EUROPEAN CENTRAL BANK

EUROSYSTEM

# Occasional Paper Series

ECB Crypto-Assets Task Force

## Crypto-Assets: Implications for financial stability, monetary policy, and payments and market infrastructures

No 223 / May 2019

# Contents

# Abstract

This paper summarises the outcomes of the analysis of the ECB Crypto-Assets Task Force. First, it proposes a characterisation of crypto-assets in the absence of a common definition and as a basis for the consistent analysis of this phenomenon. Second, it analyses recent developments in the crypto-assets market and unfolding links with financial markets and the economy. Finally, it assesses the potential impact of crypto-assets on monetary policy, payments and market infrastructures, and financial stability. The analysis shows that, in the current market, crypto-assets' risks or potential implications are limited and/or manageable on the basis of the existing regulatory and oversight frameworks. However, this assessment is subject to change and should not prevent the ECB from continuing to monitor crypto-assets, raise awareness and develop preparedness.

**Keywords:** crypto-assets, characterisation, monitoring, crypto-assets risks

**JEL codes:** E42, G21, G23, O33

# Executive summary

**For the purposes of this paper, a crypto-asset is defined as a new type of asset recorded in digital form and enabled by the use of cryptography that is not and does not represent a financial claim on, or a liability of, any identifiable entity.** Crypto-assets derive their novelty and specific risk profile, particularly their inherent high volatility, from the absence of an underlying fundamental value. Crypto-assets are highly speculative and could expose investors to large losses[1].This paper's conclusions are to be interpreted in relation to crypto-assets as defined herein.

**The ECB monitors crypto-assets and analyses potential implications for monetary policy and the risks they may entail for the smooth functioning of market infrastructures and payments, as well as for the stability of the financial system.** To this end, the ECB established the Internal Crypto-Assets Task Force (ICA-TF).

**The ICA-TF analysis shows that crypto-assets do not currently[2] pose an immediate threat to the financial stability of the euro area.** Their combined value is small relative to the financial system, and their linkages with the financial sector are still limited. There are no indications so far that banks in the EU have systemically-relevant holdings of crypto-assets.

**Crypto-assets do not fulfil the functions of money[3] and, at the current stage, neither do they entail a tangible impact on the real economy nor have significant implications for monetary policy.** The very low number of merchants that allow the purchase of goods and services with bitcoins indicates no influence of the most prominent crypto-asset on price-setting.

**In the current regulatory framework, crypto-assets can hardly enter EU financial market infrastructures (FMIs).** Crypto-assets cannot be used to conduct money settlements in systemically important FMIs. To the extent that they do not qualify as securities, central securities depositories (CSDs) cannot undertake settlement of crypto-assets. Even if crypto-assets-based products were to be cleared by central counterparties (CCPs), these would need to be authorised and to satisfy existing regulatory requirements, albeit at additional costs and with no clear benefits to EU CCPs[4].

**The sector nevertheless requires continuous careful monitoring since crypto-assets are dynamic and linkages with the wider financial sector may increase to more significant levels in the future.** Exposures may increase as the crypto-assets ecosystem (e.g. post-trade services) develops further and more clarity

1 In February 2018, the European Supervisory Authorities (ESAs) for securities (ESMA), banking (EBA), and insurance and pensions (EIOPA) issued a pan-EU warning to consumers regarding the risks of buying virtual currencies.

2 As of 31 January 2019 (cut-off date for crypto-assets data used throughout this paper).

3 Mersch, (2018a, 2018b).

4 It is worth noting though that EU clearing members may be exposed to risks stemming from crypto-assets futures offered for clearing by third-country recognised CCPs (TC-CCPs).

regarding application of standards may create a more conducive environment for investments. Depending on how they will be regulated in the future, crypto-assets may more easily enter the FMI environment, and deteriorate the FMI risk profile.

**If FMI participants were assessed to pose heightened risks to the FMIs' safety in light of their crypto-assets business, FMI operators would have the authority to impose more stringent restrictions on participation, without prejudice to fair and open access.** Particularly the Eurosystem could, if need be, require the segregation of crypto-assets business for participation in TARGET2 and could also terminate participation on grounds of prudence. CCPs could voluntarily pursue segregation via separate default funds for crypto-assets clearing services, although they would still be exposed to loss in own capital at the end of the default "waterfall"[5].

**From a prudential view, crypto-assets should be deducted from CET1 as part of a conservative prudential treatment.** In fact, the regulation on capital requirements for credit institutions and investment firms (CRR) is not tailored to crypto-assets in light of their high volatility. Without prejudice to the ongoing work at the Basel Committee on Banking Supervision (BCBS), a possible way forward for this conservative prudential treatment is the Pillar 1 deduction from CET1 similarly to other assets classified as "intangible assets" under the accounting framework.

**Independently of the stipulated prudential treatment, financial institutions undertaking exposures in crypto-assets are expected to put in place an appropriate risk management framework commensurate to the risks posed by the unique characteristics of these activities.** Furthermore, any outstanding risks not adequately covered under Pillar 1 could be addressed via supervisory action under a proportional approach.

**Disjointed regulatory initiatives at the national level could trigger regulatory arbitrage and, ultimately, hamper the resilience of the financial system to crypto-asset market based shocks.** Without prejudice to further work to be undertaken by the European Parliament, the Council and the Commission, the ICA-TF analysis suggests that a broader approach to regulation of crypto-assets could be pursued at the intersection with the financial system, where risks arise from unregulated so-called "gatekeepers" that provide an entry point for retail investors and regulated entities. Any regulation should also be balanced to avoid incentivising risky crypto-assets business.

**At present, crypto-assets' implications for and/or risks to the financial stability of the euro area, monetary policy, and payments and market infrastructures are limited or manageable.** This assessment should not be extended to other areas outside of the scope of this report (e.g. money laundering, consumer protection) where risks may have already materialised, and should not preclude continuous monitoring or the analysis of future implications of crypto-assets for the stability and efficiency of the EU financial systems and FMIs.

5 Prefunded financial resources used to cover losses caused by participant defaults are commonly referred to as a "waterfall" and may include the defaulter's initial margin, the defaulter's contribution to a prefunded default arrangement, a specified portion of the CCP's own funds and other participants' contributions to a prefunded default arrangement. See CPMI-IOSCO (2017).

# 1 Introduction

**Crypto-assets have been the subject of intense policy debate.** In particular, crypto-assets have raised concerns with regard to money laundering, market integrity and consumer protection – among other things – as well as possible implications for financial stability. Financial sector authorities in Europe and worldwide undertake various activities on crypto-assets within their mandates. International fora such as the G7, the G20, the Financial Stability Board (FSB), and standard setting bodies (SSBs) conduct work on crypto-assets aimed at monitoring crypto-assets' implications for global financial stability and coordinating policy responses. The ECB has been studying this phenomenon since its inception, and published its first report on virtual currency schemes in 2012, followed by further analysis in 2015[6].

**The ECB Internal Crypto-Assets Task Force (ICA-TF) was established in March 2018 with the mandate to deepen the analysis around virtual currencies and crypto-assets.** To fulfil this mandate, the ICA-TF has structured its work in three pillars: (i) characterising crypto-assets and related activities; (ii) monitoring crypto-assets and related activities, and the evolution of channels for the possible transmission of risks to the financial sector and the economy; and (iii) identifying potential control measures to mitigate such risks.

**The ICA-TF analysis is focused on assessing and helping to contain any adverse impact of crypto-assets on the use of the euro, the monetary policy and the safety and efficiency of market infrastructures, as well as on the stability of the financial system.** This analysis serves as a basis for ECB contributions to policy discussions at the European System of Central Banks (ESCB), European Union (EU), and international level, and with the relevant regulatory authorities.

**The ECB acknowledges that crypto-assets currently pose risks mostly with regard to money laundering/terrorism financing and consumer protection.** On these aspects, as well as on the broader assessment of the EU regulatory framework in light of crypto-assets, the ECB defers the analysis to the relevant authorities, and supports their efforts as appropriate. In particular, the European Banking Authority (EBA) and the European Securities and Markets Authority (ESMA) in line with the European Commission's 2018 FinTech Action Plan, have recently published their advices to the European Union Institutions on crypto-assets[7]. As far as this paper is concerned, selected regulatory issues are covered as part of the risks assessment and gap analysis.

**This paper summarises the main outcomes of ICA-TF analysis.** In particular, it provides an assessment of selected crypto-assets risks and the extent to which the current regulatory and oversight frameworks allow the propagation of these risks to the financial system and the economy to be contained.

