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(coordinators)

### Crypto-Asset Monitoring Expert Group (CAMEG) 2024 Conference

Book of abstracts

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# Abstract

This paper provides an overview of recent analytical work<sup>1</sup> conducted, under their own aegis, by experts from various European authorities and institutions in the field of crypto-asset monitoring. Currently, risks stemming from crypto-assets and the potential implications for central banking domains are limited and/or manageable, including as regards the existing regulatory and oversight frameworks. Nevertheless, the importance of monitoring developments in crypto-assets, raising awareness of the potential risks and fostering preparedness cannot be overstated.

In light of this, this paper sets out the background to the establishment of the Crypto-Asset Monitoring Expert Group (CAMEG) in late 2023 to bring together experts from the Eurosystem's central banks and from the European Systemic Risk Board (ESRB). It also provides abstracts of various papers and other analytical works presented at the inaugural CAMEG conference held on 24 and 25 October 2024. The conference aimed to take stock of analytical work and data issues in this area, while fostering European collaboration and monitoring in the field of crypto-assets.

Finally, this paper outlines the prospective way forward for the CAMEG, focusing on gaining greater insight into data in this area 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

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<sup>1</sup> It should be noted that although the analytical work was conducted by experts from European central banks and other institutions, 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 recent analytical work conducted, under their own aegis, by experts from various European authorities and institutions in the field of crypto-asset monitoring. Currently, risks stemming from crypto-assets and the potential implications for central banking domains are limited and/or manageable, including as regards the existing regulatory and oversight frameworks. Nevertheless, the importance of monitoring developments in crypto-assets, raising awareness of potential risks and fostering preparedness cannot be overstated.

In light of this, this paper sets out the background to the establishment of the CAMEG in late 2023 to bring together experts from the Eurosystem's central banks and the ESRB. The availability of common crypto-asset datasets for the European System of Central Banks (ESCB) was a key factor in the creation of CAMEG and a prime example of how European collaboration can proactively identify and anticipate evolving stakeholder needs regarding innovative topics, such as crypto-asset analytics.

A selection of abstracts from papers and other analytical works<sup>2</sup> presented at the inaugural CAMEG conference makes up the main body of this paper. The conference, which was held on 24 and 25 October 2024, 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 topic for the first session revolved around the question of who holds and uses crypto-assets. The second session explored virtual asset providers, crypto-asset trading and deceptive practices and frauds within crypto-asset markets. Subsequent sessions examined the interlinkages between crypto-assets and traditional finance (TradFi), as well as the interplay between crypto-assets and financial markets. The conference provided insights into the [Markets in Crypto-Asset Regulation \(MiCAR\)](#) and related data (challenges). Several presentations delved into various decentralised finance (DeFi) segments, with a particular focus on DeFi lending. The conference's final presentations showcased selected analyses of distributed ledger technology (DLT) within the context of central banking and crypto-asset monitoring.

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.

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<sup>2</sup> It should be noted that although the analytical work was conducted by experts from European central banks and other institutions, it should not be taken as representing the views of the institutions to which those experts are affiliated.

# 1 Introduction

Crypto-asset risks and the potential implications for central banking domains are currently limited and/or manageable, including as regards the existing regulatory and oversight frameworks. Nonetheless, monitoring of crypto-asset developments, raising awareness of the potential risks and cultivating preparedness continue to be important. Crypto-asset matters are discussed by the relevant ESCB committees and working groups as required. Yet, no single Eurosystem or ESCB group focuses solely on crypto-asset monitoring.

The DeFi hackathon (see Abstract 2.6.1), organised by the European Central Bank (ECB) in 2023, demonstrated a need for stronger international collaboration on crypto-asset monitoring and on the benefits and potential of using a cooperative network to this end. In the light of this, the ECB Statistics Directorate General, in conjunction with the Eurosystem Innov8 Forum,<sup>3</sup> formed CAMEG in late 2023.<sup>4</sup> CAMEG is a prime example of how European collaboration can proactively identify and anticipate evolving stakeholder needs regarding innovative topics, such as crypto-asset data analytics.

The availability of common crypto-asset datasets for the ESCB was a key factor in the creation of CAMEG. Common datasets and collaborative platforms offer significant benefits, eliminating redundancy and maximizing resource efficiency in analytical work. More than 30 experts from 13 Eurosystem central banks and the ESRB participated in the first phase of CAMEG operations. In future phases, CAMEG intends to expand its membership beyond the Eurosystem, bringing in experts from other central banks, MiCAR supervisory authorities and other European institutions.

The inaugural conference, held on 24 and 25 October 2024, marked the culmination of the first 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 bankers and other authorities as regards crypto-asset monitoring and supervision. More than 30 presentations were on the agenda, bringing together a vast amount of information.<sup>5</sup> By compiling a selection of abstracts, this paper provides insight into the issues discussed.

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<sup>3</sup> 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.

<sup>4</sup> The BISIH Eurosystem Centre is a joint venture between the Bank for International Settlements and all the Eurosystem central banks. Further information can be found at <https://www.bis.org/about/bisih/locations/eurosystem.htm>.

<sup>5</sup> It should be noted, in this regard, that although the analytical work was conducted by experts from European central banks and other institutions, it should not be taken as representing the views of the institutions to which those experts are affiliated.

## 2 Selected abstracts<sup>6</sup>

### 2.1 Who holds and uses crypto-assets (including for payments)?

#### 2.1.1 The critical role of household level survey data in monitoring crypto-asset risks: insights from an Austrian pretest and implications for financial stability analysis<sup>7</sup>

Pirmin Fessler, Beat Weber

Where a significant proportion of crypto-assets is held by private households, survey data at the household level are a key ingredient for risk monitoring. Such data make it possible to integrate crypto-assets into the broader financial context of households and to apply traditional risk analysis frameworks – such as loan-to-value ratios and debt-to-income or debt-to-asset ratios, all of which are based on asset and liability combinations for individual households – and their ratio distributions. Posing questions about the motivations and drivers underlying crypto-asset ownership also provides useful information. Results help in identifying any potential for financial distress and for spillover effects into the broader economy. By linking assets to portfolios, survey data complement other data sources (such as transaction patterns from blockchain data and off-chain data collected from crypto intermediaries) enabling a comprehensive risk assessment at the micro level.

