work was conducted by experts from European central banks and other authorities, it should not be taken as representing the views of the institutions to which those experts are affiliated.

Non-technical summary

This paper provides an overview of analytical work conducted largely in 2025, under their own aegis, by experts from various European central banks and authorities in the field of crypto-asset monitoring and presented at the Crypto-Asset Monitoring Expert Group (CAMEG) 2025 Conference. The period in scope was prolific with various crypto-asset developments, both in Europe – with the [Markets in Crypto-Assets Regulation](#) (MiCAR) becoming fully applicable – and the United States – with the favourable regime, including the Guiding and Establishing National Innovation for US Stablecoins (GENIUS) Act, fuelling renewed investor interest in crypto-assets. Currently, risks stemming from crypto-assets and the potential implications for domains concerning central banking, banking supervision and the regulation and supervision of financial markets remain limited and/or manageable, also given the existing regulatory and oversight frameworks. Nevertheless, the importance of monitoring developments in crypto-assets, raising awareness of potential risks and fostering analytical preparedness cannot be overstated.

This paper offers a brief background of the 2025 activities of CAMEG, which brings together experts from the European System of Central Banks (ESCB) and the European Banking Authority. The availability of common crypto-asset datasets for the ESCB continues to be a key factor in the operation of CAMEG. CAMEG is a good example of effective European collaboration on innovative topics, such as crypto-asset analytics, distributed ledger technology and tokenisation.

A selection of abstracts from papers and other analytical works, by CAMEG and non-CAMEG members, presented at the second CAMEG conference makes up the main body of this paper. The conference, which was held on 30 and 31 October 2025, aimed to take stock of analytical work and data issues in the field of crypto-assets, while fostering European collaboration and monitoring in this area.

The conference in its initial sessions revolved around stablecoins – covering regulatory developments, a comparison with central bank digital currencies and their price stability, including early warning indicators of de-pegging. Another session of the conference provided insights into the question of who holds and uses crypto-assets based on survey evidence. Subsequent sessions examined MiCAR reporting and institutional initiatives to close data gaps as well as terminology, classification and other developments aimed at ensuring reliable crypto-asset data. The conference provided insights into interlinkages and shocks, stress and scams in crypto-asset markets. Several presentations delved into various tokenisation aspects. Finally, the conference showcased selected analyses concerning decentralised identity and privacy.

Finally, this paper outlines the prospective way forward for CAMEG, focusing on gaining even greater insight into data in this field and further deepening analytical work on interlinkages, crypto-asset adoption and the latest trends.

1 Introduction

Crypto-asset risks and the potential implications for central banking domains are currently limited and/or manageable, also given the existing regulatory and oversight frameworks. Nevertheless, monitoring crypto-asset developments, raising awareness of the potential risks and cultivating analytical preparedness continue to be important, especially considering that the period in scope (largely 2025) was prolific with various crypto-asset developments, both in Europe – with the Markets in Crypto-Assets Regulation becoming fully applicable – and the United States – with the favourable regime, including the Guiding and Establishing National Innovation for US Stablecoins (GENIUS) Act, fuelling renewed investor interest in crypto-assets.

The Crypto-Asset Monitoring Expert Group (CAMEG), established in late 2023 by the ECB's Directorate General Statistics in conjunction with the Eurosystem Innov8 Forum², focuses solely on crypto-asset monitoring, while acknowledging that relevant committees of the European System of Central Banks address crypto-asset matters as required. The first CAMEG conference³ marked the end of the initial 2024 wave of operations. In the second wave, more than 50 experts from 15 European central banks⁴ and the European Banking Authority participated in CAMEG work.

The conference held on 30 and 31 October 2025 marked the culmination of the second wave of CAMEG work. This event provided an opportunity to update participants on developments in the field of crypto-assets and to engage in open debate on the data challenges and opportunities faced by central banks and other authorities as regards crypto-asset monitoring. More than 30 (CAMEG and non-CAMEG) presentations were included on the agenda, bringing together a vast amount of information on the analytical and monitoring activities performed, under their own aegis, by experts from European central banks and authorities. By compiling a selection of abstracts, this paper provides insights into the issues discussed.

² The Eurosystem Innov8 Forum is an informal working group that supports coordination of the Bank for International Settlements Innovation Hub (BISIH) Eurosystem Centre and serves as an information-sharing and collaboration platform for innovation within the Eurosystem.

³ ECB (2025), "[Crypto-Asset Monitoring Expert Group \(CAMEG\) 2024 Conference – Book of abstracts](#)", *Occasional Paper Series*, No 368, February.

⁴ Banca d'Italia, Banco de España, Banco de Portugal, Suomen Pankki – Finlands Bank, Bank of Greece, Banque centrale du Luxembourg, Banque de France, Nationale Bank van België/Banque Nationale de Belgique, Central Bank of Ireland, Danmarks Nationalbank, De Nederlandsche Bank, Deutsche Bundesbank, European Central Bank and Oesterreichische Nationalbank.

2 Selected abstracts⁵

2.1 Stablecoins – overview and regulatory developments

2.1.1 Just another crypto boom? Mind the blind spots

Senne Aerts, Alexandra Born,
Zakaria Gati, Urszula Kochanska,
Claudia Lambert, Elisa Reinhold,
Anton van der Kraaij

The market capitalisation of crypto-assets has surged recently, fuelled by positive and broadening investor interest, including from traditional finance. Several key financial stability risks associated with crypto-assets have been identified in past editions of this publication, and by the Financial Stability Board. They include, among others (i) interconnectedness with traditional finance, (ii) market volatility and lack of transparency, (iii) liquidity and maturity mismatches, and (iv) leverage and concentration. This special feature focuses on the first two. For these sources, risks to financial stability in the euro area appear limited, but there are signs that interconnectedness between the crypto-asset ecosystem and the traditional financial sector is strengthening. As it does, new channels of potential contagion are opening up, warranting closer monitoring. At the same time, euro area households' direct exposures are slowly rising from low levels. Data gaps, especially for the crypto-asset exposures of non-banks and leverage, pose challenges both for monitoring and for assessing the scale of these sources of systemic risk. It is therefore essential that these data gaps be closed and that responsible authorities remain vigilant. Although the EU has established a stringent regulatory framework, global regulation is either fragmented or absent, raising the risk of regulatory arbitrage and contagion from abroad.

Keywords: crypto-assets, financial stability.

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- Senne Aerts, Alexandra Born, Zakaria Gati, Urszula Kochanska, Claudia Lambert, Elisa Reinhold and Anton van der Kraaij: European Central Bank

⁵ Since not all abstracts correspond to published papers, publishing venue and JEL classification details are provided only when relevant.