6 See the 2012 and 2015 reports on virtual currency schemes.

7 On 9 January 2019, the European Securities and Markets Authority (ESMA) and the European Banking Authority (EBA) released their reports with advice to the European Union Institutions on crypto-assets.

**From a methodological perspective, this paper is premised on a characterisation of crypto-assets as a new asset type with a unique risk profile.** Within the crypto-assets phenomenon, the ECB clearly distinguishes between the infrastructure layer, where distributed ledger technology (DLT) underpins crypto-assets as one of many possible use cases, and the asset layer, which is the sole focus of this analysis. Nonetheless, the ECB acknowledges that DLT and other innovative technologies have potential to increase the efficiency of financial intermediation and the financial system as a whole, and is active in monitoring their developments and exploring their application[8].

**This paper is structured in five sections:** Section 2 discusses the ICA-TF characterisation of crypto-assets; Section 3 presents an overview of crypto-assets market trends and the evolution of links with the financial system; Section 4 provides a risk assessment and gap analysis based on the current regulatory and oversight frameworks; Section 5 offers conclusions and the next steps in the analysis of crypto-assets.

[8] The ECB and Bank of Japan are jointly exploring the potential of Distributed Ledger Technologies in the field of market infrastructures in the context of their joint project Stella. To date, two reports have been published: "Payment systems: liquidity saving mechanisms in a distributed ledger environment (September 2017); "Securities settlement systems: delivery-versus-payment in a distributed ledger environment" (March 2018).

# 2 Characterisation of crypto-assets

**There is currently no international agreement on how crypto-assets should be defined.** Given the lack of an agreed definition of crypto-assets, this paper's characterisation of this phenomenon may not necessarily coincide with the approach taken by other authorities or in the relevant international fora[9]. At the same time, the approach taken in this paper is not inconsistent with the EU regulator's definition of virtual currencies[10], which represent a broader set of assets compared to crypto-assets as defined in this paper. Within the scope of its mandate, the ECB works to facilitate a common understanding of this phenomenon so as to avoid a proliferation of definitions at a sectoral and jurisdictional level hampering international coordination efforts.

**In this paper, the term "crypto-asset" denotes any asset recorded in digital form that is not and does not represent either a financial claim on, or a financial liability of, any natural or legal person, and which does not embody a proprietary right against an entity.** Yet, a crypto-asset is considered valuable by its users (an asset) as an investment and/or means of exchange, whereby controls to supply and the agreement over validity of transfers in crypto-assets are not enforced by an accountable party but are induced by the use of cryptographic tools.

**The emergence of crypto-assets has been enabled by DLT[11].** Under some assumptions, DLT allows the supply of crypto-assets to be kept controlled and limited by enabling users to audit cryptographic links that certify the consistency of information updates over time and ensure that there is no unwarranted creation of crypto-assets. DLT also ensures that owners of crypto-assets are recognised as such by allowing (and sometimes even providing incentives for) users to converge towards a consistent view of crypto-asset holdings as testified by means of cryptography.

**Although bitcoin is the most prominent application of blockchain-based DLT, the use of this technology is currently a necessary but not sufficient element to characterise crypto-assets as a new asset class.** In fact, the distinctive feature of

9 In particular, it is worth noting that some analyses may refer to crypto-assets more broadly as any asset recorded using DLT that is not backed by any government or other authority, even when that constitutes e.g. a (privately-issued) financial or payment instrument. See in particular EBA, 2019 and ESMA, 2019. Conversely, the Financial Action Task Force (FATF) in its Recommendations (updated October 2018) excludes from the scope of "virtual" assets digital representations of fiat currencies, securities and other financial assets.

10 In the Fifth Anti-Money Laundering Directive (AMLD5), "virtual currencies" means a digital representation of value that is not issued or guaranteed by a central bank or a public authority, is not necessarily attached to a legally established currency and does not possess a legal status of currency or money, but is accepted by natural or legal persons as a means of exchange and which can be transferred, stored and traded electronically.

11 A distributed ledger is a record of information, or database that is shared across a network. From a technical perspective it can be used, for example, to record transactions across different locations. One of the technologies that make this possible is referred to as "blockchain". The name comes from the fact that some DLT solutions store all individual transactions in groups, or blocks, which are attached to each other in chronological order to create a long chain. This long chain is put together using cryptography thus ensuring the security and integrity of the data. This chain then forms a register of transactions that its users consider to be the official record. In addition to blockchains, consensus ledgers are another type of DLT whereby, instead of grouping and chaining transactions, only the balance of members' accounts is updated after each validation round. See Pinna and Ruttenberg, (2016).

crypto-assets, as defined in this paper, from which they derive their specific risk profile, is the lack of an underlying claim/liability. Units of a crypto-asset may be used as a means of exchange and are de-facto considered by their users as assets, in the sense of "something of value", although they do not correspond to the liability of, and claim on, any party. As a consequence, crypto-assets are fundamentally different from various forms of financial claims and/or their digital representation using the technology and possibly the infrastructure that underpin crypto-assets.

**Crypto-assets as defined in this paper would not qualify as electronic money (e-money) for the Second Electronic Money Directive (EMD2)[12], to the extent that they are not and do not represent a claim on the issuer.** E-money is electronically stored monetary value as represented by a claim on the e-money issuer, which is issued on receipt of funds, for the purpose of making payment transactions, and which is accepted by a natural or legal person other than the electronic money issuer[13].

**Crypto-assets as defined in this paper are not scriptural money[14] in the form of commercial bank money (CoBM),** which consists in commercial bank liabilities that take the form of deposits held at a commercial bank[15].

**Crypto-assets as defined in this paper are equally not scriptural money in the form of central bank money (CeBM),** which is the liability of a central bank in the form of either (i) existing bank deposits held at a central bank for wholesale settlement purposes or (ii) digital base money (DBM) for the general public and central bank digital currency (CBDC) (see Annex 1).

**Therefore, as the law now stands, crypto-assets as defined in this paper would fall outside the scope of application of payment services regulation.** The revised Payment Services Directive (PSD2)[16] defines payment transaction as "an act, initiated by the payer or on his behalf or by the payee, of placing, transferring or withdrawing funds […]", whereas funds are "banknotes and coins, scriptural money or electronic money" and therefore do not include crypto-assets as described and defined by the ICA-TF.

**A crypto-asset as defined in this paper is not a financial instrument, as listed in Section C of Annex 1 of the Markets in Financial Instruments Directive**

12 Directive 2009/110/EC of the European Parliament and of the Council of 16 September 2009 on the taking up, pursuit and prudential supervision of the business of electronic money institutions amending Directives 2005/60/EC and 2006/48/EC and repealing Directive 2000/46/EC (OJ L 267, 10.10.2009, p. 7).

13 This does not mean that assets recorded using DLT may not qualify as electronic money. EBA sets out the circumstance in which such assets will qualify as electronic money and will therefore fall within the scope of the EMD2. See EBA, (2019), Section 2.1.1.

14 "Scriptural money" means deposit balances held on an account at a credit institution or a central bank, or electronic money.

15 See also EBA, (2019), §18.

16 Directive (EU) 2015/2366 of the European Parliament and of the Council of 25 November 2015 on payment services in the internal market, amending Directives 2002/65/EC, 2009/110/EC and 2013/36/EU and Regulation (EU) No 1093/2010, and repealing Directive 2007/64/EC (OJ L 337, 23.12.2015, p. 35).

**(MiFID)[17], as that would typically represent a financial liability or equity on the side of some issuer[18].** On the other hand, crypto-assets could serve as the underlying of certain financial instruments, such as derivatives (e.g. relating to commodities[19]) and financial contracts for difference (CFDs)[20].

**A crypto-asset as defined in this paper is not a mere representation of any of the above-mentioned financial assets.** Mere digital representations of existing assets are referred to as "tokens", which allow recording these assets by means of a different technology. The same technology-neutral rules and legal provisions shall therefore apply, to the extent possible, to the issuance, bookkeeping and use of these "tokens" as they apply to the financial assets they represent.

**Finally, crypto-assets as defined in this paper are not to be considered as virtual currencies or digital currencies, although these terms are often – inaccurately (Mersch, 2018a) – used to identify crypto-assets that are used and accepted by some as a substitute for money in particular circumstances[21].** The absence of any specific institution (such as a central bank or monetary authority) protecting the value of crypto-assets hinders their use as a form of money, since their volatility: a) prevents their use as a store of value; b) discourages their use as a means of payment; and c) makes it difficult to use them as a unit of account.