In a 2022 pretest for the Austrian segment of the Eurosystem Household Finance and Consumption Survey, it was found that only a small percentage of households hold crypto-assets. Those that do are typically younger and male, and hold relatively modest amounts. The primary motivations cited for owning crypto-assets are their speculative potential for profiting from market fluctuations and owners' curiosity about new technology. None of the owners surveyed mentioned using crypto-assets for making payments.<sup>8</sup> Careful design and interpretation of surveys is key to obtaining useful intelligence for monitoring purposes. Online access panels tend to overestimate crypto-asset ownership owing to the technological affinity of their participants, resulting in skewed results. A well-designed, representative survey approach based on random sampling is necessary to obtain accurate data that can inform policy decisions.

**Keywords:** crypto-assets, financial risk, household survey.

**Authors' affiliation:**

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<sup>6</sup> Since not all abstracts correspond to published papers, publishing venue and JEL classification details are provided only when relevant.

<sup>7</sup> 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.

<sup>8</sup> Fessler, P. and Weber, B. (2024), "Crypto assets in Austria: an assessment of their prevalence and the motives of their holders", *OeNB Bulletin*, Oesterreichische Nationalbank

## 2.1.2 Cash holdings and crypto ownership: evidence of crisis-driven substitution effects<sup>9</sup>

Alejandro Zamora-Pérez, Andrea Marini

Comprehensive microdata from a representative survey of over 40,000 individuals conducted in 2022 across 17 euro area countries was exploited to examine crypto-asset ownership and crypto payment preferences. By leveraging pandemic-induced exogenous shocks in retail payments and using multiple supply and demand-related instruments, endogeneity was addressed and the effects of cash holdings on crypto-asset ownership were isolated. The findings reveal a substitution effect: because of heightened uncertainty, a higher share of individuals report keeping their cash holdings as a precautionary measure, reducing their crypto-asset ownership. Additionally, it was found that crypto-owners not only tend to have a great preference for the privacy and anonymity offered by cash, but also for the speed provided by cashless payments, revealing a unique transactional profile. Furthermore, crypto-owners using crypto-assets for payments are more likely to prefer cash as a practical payment method and are generally older, less digitally skilled and less financially sophisticated than those holding crypto-assets as an investment.

**Keywords:** cryptocurrency; money demand; payments; instrumental variable; discrete choice.

**JEL classification:** E41, E42, G11

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- Alejandro Zamora-Pérez, Andrea Marini: European Central Bank.

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<sup>9</sup> 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 Exploring the use of crypto-assets for payments<sup>10</sup>

Ellen Naudts, Laura Painelli,  
Antonio Perrella, Eleni Koutrouli,  
Polychronis Manousopoulos,  
Anton Gehem, Béranger Butruille

While crypto-assets were originally created with the intention of serving as an intermediary-free means of digital payment, their use has not, as yet, extended to the real economy. In the European Union (EU), the entry into force of MiCAR in 2024 could potentially have an impact on the use of crypto-assets, including stablecoins, for payment. It is therefore important to closely monitor and analyse crypto-asset-related developments, including in the field of payments. However, this is hampered by the lack of official statistics and relevant high-quality data. The authors relied on data for 2019 to 2023 that were publicly available, or provided voluntarily, to analyse the use of crypto-assets for payments, focusing on the trends and developments in Europe. The main research questions were which, where, how, why and by whom were crypto-assets used in payments.

Although crypto-assets can currently be used in selected shops and restaurants or to make peer-to-peer payments, the main use cases relate to micropayments, streaming, instant settlement for tokenised assets and cross-border payments. The rise in DeFi protocols and the collaboration between crypto exchanges and payment firms has expanded the everyday usability of crypto-assets. Furthermore, the geographic distribution of crypto point-of-sale (POS) terminals and crypto automated teller machines (ATMs), as well as their growth in numbers, may indicate that both merchants and customers might be interested in offering and using crypto-assets for payments. Data on the use of PayPal in the United States of America would seem to indicate, however, that crypto-assets are not the primary means of payment used by its customers. The analysis therefore concludes that the overall use of crypto-assets for payments is limited. Looking ahead, factors such as regulatory approval, technological advances and expanding use cases could potentially drive the adoption of certain types of crypto-assets, such as stablecoins, for payment, although issues such as settlement finality remain. The fact that crypto-assets are mostly held by younger age groups may hint at potentially broader future adoption. Moreover, some payment service providers are developing stablecoins and integrating them into their services. Such developments hint at a need to formulate proactive, pragmatic strategies to address the challenges posed by possible wider adoption of stablecoins for payments. A clear understanding of the relevant developments and monitoring of the level of adoption in different markets could contribute to maintaining the integrity and stability of the financial system, as well as to the smooth operation of payment systems.

