

Crypto-asset database and indicators at the European Central Bank (ECB)¹

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Abstract

Crypto-asset and related activities have co-existed but not endangered or played a significant role in the global financial system so far. 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 led to a global policy debate, including regulatory initiatives such as the Markets in Crypto-asset Regulation (MiCAR) in Europe. Understanding the impact of crypto-assets requires close monitoring. Taking a central bank perspective, such monitoring is important to identify possible implications crypto assets may have for monetary policy, the smooth functioning of market infrastructures and payments, and the stability of the financial system. The European Central Bank (ECB) has been observing and analysing the crypto-assets phenomenon and in this context has developed a monitoring framework, with a dedicated dataset and indicators as the focal point.

This paper aims to shed some light on the evolution of the ECB crypto-asset dataset and indicators. Specifically, this paper aims to: i) present the indicators the ECB uses for the regular monitoring of on-chain and off-chain crypto-asset activities and major crypto players, ii) elaborate on the outcome of the 2023 DeFi hackathon which focused on lending and payment protocols as well as blockchain oracles, and iii) reflect on the expected impact of the MiCAR on the crypto-asset data gaps.

Keywords: Fintech, Distributed Ledger Technology, Blockchain, crypto-assets, virtual currency, cryptocurrency, Decentralised Finance (DeFi), data quality, European Central Bank.

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

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Executive summary

The ECB has been analysing crypto-assets to identify potential implications for monetary policy, the smooth functioning of market infrastructures and payments, and the stability of the financial system. For this purpose, the ECB has set up the crypto-asset monitoring framework. This paper elaborates on the evolution of the framework since the last publication on this topic in 2020. The period following 2020 witnessed the emergence of new markets including Decentralised Finance (DeFi) and crypto-derivatives as well as the burst of the crypto-asset bubble. Given these events, the monitoring framework has expanded to include new markets and major players, while also further enhancing the understanding of the linkages mainly between the crypto-assets and the financial system. This paper elaborates on these new developments accordingly.

The ECB monitoring framework encompasses various categories of crypto-assets including bitcoin and *altcoins* as well as stablecoins (off-chain/on-chain collateralised and algorithmic). Special attention is paid to stablecoins referencing euro and/or other fiat currencies in the European Union (EU), DeFi tokens, and the *anonymity enhanced coins*.

As for the markets, the monitoring framework covers centralised exchanges (CEXes), Peer-to-Peer (P2P) exchanges, and Decentralised Exchanges (DEXes) alongside various other DeFi segments including lending, insurance, payment or staking protocols. In addition to spot trading, one of the latest extensions of the monitoring framework comprises the indicators to monitor the markets for crypto derivatives.

Conducting a comprehensive analysis of linkages poses a key challenge. Nevertheless, it is possible to gain insights into direct and indirect exposures by type of users relying on surveys, official statistics, and proxies derived from on-chain data. On-chain and alternative data are explored to estimate the geographical distribution of crypto-asset flows and proxy the usage of crypto-assets as a means of payment respectively. In the monitoring of linkages, it is important to keep track of traditional finance (TradFi) firms' provision of banking and other services to crypto-asset companies, investments in crypto-asset businesses, on-chain flows between entities, as well as links between crypto-asset markets and financial markets.

The monitoring of major players covers entities and assets that play an important role on various crypto-asset markets as described above. Typically, they are the largest or fastest growing crypto-assets within the analysed domain, significant providers of crypto-asset services, as well as intermediaries enabling and facilitating the interconnection between crypto-assets on one side and the real economy and financial markets on the other side.

DeFi hackathon organised by the ECB allowed to deepen understanding of specific DeFi segments (lending and payment) by offering hands-on exposure to detailed protocol-specific data. Obtaining insights directly from on-chain data, rather than relying on data providers, can be seen as pushing the boundaries in crypto-asset monitoring. The hackathon participants developed indicators concerning DeFi users, transactions, and insights into novel products (like *flash loans* or *money streaming*). Furthermore, they shed some light on the blockchain oracles in particular their business models, risks, and malfunction cases.