2.1.2 Electronic money tokens in Europe: the changing landscape of US dollar-denominated and euro-denominated stablecoins in the EU⁶

Conor Kelly, H lo se Rosset,
Olivier Wolff

This paper takes stock of the EU's market for stablecoins between January 2023 and September 2025, combining the granularity of geo-attributed on-chain flow data with market-wide capitalisation and volume series. It contrasts EU activity with other major economic areas and traces country-level developments to provide an overview of usage patterns and cross-border flows. Using the introduction and rollout of the Markets in Crypto-Assets Regulation (MiCAR) as a natural regime change in the EU, the paper investigates the changes in market activity attributed to member countries.

The paper employs cumulative net flows as a proxy for changes in holdings around key market developments and MiCAR milestones to investigate their potential impact on market activity. It documents the delisting of major non-compliant tokens by crypto-asset service providers, the rebalancing of on-chain and off-chain activity towards compliant US dollar-denominated alternatives, followed by a temporary compression in trading volumes despite a continued net accumulation of US dollar-denominated stablecoins by EU residents.

Using on-chain analytics, the paper then analyses the trends among euro-denominated stablecoins. While they represent a small subset of the global stablecoin market, they are steadily growing in both market capitalisation and activity. The paper provides an overview of the evolution of euro-backed electronic money token issuers since 2022, contextualises their position in the broader stablecoin market and assesses the integration of institutional players in this ecosystem amid increasing regulatory clarity.

Keywords: stablecoins, cross-border flows, MiCAR, financial stability.

JEL codes: E32, E42, E58 G11, G15, G23, G28

Authors' affiliation:

- Conor Kelly, H lo se Rosset: Central Bank of Ireland;
- Olivier Wolff: European Central Bank.

⁶ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.1.3 Stablecoin multi-issuance schemes with issuers in the EU and third countries⁷

Agapi Kasimati, Alice Filippetta,
Georgios Karanikolas

The accelerated development of global stablecoin markets has given rise to third-country multi-issuer schemes, an emerging structural innovation that is attracting increasing academic and policy scrutiny. These schemes involve the joint issuance of indistinguishable and fungible stablecoins by entities domiciled both within and outside the EU, resulting in complex cross-border linkages in governance and reserve management. This has the potential to amplify risks associated with stablecoins.

The objective of this study is to provide a factual and objective analysis of the presence of such third-country multi-issuer schemes, starting with a definition of said schemes, looking at their key components and conducting an in-depth analysis of two primary use cases within the EU stablecoin market.

The second part illustrates how these schemes may intensify vulnerabilities, particularly in the domains of reserve management, redemption rights and fragmented regulation oversight. The research further explores the prospective integration of stablecoins into the banking system and payment infrastructure, noting that such developments may induce deposit disintermediation as well as heighten liquidity and operational risks. Further challenges including volatility, the risk of runs, reserve asset fire sales, the risk of de-pegging and spillover risk could prove pertinent to financial stability.

The findings indicate that these risks may be amplified by the cross-jurisdictional nature of multi-issuer schemes.

Keywords: stablecoins, electronic money tokens, third-country multi-issuer schemes, cross-border.

JEL codes: E42, E58, F21, F38, G15, G28, O33

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- Alice Filippetta: European Central Bank;
- Georgios Karanikolas: European Banking Authority.

⁷ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.1.4 The interplay between the Markets in Crypto-Assets Regulation and the revised Payment Services Directive⁸

Agapi Kasimati, Teele Rossi

This analysis reviews the regulatory interplay between the Markets in Crypto-Assets Regulation and the revised Payment Services Directive (PSD2), with a focus on crypto-asset service providers (CASPs) offering electronic money token (EMT) services. The discussion is exclusively based on the “no action” letter published by the European Banking Authority (EBA) on 10 June 2025. This analysis does not represent new empirical findings but synthesises and interprets the guidance provided in the EBA’s letter for practitioners and policymakers.

The EBA’s no action letter highlights significant overlaps in regulatory scope, leading to potential dual authorisation requirements, dual licensing and risks of regulatory arbitrage across EU Member States. In response to the potential overlap issue, the EBA provides guidance to national competent authorities (NCAs), as well as advice to the European Commission, European Council and European Parliament. The letter recommends that, until 2 March 2026, CASPs offering certain EMT-related services should not be required to obtain PSD2 authorisation and that NCAs should deprioritise the enforcement of specific PSD2 provisions while insisting on others. From 2 March 2026 onwards, PSD2 authorisation will be required for CASPs or, alternatively, partnering with a payment service provider. The guidance further clarifies exemptions to these guidelines in terms of which services should not be classified as payment services requiring PSD2 authorisation.

These guidelines aim to reduce the regulatory burden during the transition period while PSD2 still applies, prior to a long-term resolution with PSD3 and Payment Services Regulation legislative updates.

Keywords: crypto-assets, electronic money tokens, regulation.

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⁸ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.2 Stablecoins and central bank digital currencies

2.2.1 Potential complementarity of the digital euro and euro money tokens issued in the private sector⁹

Beat Weber

Based on a joint paper by several co-authors¹⁰ entitled “Euro Money Tokens: Potential Economic Role of CBDCs and Euro-Denominated Stablecoins”, this presentation selectively explores potential complementarities between the digital euro and euro-denominated stablecoins. With the Markets in Crypto-Assets Regulation, the EU offers a legislative framework for the legal operation of “stablecoins” denominated in euro as electronic money tokens (EMTs), providing an opportunity for licensed European issuers. Currently, demand for euro-denominated EMTs is still weak.

Future growth of compliant EMTs is likely to require an increase in the quality of supply and substantial market-creating activities focused on specific use cases, making value propositions for users by innovating and/or addressing pain points in existing solutions. Among possible use cases outside of crypto trading, cross-border payments involving businesses or individuals domiciled outside the euro area offer potential. Offering such services could help strengthen the international role of the euro, complementing the future digital euro with its focus on domestic retail payments. For banks, issuing EMTs to customers for specialised payment purposes could be a way to differentiate prices, offer different “rails” of payment services and new functionalities at lower fees to retain existing customers or gain new customers in specific segments (e.g. cross-border payments), or introduce new service bundles (e.g. tokenised asset trades). The economics of the payment business provide incentives for alliance building among EMT issuers. By pooling resources, for example, they could share costs and risks, generate network effects, avoid fragmentation, achieve scale and create ecosystems around EMTs (wallets, tokenised assets, distributed ledger technology-based services) that could complement, interact with and benefit from current Eurosystem efforts to update wholesale payment systems based on new technologies.