**Keywords:** crypto-asset, stablecoin, payment, DeFi.

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## 2.2 Examining virtual asset service providers, crypto-asset trading and deceptive practices

### 2.2.1 Crypto exchanges: major players, risks and novel indicators<sup>11</sup>

Alexandra Born, Vittorio Ceparano, Daniela Della Gatta, Eldin Delić, Sabina Marchetti, Edoardo Marchi, María Cristina Molero Blazquez, Miguel Díaz López, Laura Painelli, Tatu Räsänen, Eugenio Rubera

Centralised crypto exchanges have emerged as critical players in the crypto-asset ecosystem. These intermediaries are a crucial touchpoint between the crypto world and the traditional financial system, making it possible to buy and sell crypto-assets against fiat currency and against other crypto-assets. Unlike traditional financial institutions, crypto exchanges have not yet been subject to prudential regulation so far and have frequently exhibited various vulnerabilities. The failure of FTX Trading Ltd in November 2022 highlighted the fact that some of these vulnerabilities may be exacerbated by the size and interconnectedness of these players within the crypto-asset ecosystem. The risks are particularly pronounced if crypto exchanges are involved in a broad range of different activities and operate as multifunction crypto-asset intermediaries (see Financial Stability Board (2023), [Financial Stability Implications of Multifunction Crypto-asset Intermediaries](#)). In the EU, a first comprehensive discipline for crypto-asset service providers (CASPs) has been introduced through the MiCAR and applies to CASPs since December 2024.

Against this background, this report analyses crypto exchanges and their characteristics to evaluate associated risk profiles. We identify the largest centralised crypto exchanges at global level based on their annual trading volumes for 2023. For a deeper analysis, the scope was narrowed to a subset comprising the five largest global crypto exchanges and the two largest crypto exchanges headquartered in the EU. For that subset, we collect information on a set of qualitative and quantitative indicators to assess the risk profiles of those exchanges in greater depth. Data is aggregated from multiple sources and presented in a dashboard. This dashboard serves as a user-friendly tool, offering an overview of key features of these crypto exchanges, including their trading volumes and market shares, to assist in identifying areas calling for further analysis of the associated risk factors. Overall, the findings show that the crypto exchanges analysed engage in a variety of activities that suggest a higher risk profile, in line with previous results. However, this analysis also reveals concerns over data reliability and gaps in data and information disclosure that could hamper a comprehensive risk assessment.

**Keywords:** crypto exchanges, trading platforms, MiCAR, risk indicators.

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## 2.2.2 Global and local drivers of bitcoin trading vis-à-vis fiat currencies<sup>12</sup>

Paola Di Casola, Maurizio  
Michael Habib, David Tercero-  
Lucas

We analyse the drivers of bitcoin transactions against 44 fiat currencies in the largest peer-to-peer crypto exchanges. Momentum and volatility in the crypto-asset market, as well as volatility and liquidity in global financial markets do matter for bitcoin trading. There is suggestive evidence of a global crypto cycle driven by speculative motives. However, in emerging and developing economies (EMDEs), bitcoin seems to offer also transactional benefits, since trading increases when the value of the domestic currency is unstable. Proxies of banking depth and digitalisation are negatively correlated with the currency loadings on the global factor, indicating that crypto-assets may offer a speculative alternative to traditional finance when this is not available, especially in EMDEs where the share of younger risk-prone population is higher. Our results clearly point to potential financial stability risks from cryptoisation in EMDEs with low levels of financial development and unstable fiat currencies.

**Keywords:** digital currencies, Bitcoin, peer-to-peer exchanges, financial development.

**JEL Classification:** E42 F21 F24 F32 F38 G15 O33

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<sup>12</sup> 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 Assessing the solvency of virtual asset service providers: are current standards sufficient?<sup>13</sup>

Pietro Saggese, Esther Segalla,  
Michael Sigmund, Burkhard  
Raunig, Felix Zangerl, Bernhard  
Haslhofer

Centralised cryptocurrency exchanges, which manage annual trading volumes on the scale of trillions of US dollars worldwide, are classified as virtual asset service providers (VASPs). They facilitate the exchange, custody, and transfer of crypto-assets organised in wallets across distributed ledger technologies (DLTs). As any corporation, VASPs can become insolvent. Despite the public availability of DLT transactions, their crypto-asset holdings are not yet subject to systematic auditing procedures. In this paper, we propose an approach to assess the solvency of a VASP by cross-referencing data from three distinct sources: crypto-asset wallets, balance sheets, and supervisory entity data. We investigate 24 VASPs registered with the Financial Market Authority in Austria. Regulatory data insights show that their yearly incoming and outgoing transaction volume amounts to 2 billion EUR for 1.8 million customers; the financial services they provide position them closer to brokers, money exchanges, and funds, rather than banks. Next, we empirically measure DLT transaction flows of four VASPs and compare their crypto-asset holdings to balance sheet entries. Data are only partially consistent; this enables us to identify gaps in the data collection and propose strategies to address them, towards achieving a more systematic, reliable, and automated assessment of VASPs solvency.

**Keywords:** blockchain, solvency, virtual asset, VASP, accounting.

**JEL Classification:** C81, F31, G15, G33, M41

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<sup>13</sup> 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.

## 2.2.4 Deceptive practices and fraud within crypto-asset markets<sup>14</sup>

Marco Brandi, Eleni Koutrouli

Crypto-asset transactions are an area where fraudulent phenomena are highly relevant and take different forms and intensities. Despite the decrease in the absolute number of fraudulent transactions in crypto-assets in 2023 compared with the previous year, their proportion of the volume of crypto-asset transactions would seem to have remained unchanged, based on the available data.

Deceptive practices in crypto-asset markets range from those already present in traditional finance to new forms that exploit the specific features of innovative crypto products, such as blockchain transactions and mixer services.

This article seeks to provide an overview of the main fraudulent behaviours seen in cryptocurrency transactions, covering both “traditional” frauds (such as scams, money laundering, sanctions evasion, terrorism financing) and new fraudulent phenomena. A taxonomy of fraudulent practices in crypto-asset transactions was drawn up and the various categories were analysed, providing relevant data on the number of illicit transactions for the years 2018-23, as well as specific examples. The taxonomy shows that the basic categories of crypto-asset transaction fraud identified can be classified into three groups:

- (a) fraud involving the illicit transfer of crypto-assets to the personal wallets of malicious entities (e.g. market manipulation, manipulation of DeFi protocols and of oracles, scams, ransomware and other cyberattacks, crypto-asset theft through unauthorized access and misconduct or misappropriation by centralised crypto exchanges);
- (b) trading in illicit goods and providing illegal services using crypto-assets for payment to avoid detection (e.g. darknet markets, terrorism financing, money laundering and sanctions evasion);
- (c) combinations of the above categories.