17 Directive 2014/65/EU of the European Parliament and of the Council of 15 May 2014 on markets in financial instruments and amending Directive 2002/92/EC and Directive 2011/61/EU (OJ L 173, 12.6.2014, p. 349).

18 This does not mean that assets recorded using DLT may not qualify as financial instruments. ESMA sets out the circumstances under which such assets may qualify as transferable securities and/or other types of financial instruments under MiFID II, triggering the application of existing EU financial regulation. See ESMA (2019), Section VI.

19 The US Commodity Futures Trading Commission (CFTC) found crypto-assets to be a commodity. On December 1, 2017, the Chicago Mercantile Exchange Inc. (CME) and the CBOE Futures Exchange (CFE) self-certified new contracts for bitcoin futures products and the Cantor Exchange self-certified a new contract for bitcoin binary options.

20 On 28 September 2018, ESMA agreed to renew the restriction on the marketing, distribution or sale of CFDs to retail clients, in effect since 1 August, from 1 November 2018 for a further three-month period.

21 Mersch, (2018a).

# 3 Recent developments and current status of the crypto-assets market

**This section provides an overview of recent developments in crypto-asset markets.** Section 3.1 documents the market size and price developments of crypto-assets, while Section 3.2 shows the interlinkages with the financial system and the real economy. This section is based on data from external sources that are used in the ICA-TF crypto-assets monitoring framework (see Box 1)[22].

**Box 1**

ICA-TF approach to monitoring crypto-assets

Monitoring of crypto-assets relies to a great extent on publicly available third party aggregated data. A great deal of aggregated information is available on public websites, e.g. metrics for blockchain networks, estimates of market capitalisation, prices and trading volumes on crypto-exchanges and funds gathered in initial coin offerings (ICOs). These sources differ with regard to the methodologies used, the completeness of coverage, and access to the underlying raw information, among other things. Processing the underlying raw information (when available) is also surrounded with uncertainty related to the lack of (or only partial) regulation pertaining to the various players along the crypto-asset value chain, which operate unsupervised in a borderless environment often hindering access to reliable information. Nevertheless, handling raw granular data enables some data quality controls. Besides public sources, statistics and supervisors' reporting mechanisms do not generally cover crypto-assets (e.g. exposures of supervised institutions).

To build a crypto-asset monitoring framework on this basis requires caution in handling available data, and a stepwise approach to fill current gaps. First, the ICA-TF identified a range of monitoring needs and reviewed the available data. Second, the ICA-TF developed a dataset and dashboard by using automated procedures to collect various pieces of information from public (e.g. Cryptocompare, Coinmarketcap, Blockchaininfo) and non-public (e.g. Bloomberg) data providers. The information was collected both on an aggregated basis and, where possible, at a more granular level in order to enable the calculation of customised indicators. Some examples of data with granular breakdowns are trading and pricing of each crypto-asset pair at every crypto-exchange, or disaggregated pricing and trading of bitcoin futures contracts. In developing the dataset, close attention was paid to ensuring the quality of data through the application of quality checks, and of consistent methodologies and definitions, with the aim of mitigating the drawbacks of using public data sources.

Monitoring needs will be periodically reviewed to ensure that the monitoring framework continues to be relevant and that monitoring efforts remain proportionate to the potential risks resulting from the evolving size and price developments of crypto-assets, and the links between crypto-assets and the financial system.

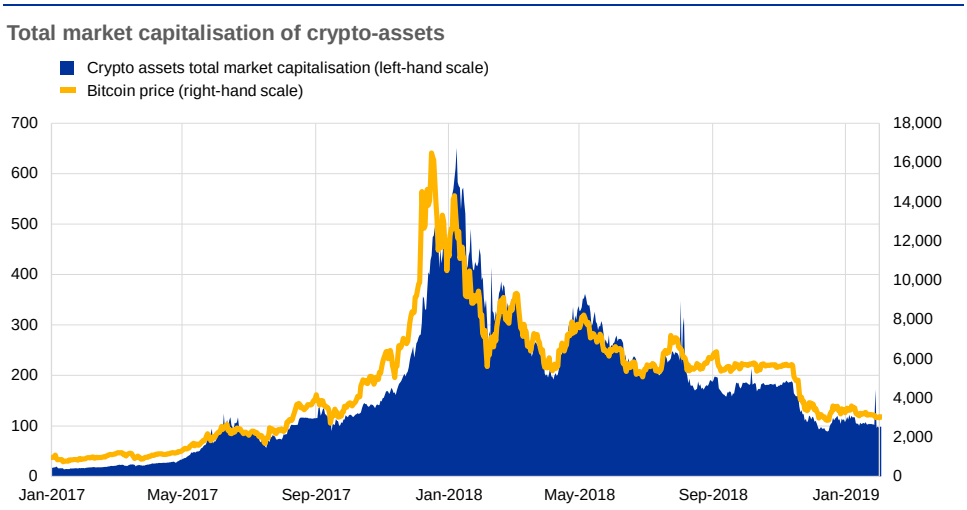
[22] The cut-off date for the data used in this section is 31 January 2019.

## 3.1 Developments in crypto-asset markets

**After an all-time high of €650 billion in January 2018 and a subsequent abrupt correction, market capitalisation of crypto-assets has declined to €96 billion in January 2019 (see Chart 1).** Market capitalisation has moved in tandem with asset prices, as exemplified by the price of bitcoin, whose correlation with total market capitalisation amounts to 95%. In relative terms, the market capitalisation of crypto-assets stands at 4% of the market capitalisation of the so-called "FAANG"[23] stocks and at 1% of euro area GDP. It is also smaller in size than the peak of the two major past bubbles, the dot-com bubble and the subprime mortgage securities bubble. When compared to monetary aggregates, the value of crypto-assets is 1.2% of the euro area M1 and 0.8% of the M3 monetary aggregates (Chart 2).

**Chart 1**

Crypto-assets' market capitalisation has decreased significantly after its peak in January 2018




Sources: Cryptocompare, Coinmarketcap and ECB calculations.
Notes: The data used here follow the "circulating supply" definition of market capitalisation, which corresponds to the "free float" for each crypto-asset i.e. excluding the part that may be owned by a company supporting the crypto-asset. Daily data from 1 January 2017 to 31 January 2019.

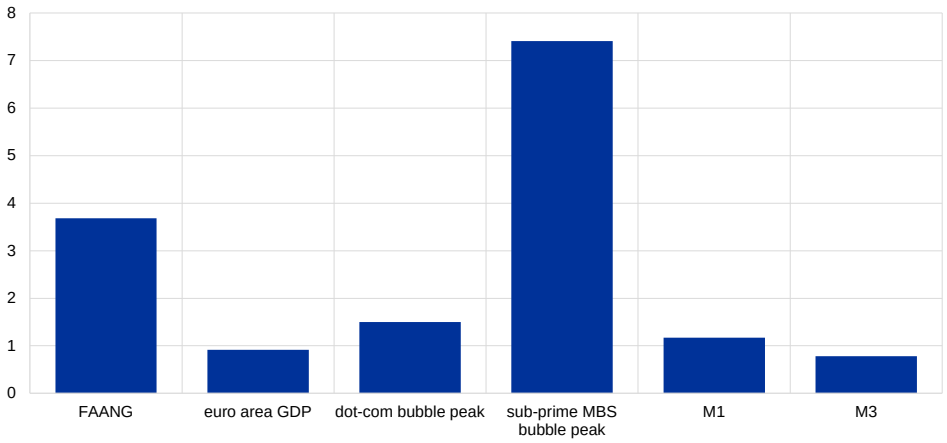
[23] Facebook, Apple, Amazon, Netflix and Alphabet's Google.