The monitoring of crypto-assets faces significant data quality and data gaps issues. These issues stem from the specificities of the off-chain crypto-asset markets which are largely unregulated and opaque. The transparency that is proclaimed for crypto-assets by crypto-asset advocates, does not correspond to the actual transparency, nor allows the usage of crypto-asset on-chain data for analysing risks and interconnectedness. Working with on-chain data can be burdensome, complicated, and prone to

misinterpretation. Misinterpretation can occur also with off-chain indicators, especially as they are mostly derived from non-verifiable data. Therefore, the data gaps are related to questions that appear to be still very simple.

There are a few initiatives that stand out in the context of addressing crypto-asset data gaps: the integration of crypto-asset domains into statistical classifications, the G20 New Data Gap Initiative (DGI), and the Markets in Crypto-asset Regulation (MiCAR) in Europe. All of them in the medium term are expected to provide a significant step towards high-quality data and statistics on crypto-assets.

1. Major developments shaping the monitoring framework

Given their potential to affect the global financial system, crypto-assets and related activities need to be closely monitored. Taking a central bank perspective, such monitoring is important to identify potential implications for monetary policy, the smooth functioning of market infrastructures and payments, and the stability of the financial system. The European Central Bank (ECB) has been analysing the crypto-asset phenomenon³ and for this purpose has set up a monitoring framework with dedicated datasets and indicators. The ECB crypto-asset datasets and indicators aim to keep up with developments in the crypto-asset ecosystem and the ever-growing monitoring needs.

This paper provides an update on the evolution of the ECB crypto-asset dataset and indicators since the last publication on this topic in 2020⁴. The period following 2020 witnessed the rise and rapid expansion of new segments of the crypto-asset ecosystem, including Decentralised Finance (DeFi) and crypto derivatives. DeFi, a blockchain-based novel infrastructure mimicking financial services, experienced explosive growth from summer 2020 to spring 2022. The notable increase in activity within the markets in crypto futures, options, and swaps happened towards the end of 2020 and this trend continues. More and more large intermediaries offering a broad repertoire of crypto-asset services and functions have started to assert their dominance in the crypto sphere. The crypto bubble build-up in 2020 burst two years later. Significant crypto losses in 2022 were triggered by a chain of events beginning with the collapse of Terra-Luna with contagion onto two crypto lenders and a crypto hedge fund and punctuated by the collapse of FTX.⁵ Then, in early 2023 the decrease in prices and activity of crypto-assets resulted in the closure of a bank exposed to crypto risks and potentially played a role in the failure of another bank⁶. In light of these events, the monitoring framework expanded to encompass: i) new markets, ii) major players, and iii) new insights into linkages with the financial system. Additionally, a significant emphasis has been placed on understanding the intricate nature of crypto failures and their resulting contagion effects, ultimately paving the way towards work on early warning indicators.

³ In 2018 the ECB established the Internal Crypto-Assets Task Force (ICA-TF), with a mandate to deepen the analysis of crypto-assets. For a summary of the outcome of the ICA-TF's analysis, see: i) ECB Crypto-Assets Task Force (2019), [Crypto-Assets: Implications for financial stability, monetary policy, and payments and market infrastructures](#), Occasional Paper Series, No 223, ECB, Frankfurt am Main, May 2019, ii) ECB Crypto-Asset Task Force (2020), [Stablecoins: Implications for monetary policy, financial stability, market infrastructure and payments, and banking supervision in the euro area](#), Occasional Paper Series, No 247, ECB, Frankfurt am Main, September 2020; and also [Macprudential Bulletin](#) No 18, July 2022

⁴ [Dataset and indicators to monitor the crypto-asset phenomenon](#), Irving Fisher Committee on Central Bank Statistics (IFC) Report No 12 Towards monitoring financial innovation in central bank statistics

⁵ See e.g. [Crypto dominos: the bursting crypto bubbles and the destiny of digital finance](#), Keynote speech by Fabio Panetta, December 2022