Keywords: crypto-assets, payments, stablecoins, electronic money tokens, digital euro.

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<https://www.oenb.at/en/Publications/payments/oenb-bcg-euro-money-tokens.html>

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⁹ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

¹⁰ Petia Niederländer, Beat Weber, Asen Naydenov, Miriam Haschka, Johannes Duong and Maximilian Pfeifer (Oesterreichische Nationalbank); and Christian Schmid, Christian N.Schmid, Benjamin Desalm, Markus Ampenberger, Bernhard Kronfellner, Susanne Zubler, Jan-Oliver Froehlich, Nikolai Pomortsev, Anna Loleit and Natalija Paczkowska (Boston Consulting Group).

2.2.2 Central bank money as a catalyst for fungibility: the case of stablecoins¹¹

Charles-Enguerrand Coste,
George Pantelopoulos

To ensure that means of payment are readily interchangeable at face value – i.e. fungible – for retail payments, three elements are required: (1) settlement finality, (2) interoperability, and (3) seamless convertibility of the means of payment into the ultimate or quasi-ultimate means of payment. This paper argues that stablecoins issued by different issuers on different blockchains can be fungible to the same extent as commercial bank deposits from different banks, provided that (i) payment and settlement technologies are interoperable, (ii) payments are transacted on ledgers that offer settlement finality, and (iii) central bank money acts as the anchor to the monetary system (assuming that the central bank money is itself underscored by a homogenous unit of account). On this basis, this paper asserts that tokenised funds and off-chain collateralised stablecoins are fungible means of payment under certain conditions, and that on-chain collateralised stablecoins can be prima facie classified as fungible means of payment as long as the identical preconditions associated with payment fungibility for tokenised funds/off-chain collateralised stablecoins can be fulfilled and the on-chain collateral can be readily converted into higher-level money. Finally, it is determined that algorithmic stablecoins are not fungible means of payment.

Keywords: stablecoins, electronic money tokens, fungibility, central bank.

JEL codes: B26; E42

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¹¹ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.2.3 Foreign exchange implications of central bank digital currencies and their integration via bridge coins¹²

Alexis Derviz

The need for central bank digital currencies (CBDCs) is often justified by the fact that they facilitate cross-border transactions. Therefore, when several central banks introduce CBDCs, interoperability requirements will create demand for a common payment infrastructure and a joint digital accounting unit (bridge coin). Many attributes of the latter resemble those of private digital currencies. At the same time, the CBDC-embracing authorities will actively contribute to elevating digital wallets to the position of household technology. In such a world, will fiat currencies and the central banks that issue them be sidetracked by the bridge coin? Are old and new forms of international transaction able to coexist? What changes await the traditional foreign exchange (FX) market? What happens to the FX market when agents are first allowed to use digital means of payment only inside the country, then the opportunity set is expanded to include exchange of these digital units for the foreign fiat currency (the bridge coin functionality) and, finally, both domestic and foreign goods can be purchased with (now truly global) digital units directly? These questions are addressed in a two-country, two-good, two-currency dynamic stochastic general equilibrium model with a global digital currency. We consider an FX transaction cost specification that reflects the currently prevailing three-tier FX participant structure (retail clients, intermediaries preferring straight-through order processing and major dealer banks). Given these FX attributes, all three partial FX markets coexist and the use of fiat currency in foreign trade is unlikely to be eliminated completely, as long as the bridge coin operator is unable to become a global banker as well.

Keywords: central bank digital currency, cross-border payments, bridge coin, FX market.

JEL codes: E02 G23 C61 C63 D58 E59

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¹² This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.3 How stable are stablecoins' values relative to reference assets?

2.3.1 Making or breaking the peg? Predicting stablecoins' Betelgeuse moment¹³

Eleonora Basilico, Laura Painelli, Maha Abbassi, María Cristina Molero Blazquez, Nico Salemans, Olivier Wolff, Paul Grau, Ronald Heijmans, Urszula Kochanska

Stablecoins, with a market capitalisation approaching USD 300 billion, are becoming increasingly entangled with the traditional financial system. While crucial for the digital asset ecosystem, they are vulnerable to de-pegging events – i.e. deviations from their intended 1:1 peg – which can trigger contagion and instability.

This paper develops an early warning indicator to monitor and predict such de-pegging risks. The research addresses the challenge of defining an economically meaningful de-pegging event by evaluating both static and dynamic thresholds, the latter adapting to market conditions such as trading volume and historical price distributions. The methodology employs supervised machine learning, testing models including XGBoost and recurrent neural networks (long short-term memory and gated recurrent unit) on a diverse dataset. This dataset encompasses high-frequency pricing and trading information, on-chain metrics, sentiment indicators and traditional financial variables. The feature set is structured around three primary catalysts of stablecoin distress: foundational vulnerabilities (e.g. reserve quality), off-chain and on-chain indicators (e.g. own volatility, crypto-asset market contagion) and acute run triggers (e.g. information shocks). The study focuses on key US dollar-pegged (USDT, USDC) and euro-pegged (EURS, EURC) stablecoins, the latter being of particular interest in the context of the EU's Markets in Crypto-Assets Regulation.

Keywords: stablecoins, de-pegging, early warning indicator, machine learning, MiCAR.

JEL codes: C45, C53, G01, G23, G28

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- Paul Grau: Deutsche Bundesbank;
- Ronald Heijmans, Nico Salemans: De Nederlandsche Bank;
- Eleonora Basilico, Olivier Wolff, Maha Abbassi, Urszula Kochanska: European Central Bank.

¹³ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.3.2 Are stablecoins stable or is their stability just a flip of the coin?¹⁴

Lala AlAsadi, Oluwasegun
Bewaji, Aayush Gugnani, Tarush
Gupta, Ronald Heijmans

This paper investigates the volatility dynamics of US dollar-backed stablecoins, challenging the assumption of inherent stability. Using a multi-level econometric framework, including generalised autoregressive conditional heteroskedasticity, structural vector autoregression and time-varying parameter vector autoregression models, we analyse how stablecoins respond to macro-financial shocks such as monetary policy changes, market uncertainty and crypto volatility. Results show that USDC and TUSD are highly sensitive to external disturbances, while USDT and DAI remain relatively resilient. Stablecoins primarily absorb volatility but become more connected to systemic risk during crises. Frequency domain analysis reveals short-term spillovers dominate during stress events, with long-term integration increasing post-2021. The findings highlight the heterogeneous nature of stablecoins and their growing ties to traditional finance, underscoring the need for tailored regulation and ongoing monitoring to mitigate systemic vulnerabilities.

Keywords: stablecoins, volatility, financial markets, monetary policy.

JEL codes: F31, G14, E42, E58.