## Chart 2

Crypto-assets' market capitalisation remains modest

**Total market capitalisation of crypto-assets as a fraction of other markets, euro area GDP, past bubbles in stock and mortgage markets and euro area monetary aggregates**

(percentages)



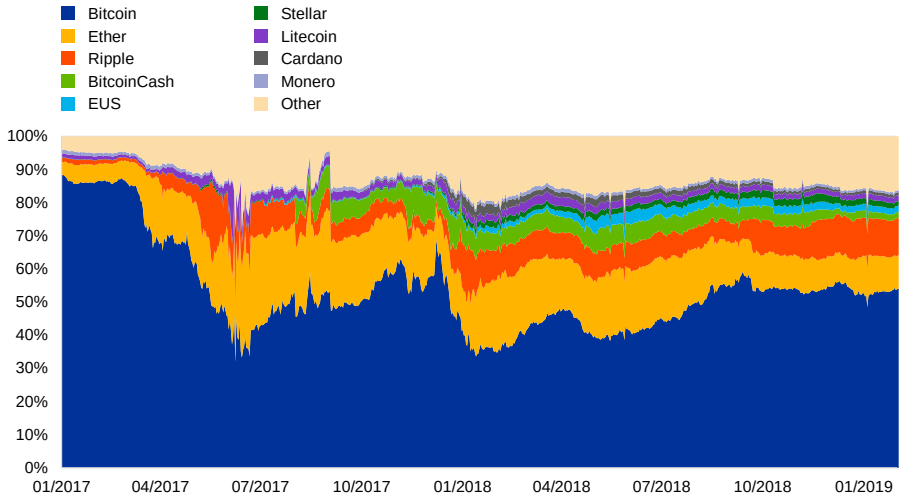

Source: Bloomberg, Cryptocompare, Coinmarketcap, Datastream, Haver, Sifma, ECB and ECB calculations.
Notes: We use the free floating market capitalisation of the stocks, consistently with the definition of supply used for the crypto-assets. "FAANG" refers to Facebook, Apple, Amazon, Netflix and Google. Dot-com bubble peak refers to NASDAQ market cap of March 2000 and subprime peak of 2006. Subprime market size is the sum of subprime, nonprime and Alt-A US non-agency residential real estate securities. As of 31 January 2019 for crypto market capitalisation and FAANG, December 2019 for euro area GDP and monetary aggregates.

**Bitcoin continues to lead the pack of crypto-assets in terms of market capitalisation, user base and popularity.** There exist around 1,900 crypto-assets, up from 7 in April 2013. Next to bitcoin, ether, ripple and bitcoin cash are considered the most important in terms of usage, market capitalisation or business model diversity. Although bitcoin lost some ground vis-à-vis other crypto-assets over the last two years in the face of increased competition and uncertainty about the relative success of the different business models underlying them, its market share recovered in the course of 2018 and currently stands at 54% (Chart 3).

## Chart 3

Bitcoin's market share among crypto-assets currently stands at 54%

**Percentage of total market capitalisation of crypto-assets**

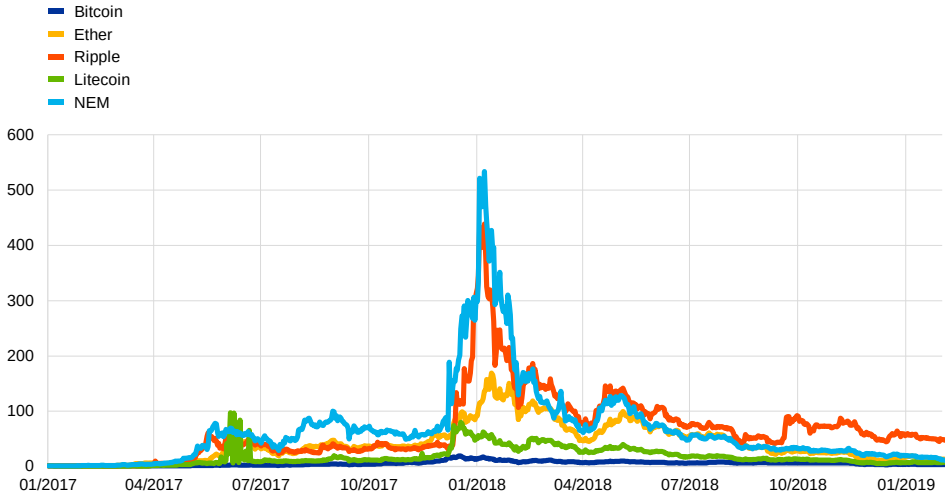



Sources: Cryptocompare, Coinmarketcap and ECB calculations.
Notes: "Other" incorporates the combined market share of all other actively traded crypto-assets listed in the source (total listings: 1,407 on 31 January 2019). Daily data from 1 January 2017 to 31 January 2019.

## Chart 4

Crypto-assets market peaked in early 2018, with bitcoin underperforming other crypto-assets

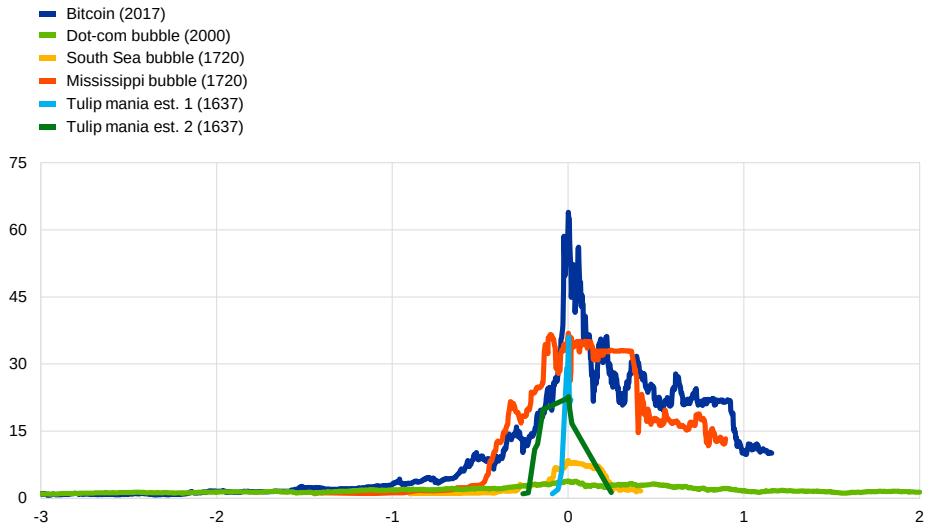
**Relative price change of selected crypto-assets since January 2017**




Sources: Cryptocompare, Coinmarketcap and ECB calculations.
Note: Price change in multiples relative to 1 January 2017, first observation normalised to value of 1. Underlying data series measured in USD. Latest observation: 31 January 2019.

## Chart 5

Bitcoin price developments were more extreme than those of historical bubbles



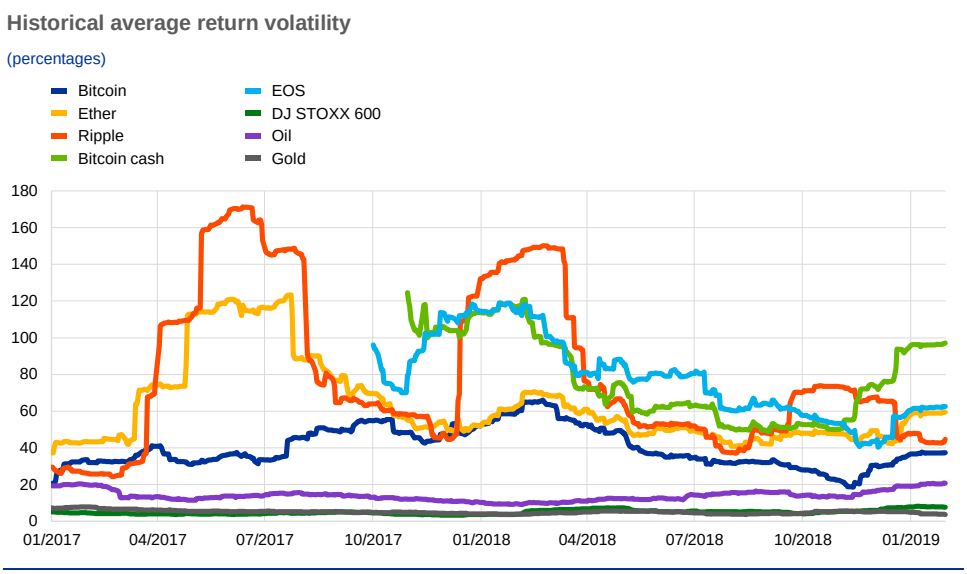

Sources: Bloomberg, Cryptocompare, Coinmarketcap, Yale school of management and ECB calculations.
Notes: Due to uncertainty about data of the Tulipmania, we show two separate estimates of the size of that bubble. All series are normalised to a value of 1 three years before its respective peak. Underlying data series measured in USD. 3 years before to 2 years after the peak.