⁶ See e.g. [Mind the gap: we need better oversight of crypto activities](#), Blog post by Elisabeth McCaul, April 2023

In conjunction with the aforementioned developments, a remarkable initiative has been achieved in the regulatory sphere – the adoption of the Markets in Crypto-assets Regulation (MiCAR)⁷ addressing crypto-asset issuance and service provision in the European Union. MiCAR regulates activities related to (i) offering crypto-assets such as asset-referenced tokens (ARTs) and electronic money tokens (EMTs) to the public, (ii) seeking admission for trading, as well as (iii) issuing such tokens. MiCAR came into force on 29 June 2023 and is of great importance also in the context of the future crypto-asset monitoring framework.

2. Elements of the crypto-asset monitoring framework

Categories of monitored crypto-assets

Bitcoin and similar unbacked crypto-assets, colloquially referred to as *altcoins*, constitute the first and the biggest category of monitored crypto-assets in terms of e.g. *reported trading volumes* or what is *informally called market capitalisation*⁸. The main feature of these crypto-assets is that they are not backed i.e. they are not and do not represent a financial claim on, or a liability of, any identifiable entity. Furthermore, they lack any mechanism for price stabilisation that would peg their price to that of other assets (i.e. neither traditional, nor crypto nor baskets of assets). The unbacked crypto-assets featuring a price stabilisation mechanism fall into the category of **algorithmic stablecoins**⁹. Algorithmic stablecoins rely only on users' expectations about the future purchasing power of their holdings, an approach which does not require custody of any underlying collateral asset, and whose operation is decentralised¹⁰. Non-algorithmic stablecoins, which are backed, can be generally classified as **off-chain collateralised** or **on-chain collateralised stablecoins**. The former are backed by other traditional asset classes that require a custodian for their safekeeping. The collateral assets are in the possession of the issuer only as long as the user does not redeem the stablecoins. The latter are backed typically, but not necessarily exclusively, by crypto assets which can be recorded in a decentralised manner and need neither an issuer nor a custodian to satisfy any claim. Our monitored crypto-assets cover all the described categories with a special focus on **stablecoins referencing euro and/or other fiat currencies in the European Union (EU), DeFi tokens**, and the **"anonymity enhanced coins"** (AEC). AECs make the tracing of the transactions more difficult by using practices of mixing¹¹ or obscuring IP addresses, wallet balances and the flow of funds from public view. They are frequently used for illicit purposes.

⁷ [Regulation \(EU\) 2023/1114](#) of the European Parliament and of the Council of 31 May 2023 on markets in crypto-assets, and amending Regulations (EU) No 1093/2010 and (EU) No 1095/2010 and Directives 2013/36/EU and (EU) 2019/1937.

⁸ For the sake of simplicity, in the remaining part of the paper we will use the terms "trading volumes" and "market capitalisation". Nevertheless, the information pertaining to crypto-asset trading volumes and market capitalisation is largely unverifiable, among other factors, thereby lacking the quality of trading volumes and market capitalisation of financial instruments.

⁹ Stablecoins are a type of crypto-assets designed to minimize price volatility by pegging their value to a reserve of assets like fiat currencies (e.g. USD, euro, etc.), commodities, or other crypto-assets. For the sake of simplicity, in the remaining part of the paper we will use the term "stablecoins". Nevertheless, without sound regulation – stablecoins are stable in name only.