Published at:

<https://www.dnb.nl/publicaties/publicaties-onderzoek/working-paper-2025/846-an-econometric-investigation-on-the-stability-of-stablecoins-are-these-coins-stable-or-is-their-stability-just-a-flip-of-the-coin/>

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¹⁴ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.4 Crypto-asset insights from survey data

2.4.1 Crypto-asset ownership in the euro area: a comparison of different retail surveys¹⁵

Pirmin Fessler, Beat Weber,
Urszula Kochanska, Ilari Määttä,
Mirko Moscatelli, Giorgia Rocco,
Pietro Vassallo, Katja
Neugebauer

Retail exposure to crypto-assets is becoming increasingly relevant, also for central banks, with implications for financial stability and consumer protection. Yet, measuring how many people own crypto-assets and who they are remains challenging. While several analytics companies provide partial insights into on-chain and off-chain holdings by country, their data cannot be linked to specific owners, rely on strong proxies or fail to capture the broader financial context. Likewise, reports from crypto-asset service providers on their customers are currently not advanced or comprehensive. Surveys therefore remain, for the time being, the only instruments that allow crypto-assets to be integrated into households' overall balance sheets, enabling the use of established risk analysis frameworks. However, methodological differences between surveys often lead to inconsistent estimates, even within the same country, thereby complicating interpretation.

We compare four major official surveys covering crypto-asset ownership: the [Household Finance and Consumption Survey \(HFCS\)](#), the [Study on the Payment Attitudes of Consumers in the Euro Area \(SPACE\)](#), the [Consumer Expectations Survey \(CES\)](#) and the [OECD/INFE Survey of Adult Financial Literacy](#), focusing on Austria, Finland, Italy and Portugal. Our analysis identifies common patterns such as crypto-asset ownership being limited and uneven across countries, and being concentrated among young, male and educated people. We explain divergences in ownership rates by analysing each survey's design and implementation, including sampling, questionnaire, survey mode, weighting and imputation. We provide insights into factors affecting results and elaborate on the strengths and limitations of each survey. Finally, we propose improvements to enhance the coverage and comparability of data across surveys.

Keywords: crypto-assets, survey methodology, household survey.

JEL codes: E42, G15, G51, O33

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- Katja Neugebauer: Banco de Portugal.

¹⁵ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.4.2 Who holds and pays with crypto-assets? Global trends and Slovak evidence¹⁶

Marek Feder

The question of who holds and uses crypto-assets is central to understanding their role within the financial system and their potential implications for consumer protection and monetary stability. This case study combines international evidence from global data providers with results from national surveys on crypto-asset ownership conducted in Slovakia in 2021 and 2023.

At the global level, research confirms that while overall adoption has broadened, regional heterogeneity remains pronounced. In advanced economies, ownership is concentrated among digitally literate investors, with speculation the dominant motive. In some emerging markets, crypto-assets are also used for cross-border remittances and, to a limited extent, retail payments. However, transactional use in the real economy continues to be modest compared with investment activity.

The Slovak surveys show a steady increase in the share of households holding crypto-assets between 2021 and 2023. The typical investor is younger and male, with investment motives primarily centred on expected price appreciation and curiosity about new technologies. Payment usage remains very limited, with crypto-assets not yet perceived as a mainstream means of exchange.

Looking ahead, the upcoming surveys could provide an opportunity to monitor whether this situation persists under the evolving regulatory framework (Markets in Crypto-Assets Regulation) and changing macro-financial conditions, or whether the patterns of ownership, reasons for investment and the actual use of crypto-assets for payments change over time.

Keywords: crypto-assets, household survey, adoption, payments, MiCAR.

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¹⁶ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.4.3 Distributed ledger technology-related activities among significant institutions of the Single Supervisory Mechanism¹⁷

Mauritia Kroon, Georg Paula

The Single Supervisory Mechanism (SSM) requires its significant institutions (SIs) to provide information on their distributed ledger technology (DLT)-related activities for the purpose of microprudential supervision. This is done annually through the short-term exercise data collection process.

The objective of the survey is to monitor the overall scale of banks' activities for various applications, complementing common and financial reporting on crypto-asset risk exposures, with the aim of identifying relevant risks as well as steering banks towards prudent and sound reporting practices. The survey collects aggregated exposures to crypto-assets, broken down according to a predefined taxonomy. It also gathers information on the status of specific DLT-related activities, including one high-level indicator per activity to measure the size of the respective business.

The outcome of the most recent data collection, conducted in the first quarter of 2025 based on data from the fourth quarter of 2024, shows that the overall engagement of SSM SIs in DLT-related activities is gradually increasing, despite remaining limited. 34% of SIs are engaged in at least one related activity, being mainly separate pilot use cases. Current exposures are still minor compared with banks' balance sheets, being smaller than €10 billion on an aggregated basis. The focus of crypto services is on DLT-based (tokenised) traditional financial instruments and assets rather than native (unbacked) crypto-assets. The main use cases comprise the issuance of tokenised traditional financial instruments, trading and custody services, with 11%, 14% and 19% of SIs respectively having live use cases. The most active participants are global systemically important banks and large universal banks, predominantly located in the major jurisdictions.

Keywords: DLT-related activities, crypto-assets, credit institutions, SSM.

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¹⁷ This abstract does not represent the views of the institutions with which these authors are affiliated. The views expressed are those of the authors alone.

2.5 Regulatory reporting under the Markets in Crypto-Assets Regulation and institutional initiatives to close data gaps

2.5.1 MIDAS: the case for EU-level market surveillance of crypto-assets¹⁸

Giulia Ferraris

Following the entry into force of the Markets in Crypto-Assets Regulation (MiCAR), national competent authorities (NCAs), under the coordination of the European Securities and Markets Authority (ESMA), faced the urgent task of developing surveillance systems for crypto-asset markets. The unique characteristics of these markets required a new approach, leading ESMA to assess possible/desirable elements of and conceive a centralised monitoring tool.

While market abuse patterns resemble those in traditional finance, crypto-asset markets present distinct challenges. First, crypto-assets are traded across both centralised and decentralised exchanges in multiple EU Member States and third countries, unlike traditional markets with a home bias. This fragmentation creates smaller, more manipulable markets. Second, although abusive behaviours – such as wash trading and pump-and-dump schemes – mirror those in financial instruments, crypto’s structure enables systematic cross-border execution, driven by direct retail participation and decentralised blockchain transactions.