**Price growth of crypto-assets had surpassed that of historical bubbles before the crash in early 2018.** The price of bitcoin increased by a factor of 19.5 from the beginning of 2017 to the peak reached in January 2018 (see Chart 4). Still, bitcoin was significantly outperformed by other crypto-assets, which were at some point even 500 times higher than at the beginning of 2017. In comparison, the NASDAQ composite index was four times higher at the peak of the dot-com bubble than three years before, while the share price of the Mississippi Company at its peak in November 1720 spiked 36 times higher than in August 1718 (Chart 5).

**Crypto-asset prices remain highly volatile (see Chart 6).** Over the last two years, the historical volatility of crypto-assets dwarfed not only the volatility of the diversified European stock and bond markets, but also that of the more volatile oil and gold prices, highlighting the market risk that crypto-asset investors are subject to. Compared to the beginning of 2018 when several crypto-assets experienced a price peak, the volatility has become smaller. Interestingly, bitcoin is not as volatile as other crypto-assets, which potentially reflects its wider investor base and its relatively higher maturity as an asset. The recent development of so-called “stablecoins” attempts to overcome the volatility drawback of existing crypto-assets by claiming to exhibit a stable value through a flexible coin supply (i.e. algorithmic money) or backing the crypto-asset with collateral (i.e. collateralised stablecoins). In fact, some stablecoins, to the extent that they have an identified issuer, are not crypto-assets according to the definition used in this paper and might qualify as e-money under some national legislation. So far, stablecoins seem to be used mostly by crypto-asset traders to hedge against market movements and have demonstrated different levels of price volatility depending on their business models.

**Chart 6**

Crypto-assets' volatility is much higher than volatility of stocks, bonds and commodities




Sources: Cryptocompare, Datastream and ECB calculations.
Note: Volatility is the 90-day standard deviation of daily returns of the asset or the market. Daily data from 1 January 2017 to 31 January 2019.

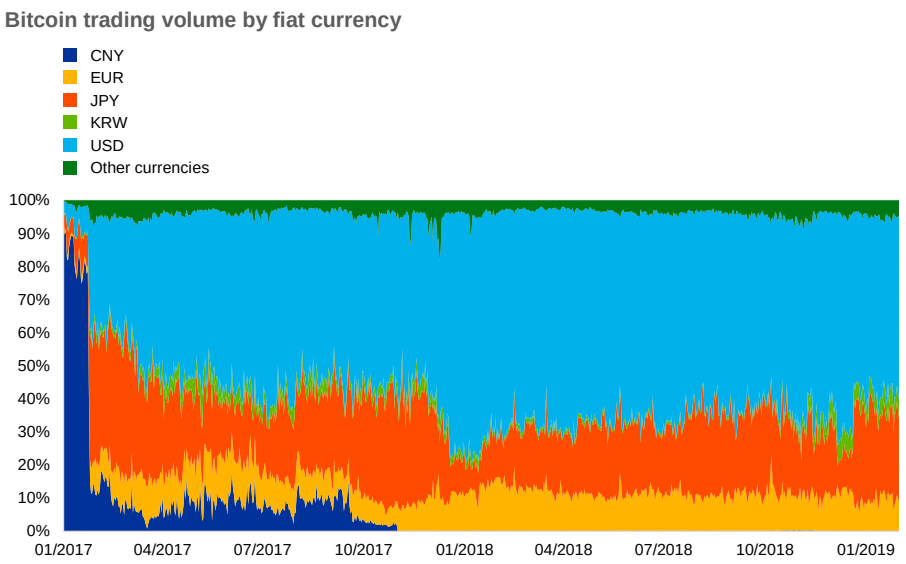
## 3.2 Evolution of linkages to the financial markets and the economy

**An important share of bitcoin's trading volume is settled in euro, suggesting a non-negligible euro area exposure to crypto-assets.** Euro-related trading has hovered around an average of 10% of the total with a daily standard deviation of 2.8% over the last two years. Compared to others, bitcoin is the crypto-asset most heavily traded. Over 2018, trades in bitcoin accounted for on average 61% of the total trading volume cleared in fiat currencies. All trading activities in Chinese Yuan shifted towards other currencies after September 2017, following an amendment in Chinese legislation regarding the treatment of bitcoin (see Chart 7).

**Private sector bitcoin holdings are quite concentrated suggesting that potential losses in case of a drastic price correction would be limited to a relatively small group of holders.** The top 1,000 addresses (0.0018% of all active addresses) represent around 36% of all bitcoin holdings and the top 10,000 hold 58%. These figures represent only a rough estimation of the concentration of holdings: on the one hand, it is possible for the same investor to hold multiple addresses, implying higher actual concentration; on the other hand, some addresses may belong to custodians/exchanges, implying that concentration is lower. For example, at the time of writing 26 out of the top 100 addresses as well as all top 5 addresses can be attributed to custodian wallet providers and exchanges.

**Chart 7**

Bitcoin trading cleared in euro hovers around 11%




Sources: Cryptocompare and ECB calculations.
Notes: Daily data from 1 January 2017 to 31 January 2019.

**Current developments and activities, such as futures contracts linked to bitcoin prices and financial investment vehicles tracking crypto-assets, may increase links to the traditional financial sector and the real economy.** This can possibly raise financial stability considerations if these links persist and further increase. Current links are limited, as the number of futures and investment vehicles are still small and futures volumes traded are low. The slow growth in the number of investment vehicles is also due to regulatory actions. For example, the US Securities and Exchange Committee (SEC) tentatively rejected ten bitcoin Exchange Traded Funds (ETFs) proposals in September 2018.

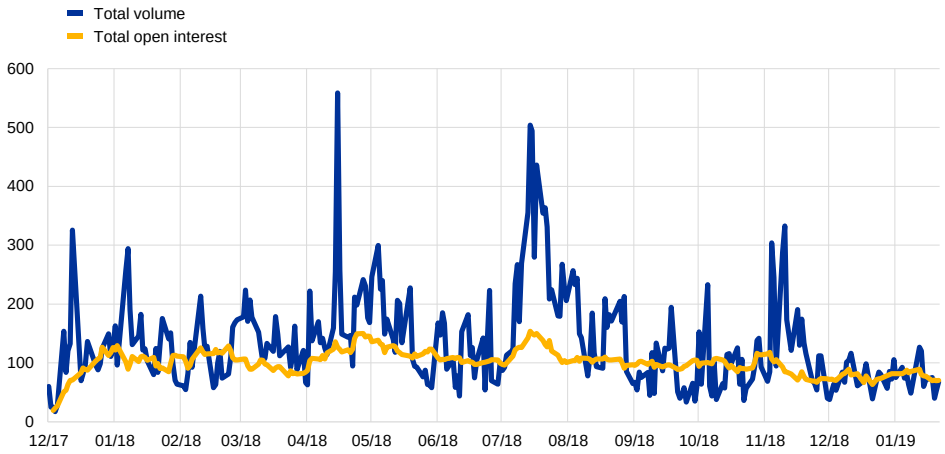
**Futures contracts linked to bitcoin prices have been available in the US since December 2017 and are traded at low, but relatively stable volumes.** The combined open interest for bitcoin futures in the two US exchanges offering these trades (CME and CBOE) currently stands at €70 million (see Chart 8). These contracts trade at prices that have become relatively tied to the spot market developments, indicating that market participants do not expect significant price movements over the next months (see Chart 9). In fact, the negative spike in the difference between spot and futures prices in November 2018 indicated that the market correction was not foreseen by the markets at this time. An expanding futures market may, however, increase the interlinkages between the financial sector and crypto-assets' price developments. This may – conditional on regulatory approval – also pave the way to the creation of more ETFs that use futures to track bitcoin prices, mirroring similar developments in commodity ETFs a few years ago.