The article also sets out certain considerations to be taken into account with regard to monitoring and preventing various types of fraudulent crypto-asset transactions and DeFi activities, allowing for their diversity and complexity, as identified in the analysis.

**Keywords:** crypto-assets, fraud, deceptive practices, crypto-asset-based scams, money laundering.

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<sup>14</sup> 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 Interlinkages between traditional finance and crypto-assets

### 2.3.1 Financial institutions weigh the opportunities and risks of crypto-assets: the latest insights from the traditional financial system's involvement in the crypto-asset markets<sup>15</sup>

Claire Brousse, Tatu Räsänen

Historically, the interconnections between traditional finance and crypto-asset markets have been limited. These interconnections have, however, been growing over the past few years, for example with the launch of crypto exchange traded products (ETPs). Although the 2022 crypto-asset market downturn did not result in wider contagion to traditional finance, it underscored the importance of understanding and managing the risks associated with the crypto ecosystem. Based on publicly available data, the report examines these interconnections for the banking sector, non-bank financial intermediaries, payment firms and crypto-asset-related market products. The findings show that the European banking and insurance sectors' exposure to crypto-assets continues to be limited. This is likewise the case for the European hedge fund sector. Crypto-asset trading and custody services were identified as the most common crypto-asset-related services provided by TradFi institutions in Europe.

Furthermore, so-called stablecoins, a ramp between crypto-asset markets and TradFi, were identified as a potential contagion channel for turmoil in the crypto-asset markets. If the use of stablecoins increased significantly, a run on stablecoin could put selling pressure on its reserve assets, such as government bonds, and could lead to stress in the market. Despite the current limited banking sector exposure, risks for individual banks and for financial stability could arise from risk concentration, given the limited number of crypto services providers. Moreover, the launch of crypto ETPs and tokenised assets, such as tokenised money market funds, may expose TradFi institutions to new threats, resulting in counterparty, operational and cyber risks. In response to the failures seen in the crypto-asset markets, regulators have come up with a coordinated response to create a global framework for regulating and supervising crypto-asset intermediaries and the issuance of stablecoins. In the EU, this response has taken the form of MiCAR and its implementation may further shape the ties between TradFi and crypto-asset markets. Addressing the risks associated with crypto-assets is crucial to ensure the long-term stability of the financial system. In this regard, the report underlines the need to increase monitoring capabilities and identifies several existing data gaps.

**Keywords:** financial institutions, contagion channels, crypto-assets, interconnectedness, risk, financial stability.

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<sup>15</sup> 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 Implications of the Basel crypto-asset exposure limit for banks in terms of portfolio and risk management<sup>16</sup>

Nicolas Soemer, John Theal,  
Alexandra Born, Georg Paula,  
Laura Tresso

From 1 January 2025 credit institutions will need to comply with the transitional arrangements for the prudential treatment of crypto-assets in accordance with Article 501d of the [Capital Requirements Regulation](#) (CRR III). The current paper examines the implications of these transitional provisions, focusing on the 1% Tier 1 capital exposure limit for crypto-assets not representing traditional assets or MiCAR-compliant stablecoins. The transitional provisions will ultimately be replaced by the final provisions, aligned to the Basel standard on the prudential treatment of crypto-asset exposures, under which a similar exposure limit will be set.

The study used daily price data from CryptoCompare covering a five-year period, from 1 January 2019 to 31 December 2023, and focused on 12 major crypto-assets which, under the transitional CRR III rules, would have been assigned a 1,250% risk weighting and have been subject to an exposure limit of 1% of bank Tier 1 capital. The analyses in this study included crypto-asset volatility and correlation assessments, hypothetical portfolio definitions and impact assessments through the calculation of a two-week value at risk at varying confidence levels. Based on this analysis, an early warning dashboard to monitor the banking sector's risk of potential breaches of the 1% exposure limit was developed, featuring heatmaps that illustrate price change severity and correlation risks.

The impact analysis revealed some of the consequences of the substantial volatility of this asset class. In particular, there is a significant probability of the 1% exposure limit being breached by banks owing to volatile price movements. A breach could result in supervisory measures, such as capital add-ons or restrictions on conducting further business, being imposed, depending on the individual case, leading to a potentially unviable business model until the exposure limit is again met. Furthermore, all the crypto-assets and portfolios included in the analysis exhibited leptokurtic return distributions, underscoring the need for robust risk management practices. From a supervisory perspective, the results suggest the need for further attention to be given to banks' compliance with exposure limits when there is exposure to crypto-assets.

**Keywords:** crypto-assets, credit institutions, capital requirements, CRR III exposure limit.

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<sup>16</sup> 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.

### 2.3.3 Toss a stablecoin to your banker. Stablecoins' impact on banks' balance sheets and prudential ratios<sup>17</sup>

Charles-Enguerrand Coste

This paper explores the relationship between banks and stablecoins and their issuers, focusing on the mechanical effects on banks' capital and liquidity ratios when issuing stablecoins or collecting deposits from stablecoin issuers. The analysis reveals that converting retail deposits into stablecoin issuers' deposits weakens a bank's liquidity coverage ratio (LCR), turning a retail deposit into a wholesale deposit, even when these funds are reinvested in high-quality liquid assets. If a credit institution issues its own stablecoins, the impact on its LCR depends on whether it can identify the stablecoin holders; unknown holders weaken the LCR which could incentivise banks to issue stablecoins where they can continually identify the holders to benefit from more favourable liquidity treatment. Additionally, banks must either hold the reserves backing the stablecoins as central bank reserves or reinvest them in low-risk assets, making these funds a less effective source for economic financing and maturity transformation compared with traditional retail deposits. The study also finds that when retail customers of bank A buy a stablecoin issued by a non-bank that keeps reserves at bank B, both banks could see an unexpected decline in their liquidity ratios, as bank A loses stable retail deposits and bank B gains volatile wholesale deposits. These insights are crucial to understanding the dynamics between banks and stablecoins in the evolving financial landscape.