To address these complexities, ESMA launched the MIDAS project, a delegated initiative whereby NCAs agreed to centralise at EU level the collection, processing and surveillance of crypto-asset data under MiCAR. While MIDAS primarily targets market abuse supervision, its capabilities may in the future support other authorities’ mandates too. Detecting abnormal trading activity – considering frequency, volume and price movements across crypto-asset service providers, exchanges and blockchains – is the first step in identifying manipulation. Additionally, assessing wash trading levels helps gauge the reliability of reported volumes.

By consolidating surveillance through MIDAS, ESMA aims to strengthen oversight and enhance market integrity in the evolving crypto landscape.

Keywords: crypto-assets, market surveillance, MiCAR.

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¹⁸ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.6 Towards reliable crypto-asset data – terminology, classification and other issues

2.6.1 Digital money and finance: a critical review of terminology¹⁹

Ulrich Bindseil, Charles-Enguerrand Coste, George Pantelopoulos

The digitalisation of payments has accelerated over the past decades thanks to the internet and ever faster and cheaper computing. Now, many believe that decentralised finance offers fundamentally new possibilities for trading, payments and settlement. Moreover, for a few years central banks have launched work on what has been called retail and wholesale central bank digital currencies. Concurrent to the rise of innovative technologies has been the advent of new terminology, which is widely used but which often seems to be biased, confusing or inconsistent. By providing an etymology of key concepts and reviewing terminology and definitions, this paper provides a new approach to clarifying the essence of new technologies in the field of payments to facilitate ongoing discussions about their eventual merits and use cases.

Keywords: digital assets, decentralised finance, distributed ledger technology, tokenisation, central bank digital currency.

JEL codes: B26; E42

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2.6.2 Crypto-asset data collection – experience and challenges²⁰

Andres Lauba

Estonia's crypto-asset market peaked in 2019 with over 1,200 service providers. Subsequent amendments to money laundering prevention laws have tightened rules, requiring physical presence, higher capital, audits, stricter identity checks and regular reporting obligations, causing the number of providers to plummet to around 50 by the end of 2023.

Since 2024 providers must submit quarterly reports to Eesti Pank. Recent data on customers' assets reveal a highly concentrated market. 85% of all customers are natural persons, and 95% of assets belong to non-residents. Around half of customers' holdings are dominated by bitcoin and Ether, while privacy-enhancing crypto-assets are negligible. Data from providers' reports show higher purchases of crypto-assets than sales, with much higher turnover of wallet services and relatively stable positions of assets, which may indicate movement of crypto-assets to other wallets that remained outside the reporting scope.

An incomplete overview of transfers between non-custodial wallets, including the identification of residency, remains the main challenge in assessing residents' assets. Part of the information, namely residents' assets held at service providers of other countries, could become available through multilateral agreements between tax offices and the most recent amendment to the Directive on Administrative Cooperation (DAC8). Further enhancements such as reporting at token level would help to link assets held at the service provider to transactions associated with non-custodial wallets.

Estonia's new Markets in Crypto-Assets Act brings crypto activities under the supervision of the Financial Supervision and Resolution Authority, which has granted authorisations since 2025. The reporting process is currently still being updated.

Keywords: crypto-assets, MiCAR, virtual asset service provider, statistics.

JEL codes: E42, F21, F24, F32, F38, G15, O33

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2.6.3 Investigating the reliability of crypto data²¹

Marco Brandi, Alberto Di Iorio,
Agata Magdalena Dziwok,
Wagner Eduardo Schuster

Regulators and central banks are deeply engaged in monitoring and analysing the crypto-asset ecosystem to make informed decisions. However, when looking at the various data sources, high-frequency information about market developments is typically provided by private companies that collect and combine raw information drawn from a number of different centralised and decentralised exchanges and which adopt different methodologies for data aggregation and management. The existence of heterogeneous datasets based on the same underlying phenomena poses challenges to policy analysis, as some exceptional events can be interpreted differently depending on the dataset used.

This study empirically investigates the reliability of crypto-asset market data by comparing key metrics, including price, volume and market capitalisation, across multiple data providers. It includes both unbacked crypto-assets and stablecoins, covering a range of token sizes to ensure broad market representation. The analysis reveals that discrepancies in price and market capitalisation are generally smaller than those observed in trading volumes. Moreover, price data become more similar over time, with differences diminishing as tokens mature. This convergence process is less evident for market capitalisation and is essentially absent for volumes. Notably, specific tokens in our analysis exhibit large discrepancies across providers.

Overall, this study suggests that the aggregate information on price and market capitalisation used to monitor the crypto-asset market is fairly reliable, given also the concentration of the market on a few tokens, while the analysis of individual tokens and volumes still requires caution and scrutiny given the potential inconsistency among various data providers.

Keywords: crypto-assets, data providers, centralised exchanges, decentralised exchanges.

JEL codes: C81, G00

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²¹ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.7 Investigating shocks, stress and scams in crypto-assets

2.7.1 What if Ether goes to zero? How market risk becomes infrastructure risk in crypto²²

Claudia Biancotti

Permissionless blockchains, the most common type of settlement infrastructure for crypto, continue to attract attention from within the traditional financial system. Using these types of blockchain may have the advantage of lower cost and higher speed compared with legacy solutions. There is, however, an often overlooked close link between volatile crypto prices and infrastructure availability and security.

Permissionless blockchains are operated by decentralised sets of independent validators, usually compensated in unbacked crypto-assets – known as native tokens. Should such tokens incur a substantial and persistent loss in market value, validators might cease operations. Transaction settlement could slow or stop, and the infrastructure's exposure to cyberattacks could increase.

Keywords: permissionless blockchains, crypto-assets, financial infrastructure.

JEL codes: G15, G23, O30

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<https://www.bancaditalia.it/media/notizia/what-if-ether-goes-to-zero-how-market-risk-becomes-infrastructure-risk-in-crypto/>

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²² This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.7.2 Digital asset integration in the financial system: evidence from Austria²³

Pietro Saggese, Michael Sigmund, Burkhard Raunig, Esther Segalla, Bernhard Haslhofer, Christos Makridis

Crypto-asset service providers (CASPs) currently handle over USD 100 billion in daily trading volumes. However, accurately measuring their on-chain activity and integration within single jurisdictions remains difficult, since blockchain transactions involve pseudonymous addresses and lack geographic identifiers. Using data on the Austrian CASP ecosystem between 2020 and 2025, we exploit high-frequency variation and macroeconomic shocks to examine stablecoin and crypto-asset flows over time, identify the presence of flight-to-quality dynamics and assess abnormal behavioural responses to large-scale events. We estimate event studies and overcome composition effects by isolating within-address variation, enabling cleaner inference on behavioural shifts. Our findings have broader implications for the design and evaluation of central bank digital currencies. By tracing how users reallocate digital asset holdings across custodial and non-custodial platforms under stress, we offer empirical evidence on the substitutability between public and private digital monies and the frictions that shape user responses to systemic risk.