## Chart 8

Open interest in bitcoin futures remains small

**Total volume and open interest in bitcoin futures**

(EUR millions)



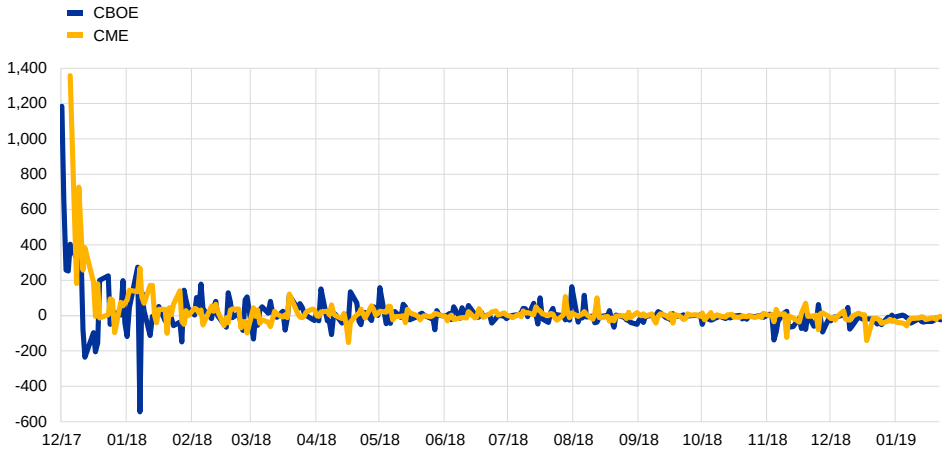

Sources: Bloomberg and ECB calculations.
Notes: The figures of the chart are the combined total volume and open interest of CME and CBOE-traded bitcoin futures. Daily data from 1 January 2017 to 31 January 2019.

## Chart 9

Futures and spot bitcoin prices have converged

**Difference between futures and spot bitcoin prices on CME and CBOE exchanges**

(EUR)




Sources: Bloomberg and ECB calculations.
Notes: Daily data from 11 December 2017 – 31 January 2019.

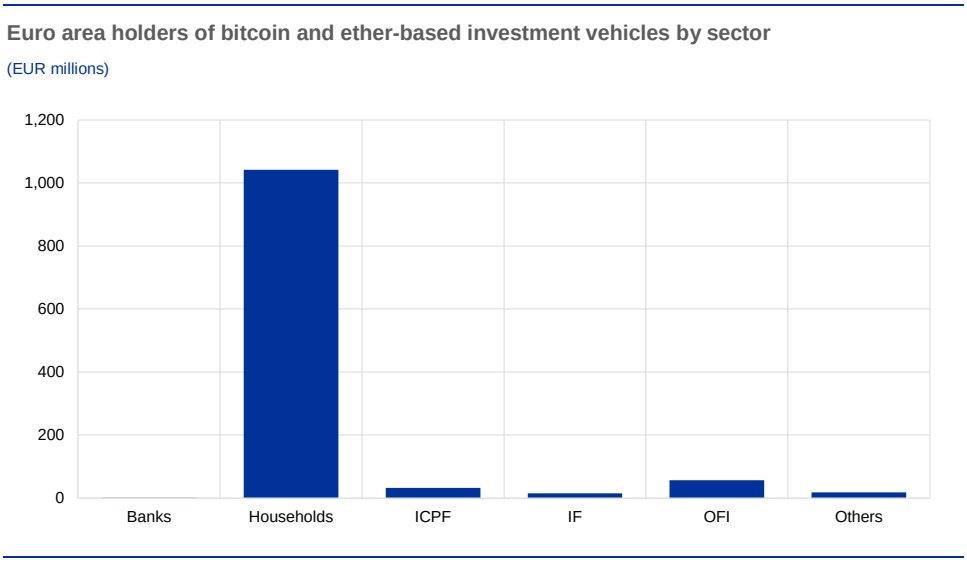
**Other financial investment vehicles, such as trusts, Exchange Traded Notes (ETNs) and Contracts for Difference (CFDs) have started to offer exposure to crypto-assets to European clients.** All such vehicles that can be found in ECB securities holdings data track either bitcoin or ether prices. Euro area holders of these instruments in Q3 2018 were mainly found in the household sector (Chart 10) with key markets in Belgium, Italy, and Germany (see Chart 11). The size of these vehicles is small when compared to the size of the household sector's portfolios and minuscule in comparison to the overall size of the euro area securities market: at the end of

Q3 2018, the combined holdings of these instruments by euro area sectors stood at €1,163 million. The total amount of holdings has grown rapidly, though. Exposures more than quadrupled in the course of 2018 starting from €269 million in Q4 2017.

**According to currently available information, banks do not seem to have systemically-relevant holdings of crypto-assets**[24]**.** Their combined indirect exposures via ETNs and CFDs did not exceed €20,000 at the end of Q3 2018 (Chart 10). Nevertheless, there has been an indication of a strong interest among hedge funds and asset managers in crypto-assets-based products. Conditional on regulatory developments, exposures to financial instruments related to crypto-assets could, therefore, rise in future.

**Chart 10**

Households are key holders of investment vehicles tracking bitcoin and ether

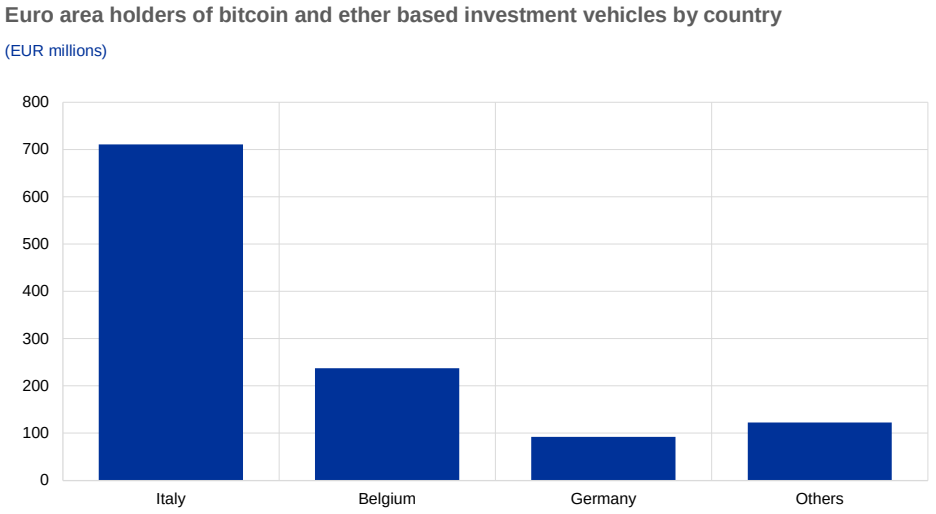



Sources: SHSS and ECB calculations.
Notes: Sector acronyms stand for insurance corporations and pension funds (ICPF), investment funds (IF), and other financial institutions (OFI). The category 'Others' captures all remaining sectors. Q3 2018.

[24] In July 2014 and August 2016, EBA issued two opinions on virtual currencies, which inter alia recommended that supervisory authorities discourage credit institutions, payment institutions and electronic money institutions from buying, holding or selling virtual currencies.

**Chart 11**

Belgium and Italy are key markets for crypto-asset investment vehicles




Sources: SHSS and ECB calculations.
Notes: Q3 2018.

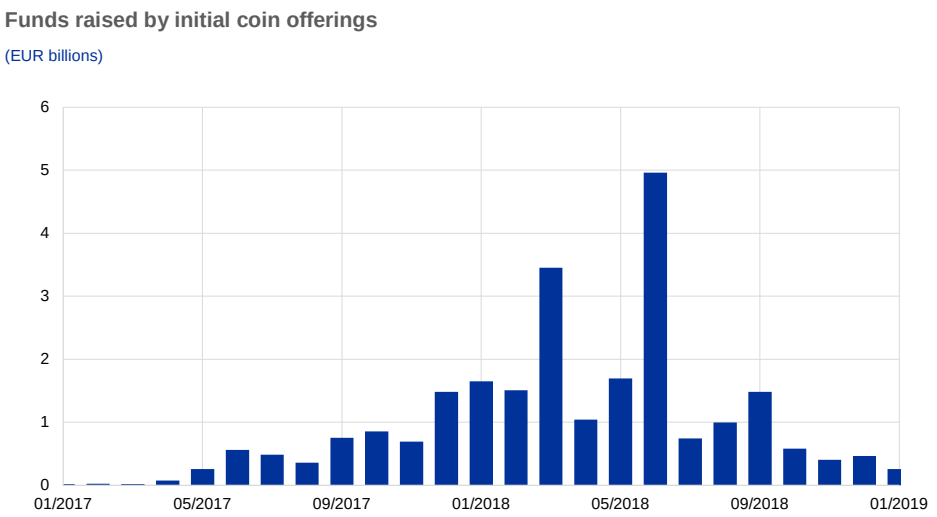
**So-called initial coin offerings (ICOs), a largely unregulated way for firms to raise capital by generating new crypto-assets akin to initial public offerings, collected about €19 billion in 2018 (Chart 12)**[25]**.** ICOs represented more than 9% of total equity raised in initial public offerings at the global level in 2018[26]. While there is no systematic information about the jurisdictions and sectors of the holders of crypto-assets from ICOs, the importance of ICOs decreased significantly over the second half of 2018. A study by Satis Group (2018), an ICO advisory firm, found that 70% of the funds raised by ICOs were invested in projects that developed further to more mature stages, while 80% of all projects that raised capital via ICOs were identified as fraud. Moreover, ICO activities are correlated with price developments of some crypto-assets – for example ether, whose underlying technology ethereum is heavily used to launch ICOs (see Financial Times, 2018a). If the importance of ICOs as well as their connections to the wider financial system rises again to levels observed in 2018, the inherent volatility of many newly generated crypto-assets could adversely affect financial stability through similar channels to conventional equity markets.