**Keywords:** stablecoin, e-money, crypto-asset, MiCAR, bank, prudential regulation, bank balance sheets.

**JEL codes:** E40, E42, E49, G11, G15, G18, G20, G21, G23, G28

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## 2.4 Analysing crypto-assets and conventional financial markets

### 2.4.1 Crypto-asset markets vs financial markets: event identification, latest insights and analyses markets<sup>18</sup>

Eleni Koutrouli, Polychronis Manousopoulos, John Theal, Laura Tresso

As crypto-assets become more widely adopted, crypto-asset markets and traditional financial markets may become increasingly interconnected. The close linkages between these markets have potentially important implications for price formation, contagion, risk management and regulatory frameworks. This study assesses the correlation between the traditional financial markets and selected crypto-assets, examines factors that may affect crypto-asset prices and identifies potentially significant events that may have an impact on crypto-asset price dynamics. Three lines of research were followed in addressing these topics.

In the first line of research, a Bayesian model averaging approach was adopted to identify change points in the Bitcoin and Ethereum daily price time series. The dates and probabilities of these change points were then used to link the change points to specific events, with nearly all of those points being associated with known historical crypto-asset-related events. The different events could then be classified into broader geopolitical developments, regulatory announcements and idiosyncratic events specific to either Bitcoin or Ethereum.

In the second line of research, the correlation between the prices and yields of Bitcoin and major European and US stock market indices was explored over a five-year period, from 2019 to 2023. In addition, the correlation between the prices and yields of Bitcoin and those of commodities, such as gold and crude oil, were computed over the same time period. The correlations calculated for the entire period were analysed, as were the changes over that time.

In the third line of research, the effect of specific significant global events on the correlation between selected cryptocurrencies was examined. In particular, the dynamic conditional correlation model was used to estimate the change in the correlation between pairs of 12 cryptocurrencies following significant global events, such as the COVID-19 pandemic and military conflict. The effect that each event had in these correlations was analysed. Finally, the main conclusions were presented, identifying practical issues that arose during the research and indicating areas for future work.

**Keywords:** crypto-asset, financial market, event identification, correlation.

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## 2.4.2 Stablecoins, money market funds and monetary policy<sup>19</sup>

Iñaki Aldasoro, Giulio Cornelli,  
Massimo Ferrari, Minesso  
Leonardo Gambacorta, Maurizio  
Michael Habib

Using a new series of crypto shocks, we document that money market funds' (MMF) assets under management, and traditional financial market variables more broadly, do not react to crypto shocks, whereas stablecoin market capitalization does. U.S. monetary policy shocks, in contrast, drive developments in both crypto and traditional markets. Crucially, the reaction of MMF assets and stablecoin market capitalization to monetary policy shocks is different: while prime-MMF assets rise after a monetary policy tightening, stablecoin market capitalization declines. In assessing the state of the stablecoin market, the risk-taking environment as dictated by monetary policy is much more consequential than flight-to-quality dynamics observed within stablecoins and MMFs.

**Keywords:** stablecoins, crypto, Bitcoin, monetary policy shocks, money market funds.

**JEL codes:** E50, F30

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## 2.5 Markets in Crypto-Assets Regulation & related data (challenges)

### 2.5.1 Deep dive into asset-referenced tokens, electronic money tokens and other stablecoins<sup>20</sup>

Anita Deflorio, Yvan Dubravica,  
Agapi Kasimati

Self-labelled “stablecoins” emerged as a more stable alternative to the fast growing and volatile, although relatively small, market in bitcoin-like crypto-assets. The introduction of stablecoins, designed to maintain a fixed value by being pegged to traditional assets, such as the US dollar or other fiat currencies, represented a pivotal moment in the crypto landscape. Stablecoin adoption has been fuelled by their potential utility in various applications, including decentralised finance (DeFi), remittances, cross-border payments and tokenisation.

Bearing in mind the prospective further evolution of stablecoins and the importance of crypto-asset regulation, supervision and oversight, this paper tries to shed light on how the current regulatory framework in the EU may impact the issuance, circulation and use of stablecoins. Furthermore, it seeks to analyse how the quality of reserve assets backing the digital value of the stablecoin might influence the potential use of this “money-like” instrument as a payment tool or reserve of value.

The paper is structured as follows. The first section sets out the features of money and contrasts them with those of stablecoins as envisaged in the various regulatory and related taxonomies and recommendations. This section also reflects on the use cases for stablecoins, such as for retail payments and cross-border transactions.

The second section gives an overview of recommendations for stablecoin regulation and dives into selected provisions of the MiCAR. Special attention is paid to the reserve of assets required under the MiCAR and the corresponding supervision.

The third section provides a comparative analysis of the EU and US stablecoins markets, focusing on measures of size.

The last section sets out conclusions.

**Keywords:** stablecoin, MiCAR, crypto-assets.

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## 2.5.2 Crypto-asset database and indicators at the European Central Bank<sup>21</sup>

Isabel Kerner, Urszula Kochanska, Thomas Teulery, Laura Tresso

Crypto-asset and related activities have so far co-existed, but not endangered or played a significant role in the global financial system. However, their potential impact on the financial sector, remarkable growth between 2020 and early 2022 and increasing linkages with various parts of the financial sector have led to a global policy debate resulting in regulatory initiatives, such as the MiCAR in Europe. Understanding the impact of crypto-assets requires close monitoring. From a central bank perspective, such monitoring is important to identify the possible implications of crypto-assets for monetary policy, the smooth functioning of market infrastructures and payments, and the stability of the financial system. The ECB has been observing and analysing the crypto-assets phenomenon and, in the light of this, has developed a monitoring framework, with a dedicated dataset and indicators as the focal points.