¹⁰ For a detailed overview of various categories of stablecoins please see: [In search for stability in crypto-assets: are stablecoins the solution?](#); see also e.g. [Stablecoins' role in crypto and beyond: functions, risks and policy](#) ECB Macroeprudential Bulletin July 2022

¹¹ Also called tumbling or blending

Crypto-asset markets

Transactions involving crypto-assets occur on multiple also interconnected markets. Off-chain transactions are recorded either on an institution's book (in the case of trading platforms) or in a private network of users which may use the distributed ledger to record the net transactions. On-chain transactions are those recorded directly on a distributed ledger. Typical markets for off-chain transactions are provided by **centralised exchanges¹² (CEXes)** and (decentralised) **Peer-to-Peer (P2P) exchanges**. CEXes are operated by companies that own them in a centralised manner and facilitate trading of crypto-assets with fiat currencies or between each other. CEXes operate as intermediaries in trades and often offer custody services to their customers, meaning they store and manage crypto wallets and private keys. Furthermore, typically they offer a wide range of services. With respect to security features, some CEXes verify the users' identity and complete Know your customer (KYC) checks for Anti-Money Laundering (AML) and Counter Terrorism Financing (CTF). Apart from holding AML licenses in some cases, the majority of CEXes are not regulated or supervised from a prudential viewpoint. P2P exchanges stand apart from CEXes mainly due to their users' ability to choose their counterparty, i.e. P2P exchanges facilitate direct transactions between users without an intermediary. They offer an escrow service for traders but do not hold crypto-assets or fiat currency for the traders, hence they are non-custodial¹³. This gives room to regulatory arbitrage.

On-chain transactions can be executed by any blockchain user. Transactions can cover a wide range of operations done with or without DeFi protocols that offer multifaceted options to interact with crypto-assets on blockchains. For example, analogically to CEXes, a **Decentralised Exchange (DEX)** provides a trading platform which, nonetheless, operates without a central authority or intermediary. Specifically, the platform runs directly on the blockchain network and facilitates the exchange of crypto assets by matching and executing trades through smart contracts. Transactions on a DEX are non-custodial which might be relevant for some of their users. DEXes have no KYC and AML/CFT policies implemented and generally do not allow users to transact with fiat currency. Furthermore, they typically suffer from poor liquidity, low trading volume, complicated interface, and longer transaction execution times. DEXes are only one example of the multifaceted **DeFi protocol** options allowing users to interact with crypto-assets. DeFi protocols can be grouped into (besides DEXes) e.g. i) credit protocols that allow users to borrow and lend assets and that pay a reward for the liquidity provision or aggregate yield from various protocols, as well as protocols that use reserves of assets to issue and back their native tokens¹⁴; (ii) insurance protocols that offer coverage against losses caused by events typically occurring in the DeFi ecosystem, such as hacking, malfunctioning of exchanges or smart contracts; (iii) payment protocols that allow users to pay/send/receive crypto-assets; and (iv) staking protocols that reward users for locking or "staking" the crypto-assets to contribute and support the protocol operations¹⁵. Moreover, DeFi protocols can offer **crypto derivatives**, although it is more common for such derivatives to be traded on CEXes.

¹² For the sake of simplicity, in the paper we will use the term crypto-asset exchanges, crypto-asset trading platforms, crypto exchanges interchangeably.

¹³ See e.g. [Global and local drivers of Bitcoin trading vs-a-vis fiat currencies](#) ECB Working Paper Series No 2868

¹⁴ Protocols' native tokens are the crypto-assets associated with each protocol which serve different functions such as governance or providing incentives to the protocols' users. These tokens thus play a key role in the functionality and sustainability of their protocols.

¹⁵ See e.g. [Decentralised finance – a new unregulated non-bank system?](#) ECB Macropprudential Bulletin July 2022

Monitoring the crypto-asset markets entails for example gauging their sizes through indicators such as trading volumes, market capitalisation¹⁶, transaction volume and value, number of blockchain addresses, or total value locked (TVL). TVL represents the sum of all assets deposited in DeFi protocols. This inflated size measurement, due to token re-usage, is examined across different categories that correspond to the various financial services mimicked by DeFi protocols. Additionally, the monitoring of crypto-asset markets encompasses the analysis of crypto-asset prices across multiple exchanges, the examination of price volatility, and the assessment of market depth. When it comes to crypto derivatives, the indicators are largely similar to those tracking traditional derivatives, such as e.g. total volume (the total number of contracts times the value of each contract) and open interest (the amount of active contracts). However, there are also specific indicators for crypto perpetual futures¹⁷, like funding fees. The funding fee is the mechanism that equalises the difference between the perpetual's price and the underlying asset's price¹⁸.