25 A token generated via an ICO may or may not be a claim on, or liability of, an issuer. See also ESMA (2019), §34.

26 Data on total initial public offerings in 2018 is taken from EY (2018).

**Chart 12**

Funds raised by initial coin offerings in 2018 amounted to €19 billion




Sources: coinschedule.
Notes: Monthly observations from January 2017 to January 2019.

# 4 Risks assessment and gap analysis

**The ICA-TF monitors developments in crypto-assets with a view to analysing the risks they might pose to the financial system and the economy, and any possible adverse impact on the discharge of the ECB mandate.** This section focuses on implications and/or risks of crypto-assets for: (i) monetary policy; (ii) financial stability; and, (iii) financial market infrastructures. Furthermore, it discusses supervision and regulatory issues arising from the analysis of the above risks.

**For these risks, mitigating factors, where they exist, are identified, and the effectiveness of current regulatory and oversight frameworks in addressing the various risks is assessed.** On this basis, this section identifies any remaining gaps and outstanding risks for which mitigating measures are not at hand or fall outside of the scope of the ECB remit and/or scope of this paper.

## 4.1 Potential implications for monetary policy

**At the current stage, crypto-assets do not fulfil the functions of money[27], and neither do they entail a tangible impact on the real economy nor have significant implications for monetary policy.** In principle, implications for monetary policy could materialise in the event that crypto-assets were to turn into a credible substitute for cash and deposits. However, the reportedly low number of merchants that allow the purchase of goods and services with bitcoins also indicates no influence of the most prominent crypto-asset on price-setting at all. The high price volatility of crypto-assets, the absence of central bank backing and the limited acceptance among merchants[28] prevent crypto-assets from being currently used as substitutes for cash and deposits, as well as making it very difficult for crypto-assets to fulfil the characteristics of a monetary asset in the near future (see Sections 2 and 3.1).

**As crypto-assets are not effectively competing against cash and deposits, their implications for economic developments and monetary policy are similar to those of other asset markets.** Since the size of the sector remains small (see Section 3.1), and linkages to the wider financial system – let alone the real economy – remain limited, crypto-asset related developments have no direct implications for monetary policy at the present stage. At the same time, the dynamic nature of crypto assets, including the development of stablecoins, warrants continuous monitoring. In this regard, it remains to be seen whether algorithmic stablecoins can effectively offer the very substantial reduction in price volatility that a wider adoption would be likely to require. By contrast, stablecoins could become less volatile if the coins were collateralised by central bank reserves, for example. Such collateralisation could result in additional demand for central bank reserves, which could have implications

27 Mersch, 2018a.

28 This site lists around 13,500 places of acceptance for bitcoin worldwide (up from around 6,000 in 2015).

for monetary policy and its implementation. However, such collateralised stablecoins are not crypto-assets as defined in this paper.

**There are hardly any suitable public data sources that allow the use of crypto-assets as substitutes for money to be measured and monitored.** Statistics on the number and value of payments received by merchants in crypto-assets are not publicly available. Information on the number of merchants that accept crypto-assets is fragmented and un-vetted. The number of crypto-assets transactions from the blockchains (on-chain transactions) is publicly available but is both hardly indicative of retail payments[29] and restricted to a fraction of total (on-chain, off-chain) transactions. These gaps in the crypto-assets monitoring framework could make it difficult to promptly identify and assess changes in the status quo that may warrant revising the above risk assessment, and need to be filled.

## 4.2 Risks to financial stability

**Crypto-assets currently do not pose a material risk to financial stability in the euro area[30].** Their combined value is small relative to the financial system. The sector nevertheless requires continuous careful monitoring, as market developments are dynamic and linkages to the wider financial sector may increase to more significant levels in the future.

**There is no hard data on exposures of supervised entities to crypto-assets.** While the ECB has gathered evidence of low and immaterial exposures (see Section 3.2), the lack of data is a gap to be filled[31], and a limitation in the assessment of systemic risks.

**Incipient yet growing brokerage and post-trade services for institutional investors may lead to increased crypto-assets exposures.** In the absence of such services, the interest of institutional investors in crypto-assets and the development and uptake of crypto-assets-based products may have been (technically) constrained. This might change in the near feature, thus possibly incentivising greater exposures.

**Currently, the means to address these potential risks from a prudential perspective are lacking.** There is no identified prudential treatment for crypto-asset exposures of financial institutions, whether direct investments, derivatives, or indirect

[29] Retail payments are payments of relatively low value made outside of the financial markets and that are both initiated by and made to individuals and non-financial institutions. See ECB Glossary of terms related to payment, clearing and settlement systems.

[30] This conclusion is in line with the earlier ECB assessment (ECB, 2018).

[31] Among other actions on crypto-assets, the EBA will develop a common monitoring template, taking into account the BCBS crypto-asset template, which competent authorities can issue to financial institutions to monitor the level and type of crypto-asset activity underway. See EBA (2019), Section 4.4.1.

investments[32]. This gap needs to be filled[33] while exposures do not give rise (yet) to systemic risk (see also Section 4.3 Supervision and prudential treatment).

**Clarifying the accounting treatment of crypto-assets could lead to a more conducive environment for such investments being created.** In fact, the absence of accounting guidance for crypto-assets is perceived by the industry as a critical constraint on investment and growth in this business (Financial Times, 2018b).

## 4.3 Supervision and prudential treatment

**The regulation on prudential requirements for credit institutions (CRR)[34], as it currently stands, is not tailored to crypto-assets in light of their high volatility[35].** Given their inherently high risk and the lack of fundamental value, the prudential treatment would justify a deduction of crypto-assets from CET1. At the time of writing, the BCBS has deliberated on advancing the analysis on the prudential treatment of crypto-assets, but no concrete developments have occurred so far[36].

**A classification of crypto-assets as intangible assets (IAS 38) would automatically mean that crypto-assets would be deducted prudentially.** Accounting standard setting bodies/authorities could pursue a harmonised accounting treatment by prescribing that banks should account for crypto-assets as intangible assets[37]. Other accounting treatments (e.g. cash[38], foreign-exchange position, or

32 The ways in which supervised entities might be involved in crypto-assets/crypto-assets-related activities include: (i) direct investment; (ii) derivatives; (iii) indirect investment (e.g. setting up wallets to assist crypto-assets transactions, commercialisation to clients of investment products or vehicles such as crypto-assets ETFs to facilitate investment in crypto-assets); and, (iv) credit to clients associated with crypto-assets (e.g. clients' use of a bank's credit card to acquire crypto-assets, loans to customers collateralised with crypto-assets, loans to entities dealing directly or indirectly with crypto-assets).

33 Among other actions on crypto-assets, the EBA is developing a common monitoring template which competent authorities can issue to institutions, payment institutions and electronic money institutions (and, as appropriate, other financial institutions) to monitor the level and type of crypto-asset activity underway. See EBA (2019), Section 5.

34 Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 (OJ L 176, 27.6.2013, p. 1).

35 The crypto-assets market is highly volatile, even during periods with a clear positive trend. Crypto-assets' volatility is much higher than the volatility of stocks, bonds and commodities. See Chart 6 in Section 3.1.

36 The EBA, in its advice to the European Commission, notes that, "pending further regulatory developments, including the outcome of the BCBS work, (…) competent authorities and institutions should adopt a conservative prudential approach to the treatment of exposures to crypto-assets in Pillar 1, supplemented by Pillar 2 requirements if necessary to achieve this outcome". See EBA (2019), §63.