This paper sheds some light on the development of the ECB crypto-asset dataset and indicators. Specifically, it: i) presents the indicators that the ECB uses for its regular monitoring of on-chain and off-chain crypto-asset activities and major crypto players; ii) elaborates on the outcome of the 2023 DeFi hackathon, which focused on lending and payment protocols, as well as on blockchain oracles; and iii) reflects on the expected impact of the MiCAR on crypto-asset data gaps.

**Keywords:** fintech, crypto-assets, virtual currency, cryptocurrency, decentralised finance (DeFi), data quality.

**JEL classification:** E42; G21; G23; O33; C18

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### 2.5.3 Data sources assessment to follow the evolution of bitcoin<sup>22</sup>

José Manuel Carbó, Hossein Jahanshahloo, José Carlos Piqueras

The crypto asset market has seen notable growth in recent years, along with changes in its value. This expansion, along with its increasingly high integration into traditional monetary and financial systems, has raised the potential risks for the economy. However, monitoring this activity is not easy due to the decentralized nature of how it works and the lack of reporting requirements for operations. To better understand the available data on crypto assets, this paper looks at different information sources, focusing on bitcoin, the most well-known crypto asset. We look at two types of data: direct data from the Bitcoin blockchain, and third-party data from exchange platforms, information aggregators and specialized service companies. We discuss the strengths and weaknesses of both types of data when it comes to issues important to financial authorities. While blockchain analysis has the advantage of being public and reliable, addressing issues such as money laundering or financial stability requires additional third-party data, with the associated risks this entails.

**Keywords:** bitcoin, blockchain, cryptocurrencies, financial risks.

**JEL classification:** G15, G2, E42, L86.

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## 2.6 Gaining a deeper understanding of decentralised finance

### 2.6.1 Exploring blockchain data from central banks: outcomes from a decentralised finance hackathon<sup>23</sup>

Pedro Bento Pereira Da Silva,  
José Manuel Carbó Martínez,  
Anita Deflorio, Alexander  
Hodobod; Mikaël Kalfa, Urszula  
Kochanska, Thomas Teulery,  
Eleni Koutrouli

Readily available public data on DeFi, which has gained a significant user-base since 2020, generally lack granularity and are prone to gaps. Data retrieved from blockchains directly remain opaque and cumbersome to analyse. Against this backdrop, this paper offers a case study elaborating on the findings of the winning team at the March 2023 DeFi hackathon organised by the ECB. The objective of the hackathon was to deepen understanding of specific DeFi segments by offering participants hands on-exposure to detailed data on DeFi protocols and the opportunity to analyse issues of relevance to the interests and mandates of central banks and banking supervisors. Obtaining insights directly from blockchain data, rather than relying on data providers, can be seen as pushing the boundaries in crypto-asset monitoring.

This case study is organised into four sections. The first section covers challenges related to blockchain data preparation for the hackathon. The second elaborates on the features of DeFi credit and lending, including flash loans, and on the outcome of analysis of Aave on-chain data. The third section presents the DeFi payment segment with its money streaming facilities and offers insights from an examination of Sablier on-chain data. In the fourth section, the focus shifts to blockchain oracles, and a number of specific characteristics and related malfunctions and exploits (inaccuracies) are presented and analysed. The concluding section offers certain policy recommendations, discusses prospective future work and evaluates the efficacy of hackathons for acquiring knowledge and honing skills.

**Keywords:** decentralised finance (DeFi), DeFi lending, DeFi payment, blockchain oracles, blockchain data.

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## 2.6.2 Crypto derivatives: an overview of decentralised finance products and protocols

Anita Deflorio, Ellen Naudts,  
Katja Neugebauer, Laura Painelli,  
Salim Talout Zitan

The crypto derivatives market has grown exponentially, with trading volumes surging from under USD 100 billion in January 2019 to over USD 4 trillion by May 2021. Despite a downturn during the crypto winter of 2022-23, the monthly trading volume rebounded to USD 1.33 trillion in September 2023, outpacing the spot market. Crypto derivatives, based on inherently volatile crypto-assets such as bitcoin (BTC) and ether (ETH), are attractive instruments for speculation and hedging but carry substantial risks.

The rapid expansion of this market poses potential risks to financial stability and consumers' financial welfare owing to the products' complexity, volatility and vulnerability to market manipulation and cyberattacks. The UK's Financial Conduct Authority banned crypto-linked derivatives in 2020, reaffirming its stance in 2024. This measure underscores the potential harm to vulnerable consumers, especially younger investors, who may engage in trading without understanding the risks. Unlike conventional derivatives linked to stocks or commodities, crypto derivatives are subject to the evolving regulatory landscape for crypto-assets. While proponents argue that blockchain technology and smart contracts enhance transparency and reduce counterparty risk, crypto markets continue to suffer from high volatility and liquidity issues. Since the introduction of BTC futures by the Chicago Mercantile Exchange and Chicago Board of Trade in 2017, crypto derivatives have faced risks typical of both crypto and derivatives markets, such as liquidity and counterparty risks. In DeFi, crypto derivatives protocols, such as dYdX and GMX, have gained popularity by enabling trading without intermediaries, often being governed by decentralised autonomous organisations (DAOs). However, the lack of a comprehensive global regulatory framework for DAOs presents challenges for compliance, governance and consumer protection. In conclusion, while offering potential opportunities for sophisticated investors, the crypto derivatives market presents substantial risks, amongst others owing to its speculative nature and extreme volatility. Regulators could provide more clarity on the treatment of DAOs, continue to balance fostering innovation with consumer protection, monitor unregulated trading activities and promote transparency within DeFi protocols.