Keywords: crypto-assets, stablecoins, crypto-asset service providers, blockchain.

JEL codes: C81, E42, E58, F31, G19, G23, O33

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²³ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.7.3 What can we learn from a major crypto-asset scam? A Slovak case study from 2025²⁴

Marek Feder

The first half of 2025 saw one of the most prominent crypto-asset-related scams targeting retail users in Slovakia, with estimated losses in the millions of euro and widespread media attention. This case study dissects the anatomy of the fraud scheme, which involved a professionally presented but fictitious crypto investment platform and aggressive in-person marketing strategies that lured in tens of thousands of victims. The analysis draws on incident data reported to national authorities, consumer complaints and an internal analysis of the fraud scheme.

The findings reveal several characteristics that enabled the fraud to proliferate: weak digital literacy, limited public understanding of crypto-assets and a high degree of psychological manipulation in the scam's communication strategy. The case illustrates the challenges of communicating complex digital financial risks to non-expert consumers, particularly in an environment of limited financial and digital literacy. It further shows that traditional investor warnings may often lack the behavioural resonance needed to deter victims.

The case study offers guidance on how national competent authorities (NCAs) can communicate complex risks to consumers more effectively, for example through targeted articles or scenario-based awareness campaigns. Moreover, it proposes several concrete steps that NCAs can take to reinforce their consumer protection mandates.

Keywords: crypto-assets, fraud, consumer protection, crypto scam, financial supervision.

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2.7.4 Private money and public debt: stablecoins and the global safe asset channel²⁵

Massimo Ferrari Minesso,
Daniele Siena

This paper studies the international macro-financial implications of US dollar-backed payment stablecoins. These digital assets, unremunerated, fully backed by short-term US Treasuries and designed by US regulators to reinforce the dollar's global role, create a new global safe asset channel that links private money creation directly to US public debt. We develop a three-country model to study how this channel affects monetary transmission, global financial linkages and the geography of safe asset demand. Stablecoins lower the level of risk-free yields, increase the domestic pass-through of US monetary policy to yields but dampen its real effects, and increase the sensitivity of US yields to foreign shocks. Consistent with the model, we find empirically that higher stablecoin capitalisation increases the response of short-term Treasury yields to US policy shocks. The effects are limited at low adoption levels but rise non-linearly with market size, generating new trade-offs between monetary policy, fiscal risk and global financial stability.

Keywords: stablecoins, global safe asset, monetary policy, financial stability.

JEL codes: E44, E42, E52, E58

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2.8 Interlinkages

2.8.1 Interconnections between financial markets and crypto-asset markets²⁶

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Kochanska, Eleni Koutrouli,
Polychronis Manousopoulos,
Rasmus Bobek Søndergaard,
John Theal

Crypto-asset markets have been rapidly evolving in recent years, falling under the spotlight of both investors and regulators. Their potential interconnections with traditional financial markets are important, and identifying them can provide useful insights into topics such as risk contagion, risk mitigation and price formation.

In order to identify such interconnections, we examine the correlation between prominent stock market indices and crypto-assets from 2018 to 2025, using both daily and high-frequency datasets. Starting from 2020, stock market indices and crypto-assets exhibit moderate correlation in daily returns, which varies over time and is affected by major global events. Furthermore, US indices exhibit higher correlation with crypto-assets than EU indices, while the correlation of weekly returns is affected by the selected day of the week. We also focus on volatility. Besides the expected finding that the volatility of crypto-assets is considerably higher than that of stock market indices, we detect potentially relevant intraday variation in crypto-asset volatility within stock market trading hours, as well as a partial effect of volatility on the correlations.

Furthermore, we examine the effect of news, events and announcements. Concerning the impact of news on crypto-asset volatility, we identify an asymmetry in favour of positive news, which decreases over time. We also identify a considerable impact from US Administration announcements, such as tariffs, on crypto-asset volatility. Finally, our analysis indicates that using high-frequency datasets on crypto-assets is meaningful and provides additional insight, considering the continuous operation of crypto-asset markets.

Keywords: crypto-assets, financial markets, correlation, volatility, event impact.

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2.8.2 Crypto-assets and macroeconomic conditions: a reassessment²⁷

Andrea Nobili

We study the empirical link between developments in main crypto-assets and some macroeconomic shocks identified by means of the sign-restricted approach for vector autoregression models over the period 2017-25. Our estimates suggest that unbacked crypto-assets, notably bitcoin and Ether, are mainly used as speculative assets, with market capitalisation increasing following the loosening of monetary policy in the United States, mirroring search-for-yield practices in the equity market. By contrast, we find limited adoption of such tokens as safe-haven assets in response to geopolitical tensions or strains in traditional financial markets or as hedges against inflation, in contrast to the physical gold market and notwithstanding the fact that their supply conditions have been designed to create a scarcity effect. We also find that the main stablecoins (USDT and USDC) so far serve primarily as base pairs in crypto trading activity rather than as a store of value. Finally, most fluctuations in crypto-assets are often not explained by the identified shocks, probably reflecting crypto-specific events or news that may affect investors' demand for crypto-assets while not affecting traditional financial markets. Looking forward, the link between the macroeconomy and the crypto ecosystem could change and grow stronger, for example due to the adoption of crypto-related products on regulated financial markets, the US Administration's initiatives to strengthen dollar-based crypto-assets and/or a new regulatory framework. Moreover, the adoption of stablecoins could extend to other use cases, notably cross-border payments. In this regard, central bankers and regulators face significant challenges in monitoring crypto-assets and economic research needs to develop new models for policy analysis.

Keywords: crypto-assets, search for yield, safe haven.

JEL codes: E42, G32, L14, O16

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2.9 Tokenisation

2.9.1 The fully tokenised bank's balance sheet²⁸

Georg Paula, Petra Porubcanová,
Nicolas Soemer, Lamprini Ziaka

Blockchain has recently emerged as a transformative technology in the financial sector, valued for its programmability, automation capabilities, continuous availability and instantaneous global collateral mobility. This research analyses four real-world applications of digital financial assets²⁹: (1) deposit tokenisation under J.P. Morgan's Kinexys³⁰ chain, enabling participating clients to manage real-time liquidity across borders and eliminate traditional treasury friction points such as currency cut-off times and non-banking hours; (2) stablecoin issuance by SG Forge³¹, a subsidiary of Société Générale, supporting a wide range of crypto-asset services for retail and institutional clients, including collateral and cash management; (3) digitalisation of securities issuance by KfW³², one of the largest bond issuers globally; and (4) KfW's acquisition of different crypto securities in primary and secondary markets³³.