Linkages

Monitoring of who uses crypto-assets on any of the crypto markets poses a key challenge (see the *Data quality, data gaps and directions for further work section*). Although conducting a comprehensive analysis of **direct and indirect exposures** is challenging, it is still possible to gain valuable insights. In this regard, the monitoring framework relies on **surveys** which continue to be the unique source of harmonised information on the **direct exposures** especially of banks or retail users to crypto-assets¹⁹. Official statistics are also already helpful in shedding some light into aggregated **indirect exposures** of the main economic sectors to crypto-assets. In this context, the ECB's **Securities Holdings Statistics (SHS)**²⁰ dataset provides such information covering the Exchange Traded Products (ETP) linked to crypto-assets. Furthermore, the **European Market Infrastructure Regulation (EMIR)** data will offer additional insights into the exposures to crypto derivatives due to the forthcoming changes in the exchange-traded and OTC derivatives data reporting²¹. Finally, the monitoring framework includes a range of proxies for direct exposures derived from on-chain data.

Several methodologies to estimate the **geographical breakdown of on-chain crypto-asset transactions** were developed²² and included to the extent possible in the ECB monitoring framework. While they provide valuable insights, they are still susceptible to notable constraints that may impact their representativeness and consequently their value for policy analysis. These constraints primarily

¹⁶ For details on the calculation of and issues with these indicators and data quality issues please see: [Understanding the crypto-asset phenomenon, its risks and measurement issues](#), ECB Economic Bulletin Article, Issue 5/2019

¹⁷ Perpetual futures, also called perpetual swaps, perpetuals, or perps are futures that do not expire. See e.g. [A primer on perpetuals](#) SSRN, September 2022

¹⁸ The methodology for calculating funding payments varies widely across exchanges.

¹⁹ See e.g. the [Study on the payment attitudes of consumers in the euro area](#), [Decrypting financial stability risks in crypto-asset markets](#), Special Feature, ECB Financial Stability Review May 2022; [The crypto dashboard](#) published by the Basel Committee on Banking Supervision (BCBS).

²⁰ See e.g. https://www.ecb.europa.eu/stats/financial_markets_and_interest_rates/securities/html/index.en.html

²¹ EMIR REFIT (Regulatory Fitness and Performance Programme) has created a new field called "Derivatives with crypto assets as reference value" to identify crypto-based transactions in order to make future derivatives on crypto-asset transparent.

²² E.g. the [Chainalysis](#) methodology provides a geographic breakdown of on-chain crypto-asset transactions which are allocated to countries based on the location of visitors to the websites of crypto-asset trading platforms and DeFi protocols. [CrystalBlockchain](#) and the BIS Innovation Hub Eurosystem Centre Project Atlas use a similar methodology to that of Chainalysis but allocate on-chain flows according to the country in which a trading platform is registered rather than the location of its users. More information: [Project Atlas: mapping the world of decentralised finance](#); BIS Innovation Hub Report, October 2023.

arise from: i) the lack of transparency in crypto exchanges stemming from their inadequate adherence to regulatory and reporting regulations, and ii) the pseudonymous nature of blockchain data, which poses challenges in determining the geographical origin/location of the parties to a crypto-asset transaction. In the off-chain transaction sub-segment covering peer-to-peer (P2P) exchanges, it is possible to derive the lower bound estimates of **cross-border payment flows using bitcoin**²³. The estimates rely on matching identical-size bitcoin to fiat transactions occurring within a 3-hour window on the two biggest P2P exchanges²⁴. When such transactions involve two different fiat currencies, they are assumed to represent the use of BTC as a vehicle currency for cross-border transfers between the countries issuing the respective fiat currencies. The method covers only two P2P exchanges, yet it provides a novel and unique insight into crypto payment channels which the ECB aims to explore further. Current efforts cover investigating and developing indicators using **alternative data sources** for e.g. POS-terminals accepting crypto-assets.