**Keywords:** crypto-assets, crypto derivatives, statistics.

**JEL classification:** E61 G12 G13 G15

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## 2.6.3 Who to regulate? Identifying actors within decentralised finance governance<sup>24</sup>

Alexandra Born, Zakaria Gati,  
Claudia Lambert, Mahvish  
Naeem, Antonella Pellicani

When DeFi emerged as a fast-growing segment in the crypto-asset universe in 2021, it quickly captured the attention of policy makers owing to its innovative approach in delivering financial services without relying on centralised intermediaries. DeFi's purported decentralised governance, its opaque structure and pseudonymous nature poses challenges for policy makers in effectively regulating and supervising DeFi protocols. This is important given that the vulnerabilities in DeFi are not so dissimilar from those in the traditional financial system, although at times manifesting differently.

Against this background, this paper aims to assess the implications of DeFi governance arrangements for regulating and supervising DeFi with the aim of informing policy discussion on possible regulatory anchor points. We do so by: (1) analysing the governance token holdings of four DeFi protocols (Aave, MakerDAO, Ampleforth, Uniswap) to identify the largest players; (2) examining the governance proposals shaping the protocols; and (3) assessing the voting distribution on governance proposals. For the analysis, we compile a comprehensive data set relying on different techniques, such as web scraping, manual data gathering and accessing public sources. We hand-collect information on token holders across major protocols located on the Ethereum blockchain. In particular, the database contained information on governance token holders, voters and delegates, where possible including information on their identities or associations, and on governance proposals. Analysing the distribution of governance token holders, we find that this is highly concentrated, confirming previous findings. Assessing who was behind the concentrated holdings, it emerged that, for most protocols, around half or more of all holdings can be attributed to addresses associated with either the protocols themselves or with centralised and decentralised exchanges. Analysing the top voters, we find that the top voters are mostly delegated agents, who, in many cases, could not be identified, however, nor linked with the token holders. Overall, the study offers valuable insights for policymakers regarding the implementation of policy measures aimed at bringing relevant entities under the regulatory umbrella. The difficulty in identifying holders and voters using public data may make it hard to rely on some of the regulatory anchor points often put forward in the policy debate such as governance token holders, developers or centralised exchanges.

**Keywords:** decentralised finance, governance, financial stability risks, regulation.

**JEL codes:** G18, G23, G28, O33

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## 2.7 Insights into decentralised finance lending

### 2.7.1 DeFi-ying the Fed? Monetary policy transmission to stablecoin rates<sup>25</sup>

Andrea Barbon, Jean Barthélemy,  
Benoît Nguyen

Does the Federal Reserve's monetary policy transmit to stablecoins pegged to the US dollar? Large stablecoin issuers do not pay interest, but investors can lend stablecoins in Decentralized Finance (DeFi) lending protocols, where interest rates are governed by predetermined interest rate rules enforced by smart contracts. This leads to markedly different interest rates between conventional short-term rates and stablecoins' interest rates. We document that the recent Federal Reserve's interest rate hiking cycle coincided with falling stablecoin interest rates until July 2022, after which the correlation became positive. To make sense of the observed dynamics, we develop a simple model of DeFi lending and bring it to the data. The model successfully reproduces the observed shift in monetary policy transmission to stablecoin rates.

**Keywords:** crypto, stablecoins, monetary policy.

**JEL Classification:** G14, G23, G29

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## 2.7.2 Why decentralised finance lending? Evidence from Aave V2<sup>26</sup>

Giulio Cornelli, Leonardo Gambacorta, Rodney Garratt, Alessio Reghezza

Decentralised finance (DeFi) lending protocols have experienced significant growth recently, yet the motivations driving investors remain largely unexplored. We use granular, transaction-level data from Aave, a leading player in the DeFi lending market, to study these motivations. Our theoretical and empirical findings reveal that the search for yield predominantly drives liquidity provision in DeFi lending pools, whereas borrowing activity is mainly influenced by speculative and, to some extent, governance motives. Both retail and large investors seek potential high returns through market movements and price speculation, however the latter engage in DeFi borrowing relatively more than the former also to influence protocol decisions and accrue more significant governance rights.

**Keywords:** cryptocurrency, DeFi, decentralised finance, lending.

**JEL Classification:** G18, G23, O39.

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## 2.8 Selected aspects of distributed ledger technology in central banking

### 2.8.1 Validation of crypto-asset on-chain transactions - relevance, risks, and challenges for official statistics<sup>27</sup>

Eldin Delić, Urszula Kochanska,  
Salim Talout Zitan, Laura Tresso

With the steady evolution of crypto-assets into a more mainstream phenomenon, various crypto-asset services and related business models have emerged in this field. The validation of crypto-asset transactions, especially mining and staking pools and validation-as-a-service, provides an interesting case in this regard. These constructs can be seen as entities raising capital from the public to generate a common return for investors. The validation of crypto-asset on-chain transactions requires and generates the equivalent of millions of US dollars daily – amounts that are not yet captured in any official statistics. This paper seeks to provide insights into the latest developments for this phenomenon and to progress towards closing the statistical gap.

The first part of the paper examines the current trends and specific features of the validation of crypto-asset transactions, covering mining and staking on selected blockchains as well as in DeFi. Given that the validation of transactions is largely dominated by mining and staking pools, these are analysed in the second part of the paper based on their geographical incorporation, business model and governance. The objective of the analysis was to explore the relevance of the mining and staking pools and their inherent risks. The third part of the paper elaborates on the challenges of incorporating the validation of crypto-assets into macro-economic statistics. In this regard, the paper elaborates on diverse approaches to measuring the country-specific output of validation services and the geographical distribution of validation fees. It also provides initial estimates for each of these. In collecting the new data required for the estimates, the analysis drew on multiple data sources, and the paper provides a detailed analysis of the related challenges.