The use cases span the entire balance sheet but are mostly in the experimental or pilot stages, with limited exposures, transaction volumes and assets in circulation. The blockchain solutions rely on proof-of-stake consensus mechanisms for validation. Both permission and permissionless blockchains were observed in the use cases.

From a regulatory perspective, tokenisation falls under several regimes, often depending on the particular use cases and jurisdictions. Looking ahead, scalability and integration with existing platforms, particularly with wholesale central bank digital currencies, will play a crucial role in shaping its evolution.

Keywords: tokenisation, crypto-assets, blockchain, programmability, settlement.

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²⁸ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

²⁹ This study does not claim to be exhaustive, nor does it aim to provide marketing for the selected use cases. Rather, these use cases were selected due to the willingness of the institutions to participate in interviews.

³⁰ See J.P. Morgan's [Kinexys Digital Payments interface](#) and Toh, W.K., Brownworth, A., Bench, R. Li, N. and Sarwar, S. (2024), "[Application of Programmability to Commercial Banking and Payments](#)".

³¹ See SG Forge (2024), "[Blockchain & Digital Assets](#)", May; and the company's [website for CoinVertible](#).

³² See KPMG and KfW (2025), "[DLT-based capital market: An analysis of the degree of maturity based on KfW's first two blockchain-based digital bonds](#)", February.

³³ See KfW (2025), "[Changing it up: KfW active as an investor in crypto securities for the first time](#)", *press release*, 29 April; and NRW.BANK (2025), "[NRW.BANK issues first blockchain-based bond](#)", *press release*, 10 July.

2.9.2 Distributed ledger technology-based bonds – level of adoption and business models³⁴

Sarah Cheliout, Daniela Della Gatta, Eleni Koutrouli, Georg Paula, Nicolas Soemer

In recent years, we have witnessed a growing number of distributed ledger technology (DLT)-related activities involving credit institutions, in particular DLT-based bond issuances and related transactions. These developments are introducing new business models and roles within the financial ecosystem. This paper aims to examine the adoption of DLT-based bond issuances by credit institutions and the evolution of associated business models.

Drawing on public reports and available supervisory data, we present insights into issuance volumes in recent years, geographical distribution, issuer types, blockchain platforms and regulatory frameworks for DLT-based bonds. We also review the current status of the DLT pilot regime, the issuance of DLT-based government bonds, bond classifications and cash settlement mechanisms.

The analysis reveals increasing activity – while still being modest in scale – driven largely by central bank trials and using mostly permissioned platforms, alongside growing expectations for settlement solutions in central bank money. Europe and Asia currently lead this trend, with government bond issuances gaining traction. While the uptake of the DLT pilot regime remains limited, it could accelerate with regulatory amendments.

Finally, we identify emerging trends towards common standards for DLT securities and tokenisation initiatives by major players and large-scale cooperations.

Keywords: DLT-based bonds, tokenisation, public/private blockchains, permissioned/permissionless blockchains.

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2.9.3 Use of permissioned vs permissionless and public vs private distributed ledger technology platforms in the financial sector³⁵

Alexandra Born, Carles Cerqueda Gallardo, Eleni Koutrouli, Polychronis Manousopoulos, Edoardo Marchi, Jean Teyssedre

Tokenised financial ecosystems have grown in recent years, while financial sector interest in experimenting with distributed ledger technology (DLT) has also increased. DLT can be broken down according to access type and permission configuration into the following commonly recognised forms: public, private, permissionless and permissioned ledgers.

Early DLT-based projects by financial institutions seem to have favoured private, permissioned blockchains for risk management and regulatory compliance reasons. Such infrastructures usually lack interoperability and may create fragmentation. Recent projects also use public and permissionless blockchains or platforms featuring the characteristics of both permissioned and permissionless blockchains.

We examine the different types of DLT platform used in financial markets in order to understand their functioning. Based on an analytical framework, we conduct a comparative study to identify trends in the use of specific types of DLT, the associated risks as well as security and supervisory considerations.

First, we classify existing DLT platforms based on their characteristics into distinct categories, which include public/private and permissioned/permissionless as well as combinations. Then, we select and analyse a number of prominent use cases and financial projects involving different types of DLT. We identify the following trends: preferred platforms are influenced by specific use cases and regulatory considerations, while DLTs experiencing increased adoption tend to emphasise neutral shared ledger characteristics or the development of common standards.

Keywords: permissionless, permissioned, public/private blockchains.

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2.9.4 Reinventing custody services to address the tokenisation revolution³⁶

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Eleni Koutrouli, Polychronis
Manousopoulos, Pauline
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Cheliout

The recent hype around tokenisation and its potential to transform financial markets raises questions about how custody services might evolve. Although promising, the tokenisation ecosystem has yet to gain substantial traction, and most real-world initiatives remain at an experimental stage. To explore this topic, we conducted an analysis combining insights from existing literature and market evidence with informal discussions held with 11 major market participants actively engaged in the field. The goal was to assess, from a practical perspective, the current development of custody services for assets re-issued on-chain (AROs), seen as a pivot between traditional and digital finance.

Our findings show a notable absence of new custody solutions designed to leverage the potential of the tokenised ecosystem, aside from basic services (i.e. key custody and account management), despite the interest shown by investors and market operators. The research identified three primary obstacles: (i) the lack of a unified ecosystem, with fragmentation and a lack of interoperability across different blockchains preventing custodians from relying on a standardised framework to deliver new services, limiting their offerings to traditional ones; (ii) the current low liquidity in AROs and the near absence of secondary markets, which are failing to provide sufficient economic incentives to invest in new solutions; (iii) risk managers' preference for traditional custody services, driven by their risk-averse approach and existing regulatory requirements. Regulation for AROs, evolving under different approaches across jurisdictions, generally adheres to the principle of technological neutrality, aiming to maintain the same custody requirements as those applied to traditional assets.

Keywords: crypto-assets, custody services, trading, securities.

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2.9.5 Evolving secret sharing for crypto-asset custody and regulatory compliance³⁷

Sara Giammusso

In crypto-asset custody, control of private keys equals control of assets. Exchanges and custodians therefore rely on cryptographic protocols to protect keys against theft and insider misuse. At the same time, they operate in regulated environments, where laws define how reporting and audit logs must be maintained and accessed by supervisors. Current cryptographic tools, such as on-chain multi-signature wallets, multi-party computation and threshold signature schemes, have strengthened the resilience of crypto-asset custody. However, all of these tools assume a static set of participants and fixed reconstruction rules. In practice, crypto-asset custody operates in a dynamic environment. On the operational side, custodians face continual change as employees join or leave and internal approval policies evolve. On the regulatory side, custodians may wish to enforce privacy-preserving oversight: sensitive audit data should only be accessible when multiple supervisory authorities jointly authorise access, preventing unilateral inspection, and the set of authorised regulators may also change over time.