The monitoring of linkages also involves keeping track of **TradFi firms' provision of banking and other services to crypto-asset companies**. The events in early 2023 highlighted the liquidity risk banks may face when providing deposit- or other types of accounts and payment services to crypto-asset service providers. In addition, TradFi companies are exploring the possibility of entering the **crypto-asset custody** business and engaging in **tokenisation of assets**²⁵. The tokenisation of products like deposit liabilities, equities and trade finance receivables has been impeded by technology costs, operational challenges, and diminishing venture funding. However, banks continue to work on tokenising deposit liabilities. Indeed, the tokenisation of bank liabilities offers benefits in the form of faster settlement and reduced back-office costs and can also support the tokenisation of other assets. In addition, tokenised bank liabilities can act as the settlement asset for securities issued on a blockchain. Finally, the monitoring of linkages also focuses on the analysis of **investors in crypto-asset businesses, on-chain flows between entities**, as well as the correlation-based indicators and network analysis to examine the **links between crypto-asset markets and financial markets**.

Major players

The monitoring of major players covers entities or assets that play an important role on various crypto-asset markets as described above. Typically, the largest or fastest growing crypto-assets within all segments and markets are examined, as well as those that have a special connection to the euro area and the European Union, e.g. EUR-referenced stablecoins. Furthermore, the monitoring encompasses also major players in terms of providing crypto-asset services or enabling and facilitating the interconnection between crypto-assets on the one side and the real economy and financial markets on the other side. In recent years, there has been a surge in intermediaries (typically made by a group of companies) that have substantially expanded their offers to cover a broad range of crypto-asset services and functions. The entities are often called **multifunction crypto-asset intermediaries (MCI)**²⁶. MCIs revolve around the operation of a trading platform and they provide a wide range of financial and payment services connected to that platform. Many MCIs engage in proprietary trading and investment activities, and some are also actively involved in the direct issuing, promoting, and distributing of crypto-assets, including stablecoins. Several of these activities and their combinations

²³ Graf von Luckner et al., [Decrypting new age international capital flows](#), Journal of Monetary Economics 138 (2023).

²⁴ Paxful and Localbitcoins.

²⁵ Tokenisation of assets involves the digital representation of real (physical) assets on distributed ledgers, or the issuance of traditional asset classes in tokenised form. See e.g. [Stablecoins versus tokenized deposits: implications for the singleness of money](#) BIS Bulletin No 73.

²⁶ [FSB Global Regulatory Framework for Crypto-Asset Activities](#), Financial Stability Board, July 2023.

exist in TradFi but are frequently not offered by the same (group of) undertakings or are subject to strict limitations and regulatory frameworks to avoid/mitigate conflicts of interest and ensure market integrity, investor protection, and ultimately financial stability.

Other

Other elements of the ECB's crypto-asset monitoring cover the analysis of deceptive practices as well as markets failures with the view of developing **crypto-asset early warning indicators**. For this purpose, there is an ongoing stock taking exercise of various crypto failures which will be juxtaposed with various early warning indicators. This medium-term endeavour will allow for a back-testing of these new indicators to assess their performance and adequacy in signalling any negative trends. Such new indicators draw from e.g. high-frequency pricing and trading information, as well as alternative datasets covering social media sentiment and news related to crypto-assets.