**Keywords:** distributed ledger technology, DLT, blockchain, crypto mining, staking, decentralised finance, DeFi, official statistics.

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## 2.8.2 Byzantine fault tolerant consensus with a confidential quorum certificate for a central bank distributed ledger technology<sup>28</sup>

Marco Benedetti, Francesco De Sclavis, Marco Favorito, Giuseppe Galano, Sara Giammusso, Antonio Muci, Matteo Nardelli

Some essential characteristics of DLTs, such as programmability and the use of advanced cryptographic techniques, can also be used effectively in controlled environments overseen by a central authority or a group of delegated entities. This is especially relevant in the financial sector and in settings where compliance with regulation is essential. Technically, this requires DLTs to be deployed in permissioned versions, with only one set of authorized participants – referred to as validators – being allowed to approve or reject transactions. All DLTs rely on a cooperative decision-making process, known as a consensus protocol, designed to reach an agreement on the next state of the ledger. In permissioned contexts, proof-of-authority (PoA) protocols entrust a predetermined group of validators with the power to accept or reject transactions proposed by participants, without requiring extensive resource commitments. Typically, these validators achieve consensus through qualified majority voting.

This paper presents the FROSTed Byzantine Fault Tolerance (FBFT) protocol, a novel approach to PoA that is meant to strengthen the security of a ledger, including its tolerance to faults or attacks, and to preserve the confidentiality of validators. Leveraging state-of-the-art privacy-enhancing techniques, the FBFT builds a collective agreement certificate (or “joint cryptographic signature”), which represents the endorsement of a given set of transactions by a quorum of validators. In addition, it provides strong guarantees of tolerance to Byzantine faults – situations in which some validators may stop functioning, possibly owing to software bugs, cyberattacks or network disruptions, or may behave dishonestly. We integrate our FBFT protocol into the code of a Bitcoin-like blockchain, adapting its consensus component to a permissioned context, and we evaluate its performance in geographically distributed, realistic scenarios. To demonstrate its practicality and encourage further research, we provide an open-source implementation of our DLT. The resulting system, although experimental and lacking certain features expected of production-ready solutions, can be seen as an alternative platform for a distributed, resilient transactional system. Operated by a set of trusted actors, distributed at geographic scale, it has the potential for mission-critical applications, such as for wholesale and retail central bank digital currencies, and, going forward, for asset tokenisation schemes.

**Keywords:** distributed ledger; blockchain; Byzantine consensus; confidential quorum; threshold signatures.

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## 2.8.3 Some applications of distributed ledger technology to central banking in the Eurosystem<sup>29</sup>

Guillermo Andres Marquez Musso

Crypto-assets are becoming increasingly commonplace. The underlying technology, DLT, having been used to generate new types of financial instruments and markets, has moved public and private institutions to integrate it into the *existing* financial infrastructure. In the long term, the future of this transition is sufficiently compelling for central banks to investigate how they might operate in this environment. In this paper, the first step is taken and the ECB's existing operational framework, supplemented with so-called "smart contracts", was applied to the policy-making process. This raised the following question: "Can a central bank implement monetary policy using DLT?" The short answer is yes. This report presents a subset of the long answer and focusses on replicating the existing monetary policy framework for the Eurosystem – i.e. [Guideline \(EU\) 2015/510](#). In practice, this means having a literal codification of the legal requirements for smart contracts, ensuring that those requirements correspond to the functions of the ESCB. This system of smart contracts was put into code, and then adequately tested to correspond for how the ECB conducts its open market operations. The conclusion reached is that DLT would give central banks substantial benefits in both setting and adjusting their operational framework.

**Keywords:** central banking, market operations, collateralization, smart contracts, distributed ledger technology, monetary policy implementation.

**JEL Classification:** E42, E50, O30

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## 3 Way forward

A key task in managing the risks posed by crypto-assets is to delve deeper into the financial system's resilience to potentially harmful future developments in order to pinpoint any gaps that need to be addressed. The crypto-asset market is constantly changing and its links to the financial system and the wider economy could grow and strengthen going forward. Greater exposure to both regulated and unregulated crypto-assets could arise from a number of factors, such as the evolving regulatory landscape or advancements in crypto innovation. In the light of this, the CAMEG's next wave of operations, extending for a period of nine months from January 2025, will prospectively deal with topics such as:

- early warning indicators to be developed by gaining an understanding of the root causes of major crypto market failures;
- interlinkages of crypto-assets with the financial system, the broad economy and within the crypto-asset ecosystem;
- CASP issues: major provider players, the risks and novel indicators;
- deep dives into stablecoins;
- studies of the main/novel crypto-asset segments.

CAMEG aims to broaden its collaboration with experts from ESCB central banks, authorities supervising crypto-asset issuers and service providers, and other European institutions, extending its membership beyond the Eurosystem itself. European cooperation is key to unlocking smooth and effective crypto-asset monitoring. With CAMEG's strong focus on data, further joint exploration of crypto-asset data sets is planned for the second wave. Both on-chain and off-chain data will be scrutinised in greater depth, using novel statistical techniques to develop methodologies and indicators. Significant emphasis will be placed on establishing shared datasets for collaborative analysis by CAMEG members.

The CAMEG 2024 conference fulfilled the objectives of taking stock of analytical work undertaken and of outstanding data issues, as well as fostering European collaboration and discussion of crypto-asset monitoring. Given the success of this first conference, CAMEG's plan is to organise a second conference, towards the end of October 2025, in which the progress in crypto-asset monitoring made in the intervening period will then be examined.

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