This gap points to the need for cryptographic mechanisms that adapt to both organisational and regulatory change. Evolving secret sharing (ESS) extends classical secret sharing by allowing both the set of participants and the reconstruction policy to evolve. New participants can be added without updating existing shares, enabling custody systems to seamlessly incorporate new employees or regulators while maintaining strong security guarantees. By combining flexibility, security against adaptive corruption and efficiency – share sizes remain compact and existing shares do not need to be reissued – ESS provides a promising cryptographic foundation for next-generation custody and compliance infrastructures in the crypto-asset ecosystem.

Keywords: crypto-assets, evolving secret sharing.

JEL codes: E42 F21 F24 F32 F38 G15 O33

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2.10 Issues related to decentralised identity and privacy

2.10.1 Decentralised identity with selective disclosure³⁸

Eldin Delić, Eugenio Rubera

This work provides an overview of decentralised and self-sovereign identity (SSI) models as practical digital identity solutions that let users hold verifiable credentials in a wallet and present only policy-relevant facts to services. An SSI model gives users control over personal information and allows them to overcome the necessity for identity providers; especially in combination with privacy-enhancing techniques, it allows for the implementation of privacy safeguards when dealing with identity, both online and offline. Verification is local: the relying party validates the cryptographic proof, checks the credential status (active/suspended/revoked) and confirms the issuer against a signed trust list. We synthesise what works across deployments: governance via explicit trust lists, interoperable artifacts and machine-verifiable status; the rest (vendor or ledger) is secondary.

The 2024 European Digital Identity Regulation establishes a common basis for secure cross-border electronic identification and introduces the EU Digital Identity Wallet to authenticate and share verifiable credentials with data minimisation and selective disclosure by design. Consistent with technological neutrality, the Regulation refers to electronic ledgers – not blockchain – whose role is to ensure integrity and correct sequencing of records.

Pilot experience suggests tangible benefits, such as faster onboarding and fewer false rejections, when credentials are reusable and decisions are policy-driven. The relevance of trust, local verification with status and zero-knowledge selective disclosure for minimal data exposure was demonstrated through a small, comparable KPI set focused on onboarding speed, decision accuracy and service availability.

Keywords: decentralised identity, selective disclosure, zero-knowledge proof, blockchain, digital identity, wallet, ledger, EU Digital Identity Wallet, electronic identification.

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2.10.2 Privacy-enhancing mechanisms³⁹

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Public blockchain networks offer a high degree of transparency, which can be problematic in environments where confidentiality is required, including the financial sector and other industries that manage sensitive information. This paper establishes a taxonomy of techniques for enhancing confidentiality in permissionless networks and discusses their implications at regulatory level. The study includes an analysis of mixing solutions, including custody mixers and CoinJoin-type coordination, as well as zero-knowledge (ZK) proofs, multi-party computation (MPC), fully homomorphic encryption and stealth addressing. Each type of mechanism is considered in respect of its alignment with trust assumptions, verifiability, performance, operational complexity and compliance with anti-money laundering and counter-terrorist financing requirements. We summarise observed trends in misuse and enforcement actions to identify drivers of risk and governance requirements. To illustrate this principle, we explore the Mandala project of the Bank for International Settlements Innovation Hub, which combines MPC-based control mechanisms with ZK proofs on public blockchain networks. Our study aims to provide architects and policymakers with a detailed taxonomy to better understand the challenges involved in designing and implementing appropriate privacy-enhancing mechanisms. We conclude that an appropriate combination of these technologies could provide a solution that ensures user privacy while allowing for sufficient supervision of payments and tokenisation.

Keywords: privacy-enhancing technologies, taxonomy, anti-money laundering/countering the financing of terrorism compliance.

JEL codes: E42, G28, K42, O33, L86, D82, E58

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³⁹ This abstract does not represent the views of the institutions to which these authors are affiliated. The views expressed are those of the authors alone.

2.10.3 Balancing privacy and regulation in the design of future digital payment systems⁴⁰

Matteo Nardelli

This contribution summarises a research study published as a [technical report on arXiv](#) and forthcoming on the Banca d'Italia website. The work investigates how privacy and regulatory oversight can be jointly achieved in the design of future digital payment systems, where the protection of users' data must coexist with compliance and accountability requirements. It surveys privacy-enhancing technologies that provide confidentiality, anonymity and unlinkability, while supporting auditability and selective disclosure. Building on an extensive literature review, the analysis introduces a unified taxonomy connecting privacy goals to the cryptographic primitives that underpin them – commitments, encryption schemes, blind and group signatures, and zero-knowledge proofs – and compares their integration across system architectures, from early electronic cash models to privacy-native crypto-asset systems and central bank digital currency prototypes. By tracing the evolution of these systems, the study identifies emerging design patterns, such as threshold decryption, homomorphic commitments and zero-knowledge proofs for verifiable computation, that can reconcile privacy with effective supervision. It concludes that achieving sustainable privacy in digital payments requires layered cryptographic designs and close alignment between technological innovation, institutional governance and regulatory policy.

Keywords: literature review, cryptography, privacy, auditability, accountability, privacy-enhancing technologies, central bank digital currency.

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3 Way forward

The crypto-asset market has been constantly evolving, and its integration with the financial system and the broader economy has the potential to expand and intensify further in the future. While European authorities are gaining better insights into crypto-asset developments, gaps remain, necessitating further monitoring and analytical work. In light of this, CAMEG's next wave of operations in 2026 will prospectively deal with further investigating and quantifying interlinkages between crypto-assets and the traditional financial system and the broad economy, and within the crypto-asset ecosystem itself. With CAMEG's strong focus on data, further joint exploration of crypto-asset datasets is planned. Both on-chain and off-chain data will be analysed in greater depth, using novel statistical techniques to develop methodologies and indicators, such as on the geographical location of crypto-asset activities. Significant emphasis will be placed on developing common datasets and dashboards for collaborative analyses by CAMEG members. CAMEG's work will concentrate on empirical studies covering novel and developing crypto-asset segments. Moreover, ongoing projects such as looking at retail surveys and early warning indicators will continue in 2026.

CAMEG invites experts from ESCB central banks, authorities supervising crypto-asset issuers and service providers, and other European institutions to participate. European cooperation is key to unlocking smooth and effective crypto-asset monitoring.

The next CAMEG conference is planned for the end of October 2026.

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