3. Expanding the monitoring framework with the DeFi Hackathon

The ECB organised the DeFi Hackathon²⁷ in March 2023. The purpose of this hackathon was to stir up new ideas, provide valuable contributions and enable fast learning in tackling important challenges related to the crypto-asset monitoring faced by many authorities at present. The objective was to expand the current monitoring of crypto-assets, broaden the analytical scope, and explore novel data sources. Obtaining insights directly from on-chain data, rather than relying on data-providers, can be seen as pushing the boundaries in crypto-asset monitoring. The readily available public data for monitoring DeFi markets lacks sufficient granularity, while data retrieved from blockchains directly remains opaque and cumbersome to analyse. Therefore, the objective of the DeFi Hackathon was to deepen understanding of specific DeFi segments by offering participants hands on-exposure to detailed DeFi protocol data and conducting analyses relevant to the perspective of central banks. The hackathon challenges covered Aave²⁸ and Sablier Finance²⁹ as prime illustrations of **DeFi lending and payment** protocols, respectively. Furthermore, hackathon participants were requested to thoroughly delve into the intricacies of blockchain oracles³⁰. With respect to the lending protocol, the analytical questions guiding the participants covered aspects like protocol usage; loans' conditions, performance, risk characteristics and mitigants; novel products (like flash loans³¹), borrowers' features and differences across various blockchains. As for the payment protocol, hackathon participants searched for insights into users (including vendors); transactions (purpose, type, geographical distribution), and novel products (like money streaming³²) among others. Finally, the hackathon oracle challenge aimed to gain valuable insights into the structure, business models and operations of

²⁷ The DeFi Hackathon was open to participants from the European System of Central Banks (ESCB) and the Single Supervisory Mechanism (SSM).

²⁸ Aave is one of the biggest DeFi lending protocols in terms of Total Value Locked (TVL). Aave was first launched in Finland in November 2017 and has since relocated to the UK. Aave provides lending and borrowing services, initially on Ethereum and now on multiple blockchains as well.

²⁹ Sablier Finance is one of the biggest DeFi payment protocols in terms of TVL. It offers e.g. money streaming which encompasses open-ended continuous payments. Such payments can be used to establish a real time direct link between the value transfer and the service provision.

³⁰ Oracles are decentralised middleware entities (intermediaries) that connect smart contracts to validated resources outside their native blockchains. Oracles are widely used in DeFi to provide e.g. price feeds. Oracles serve as bridges connecting any blockchain with data from both other blockchains as well as off-chain systems.

³¹ Uncollateralized loans, providing users with loans that must be repaid within the same blockchain transaction from which there were instantiated.

³² Transaction executed continuously through time across increments, on a defined frequency.

blockchain oracle service providers alongside their risks, malfunction cases, and issues with the reliability of oracles' data feeds. It was not possible to find answers for all the analytical questions. Pseudonymity, unavailability of certain information, and a lack of the necessary data descriptions were all factors that presented challenges. Nevertheless, the hackathon participants were able to provide a comprehensive and valuable set of DeFi indicators covering i) for the lending protocol: daily deposited/lending amounts across blockchains and crypto-assets, loan features (amounts, maturity, lending rates, repayments, liquidations), and flash loan lending amounts and rates, and ii) for the payment protocol: money streams (number, duration, cancellation rate), users (sender/recipients), deposits and withdrawals. Furthermore, the hackathon constituted an excellent opportunity to deepen the collective European System of Central Banks (ESCB) knowledge and collaboration on DeFi and crypto-assets, which may result in the creation of an ESCB crypto-asset monitoring dashboard. Recently established ESCB Crypto-Assets Monitoring Expert Group (CAMEG) drew extensively from the DeFi hackathon participants.

4. Data quality, data gaps and directions for further work

The ECB crypto-asset database was created based on a few selected datasets that were put together with automated procedures using APIs and big data technology. These datasets were selected following a review of available third-party data (provided by commercial and non-commercial data sources), which covered the availability of granular information, completeness of the coverage as well as details of the methodologies used. Even though the data sources were carefully chosen, data quality issues remain, basically due to the specificities of the crypto-asset markets which are largely unregulated and opaque. Furthermore, these markets are not only susceptible to fraud and hacking but also to various technical and operational issues that can result in erroneous transactions affecting the overall quality of data. Wash trading, which is trading conducted by market participants that sell to themselves to deceive other market participants, is a known issue in this context. Crypto exchanges can create fake transactions to inflate their trading volumes thereby gaining market share and individual (usually large) investors can manipulate market developments in a desired direction by shifting the amounts from own buying to selling accounts.

Keeping up with the ever-changing crypto-asset landscape, including the emergence of new players and linkages, typically requires developing new indicators and exploring new and existing data sources. The theoretical transparency that is proclaimed for crypto-assets does not correspond to actual transparency nor allows the usage of the data for analysing risks and interconnectedness properly. Working with on-chain data can be burdensome, complicated, and prone to misinterpretation. Misinterpretation can occur also with off-chain indicators, especially since they are mostly derived from non-verifiable data. Therefore, the data gaps we are still facing are related to questions that appear to be very simple: Who transacts with whom and where? Who is exposed to crypto-assets and to what extent? How extensively are crypto-assets used for payments? How extensively are crypto-assets used for other purposes? What are the linkages between major players? Hence, future work involves finding the best answers to these questions and developing top-notch high-quality official statistics on crypto-assets eventually.

There are a few initiatives that stand out in the context of addressing crypto-asset data gaps. The first one covers the integration of **crypto-asset domains into statistical classifications**. Despite the significant progress in allocating crypto-asset activities in the revised structure of the Statistical

classification of economic activities in the European Community (NACE)³³ and the International Standard Industrial Classification of All Economic Activities (ISIC)³⁴, further refinements in the future will be highly beneficial³⁵. Furthermore, the ongoing discussions concerning adjustments to the Classification of Products by Activity (CPA) and to the Central Product Classification (CPC) with regards to crypto-assets are poised to greatly expedite the future development of crypto-asset statistics. The second initiative comprises the **G20 New Data Gap Initiative (DGI)**³⁶. **DGI Recommendation 11 Digital Money** aims to develop a common data collection framework and collect data on digital money focusing on Central Bank Digital Money (CBDC), stablecoins, and other types of crypto-assets used as means of payment to ensure the proper coverage of monetary aggregates and international capital flows. The third initiative is **MICAR**, already briefly mentioned above. In general, MICAR prescribes that for each ART with an issue value exceeding EUR 100 million³⁷, the issuer should report on a quarterly basis to the competent authority the following information: i) the number of holders, ii) the issuance value and the size of the asset reserves, iii) the number and the value of daily transactions, and iv) estimates of the number and the value of daily means of exchange transactions within a single currency area³⁸. This reporting requirement, for which the details are currently being prepared³⁹, also apply to significant ARTs and EMTs. The MICAR reporting provisions pertaining to ARTs and EMTs are applicable from 30 June 2024. The implementation of data reporting by ARTs and EMTs will constitute a milestone step towards high-quality data and statistics on crypto-assets.

³³ The acronym is from the French name “Nomenclature statistique des Activités économiques dans la Communauté Européenne”, more details about NACE: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=NACE_background

³⁴ More details about ISIC: <https://unstats.un.org/unsd/classifications/Econ/isic>

³⁵ [Fintech in statistical classifications: suggestions and tentative figures in a central bank context](#), BIS Bulletin Nr 58 *Post-pandemic landscape for central bank statistics*, June 2023

³⁶ More details: <https://www.imf.org/en/News/Seminars/Conferences/g20-data-gaps-initiative>

³⁷ The competent authority may require issuers to comply with the reporting obligation for a ART issue with a value of less than EUR 100 million.

³⁸ To allow competent authorities to monitor the use of ARTs and compliance with the reserve of assets requirements, Article 22 of MICAR requires the issuer of a significant ART to report on a quarterly basis to the competent authority: “i) the number of holders, ii) the value of the ART issued and the size of the reserve of assets, iii) the average number and average aggregated value of transactions per day during the relevant quarter, and iv) an estimate of the average number and average aggregated value of transactions per day during the relevant quarter that are associated to uses of ART as a means of exchange within a single currency area.” In accordance with Article 58(2) of MICAR, the provisions of Article 22 (and others) shall also apply to EMTs denominated in a currency that is not an official currency of an EU Member State.

³⁹ More details: <https://www.eba.europa.eu/markets-crypto-assets>

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