37 The International Financial Reporting Standards (IFRS), in IAS 38.8, define an intangible asset as "an identifiable non-monetary asset without physical substance". Crypto-asset units are identifiable and lack physical substance, as they are only available in digital form. As to whether a crypto-asset is a non-monetary asset, the Standards do not provide such a definition. However, IAS 32.AG3, by explaining why currency/cash is considered a financial asset, sheds some light on the distinctive characteristics of currency (cash/money): "Currency (cash) is a financial asset because it represents the medium of exchange and is therefore the basis on which all transactions are measured and recognised in financial statements." According to IAS 32.AG3 two principal elements are characteristic for cash: (i) the asset must be widely accepted as consideration in transactions (medium of exchange); (ii) it must be the "basis on which all transactions are measured" (unit of measurement). As discussed in this report, crypto-assets are far from being widely accepted as a medium of exchange or as a basis to measure transactions. As a consequence, crypto-assets appear to fit the definition of intangible assets (IAS 38.8).

38 Classification of crypto-assets as cash or cash equivalent does not seem possible where crypto-assets are not generally accepted as a medium of exchange. Only in those cases where crypto-assets meet the conditions for medium of exchange, they could be considered as cash or cash equivalent.

commodities) would result in alternative prudential treatments under the market risk framework of the CRR that are not fully suited to capture the volatility of crypto-assets[39]. Nevertheless, the accounting standard-setters might opt for an accounting treatment of crypto-assets other than IAS 38 intangible assets. In this case, Pillar 2 deductions would become an even more crucial element in addressing the risks of crypto-asset investments and activities.

**Regardless of the type of exposure and prudential treatment, a specific risk management framework would be required to cover the specific risks entailed in crypto-asset activities[40].** The governance and internal control arrangements of financial institutions undertaking crypto-asset investments and/or activities may not adequately reflect the specific nature and risk profile of these activities. Similarly, the internal capital adequacy assessment process (ICAAP) of supervised entities investing in crypto-assets might not be fully in line with the risk taken in such activities and the relating consumption of internal capital.

**With regard to liquidity requirements, crypto-assets are not included in the list of eligible instruments for the liquidity coverage ratio (LCR) liquidity buffer[41].** Even if included, liquid assets also have to comply with the general and operational requirements specified in the LCR Delegated Regulation (LCR DR)[42]. In principle, in order to qualify as liquid assets, crypto-assets would need to meet some fundamental characteristics such as low price volatility[43]. Given the high fluctuation of crypto-assets prices, it is questionable whether this requirement can be met. On the other hand, derivatives on crypto-assets would be currently treated as any other derivative transaction in the LCR.

**Crypto-assets are most likely to be subject to a 100% stable funding requirement.** This would apply irrespective of whether crypto-assets would be classified as intangible assets to be deducted from own funds[44]. From a prudential

39 If crypto-assets were treated as a foreign-exchange position or commodities, they would be subject to own funds requirements for foreign exchange risk or for commodity risk respectively (Title IV CRR). For traded crypto-assets, additional (or alternative) prudential treatments within the market risk framework for general and specific position risk (Title IV CRR) could apply. Any treatment under the market risk framework would not rely on accounting values of derivatives but would determine the exposure according to the prudential rules of the CRR. All of these solutions are sub-optimal, since the specific features of crypto-assets do not seem to fully suit any of these two risk classes. Fall-back treatment would be the 100% risk weight for other tangible assets under the Standardised approach (Article 134(1) CRR) or other non-credit obligations under the IRB approach (Article 156 CRR). The exposure value would be the accounting value of the crypto-asset. However, this might be insufficient for the actual volatility of crypto-assets, because a 100% risk weight covers an unexpected loss of not more than 8% on the current accounting value.

40 On 13 March 2019, the Basel Committee on Banking Supervision (BCBS) published a "Statement on crypto-assets" setting out its prudential expectations related to banks' exposures to crypto-assets and related services.

41 As provided in the LCR DR. Crypto-assets do not fall under any of the asset classes currently included in Articles 10-16, 19 or 35-38 LCR DR.

42 Commission Delegated Regulation (EU) 2015/61 of 10 October 2014 to supplement Regulation (EU) No 575/2013 of the European Parliament and the Council with regard to liquidity coverage requirement for Credit Institutions (OJ L 11, 17.1.2015, p. 1).

43 Although this is not a requirement explicitly provided in EU legislation.

44 Intangible assets to be deducted from own funds are subject to a 100% stable funding requirement in accordance with Article 428ag(1)(b) of the proposed amendments to the CRR. Even if crypto-assets were not classified as intangible assets, they would not fall under any of the assets referred to in Articles 428r to 428af of the proposed amendments to the CRR (in particular it is assumed that crypto-assets would not meet the definition of physical traded commodities in accordance with Article 428af(g) of the proposed amendments to the CRR).

perspective, a 100% stable funding requirement appears adequate in particular since it reflects the potential difficulties of monetising crypto-assets through sale (or using it as collateral in secured borrowing transactions) over the course of one year without significant expense. On the other hand, derivatives on crypto-assets would be currently treated as any other derivative transaction in the net stable funding ratio (NSFR).

**Finally, the holistic approach of the supervisory review and evaluation process (SREP) allows for the review of crypto-assets' direct and indirect investments – when significant – from different risk perspectives,** including: (i) credit and counterparty risk; (ii) market risk; (iii) operational risk; (iv) governance; (v) solvency risk; and (vi) liquidity risk. The Supervisory Manual and the supervisory tools should be updated in the future if investments in crypto-assets become material.

## 4.4 Risks to financial market infrastructures

**The extent to which crypto-assets represent a risk to the safety of financial market infrastructures (FMIs) depends on how crypto-assets may enter FMIs.** As it currently stands, the regulatory framework for FMIs serves as a first-line defence against crypto-assets risks.

**Crypto-assets cannot be used to carry out money settlement in FMIs, since the Principles for Financial Market Infrastructures (PFMI) of the Committee on Payments and Market Infrastructures (CPMI) and the International Organisation of Securities Commissions (IOSCO) prescribe the use of central bank money where practicable and available and commercial bank money in the remaining cases.** Crypto-assets are neither central bank money nor commercial bank money. The PFMI requirements on money settlement have been translated in the European Market Infrastructure Regulation (EMIR)[45], the Central Securities Depositories Regulation (CSDR)[46] and the ECB Regulation on oversight requirements for systemically important payment systems (SIPS Regulation)[47] in equally strict terms[48].

**Moreover, it is not envisaged in the CSDR that CSDs can undertake settlement of/in crypto-assets since crypto-assets do not qualify as transferable securities.** For the same reason, crypto-assets schemes do not qualify as CSDs under CSDR. In principle, a trade involving the settlement of a transferable security against crypto-assets could nevertheless be executed in the form of a free-of-payment security transfer by the CSD while the crypto-asset leg would have to be settled

45 Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories (OJ L 201, 27.7.2012, p. 1).

46 Regulation (EU) No 909/2014 of the European Parliament and of the Council of 23 July 2014 on improving securities settlement in the European Union and on central securities depositories and amending Directives 98/26/EC and 2014/65/EU and Regulation (EU) No 236/2012 (OJ L 257, 28.8.2014, p. 1).

47 Regulation of the European Central Bank (EU) No 795/2014 of 3 July 2014 on oversight requirements for systemically important payment systems (ECB/2014/28) (OJ L 217, 23.7.2014, p. 16).

48 From a payment system perspective though, while Systemically Important Payment Systems (SIPS) and Prominently Important Retail Payment Systems (PIRPS) are subject to the requirement on money settlement, Other Retail Payment Systems (ORPS) are not. In principle, ORPS could choose to use crypto-assets to effect money settlements.

separately. Free-of-payment arrangements expose counterparties to principal risk and additional costs linked to reconciliation, among others.

**Current (limited) exposures to crypto-assets of European financial institutions have not been assessed to have an impact on FMIs participants' ability to meet their obligations in FMIs.** Should the size of exposures increase and/or market circumstances evolve such that participants' activities in crypto-assets are assessed to pose a threat to the FMI safety, the FMI operator could, without prejudice to the principle of fair and open access, revise FMI participation requirements to ensure that crypto-assets business be segregated in order to minimise or eliminate spill-over risks[49].

**Similarly, should risks arising from crypto-asset activities of TARGET2 participants be assessed to threaten the system's soundness and safety, the Eurosystem is in a position to revise TARGET2 Guideline[50] along the lines above and also to terminate participation on grounds of prudence.** For such measures to be viable and appropriate, they would have to be substantiated by a Eurosystem/EU-wide oversight policy stance and a robust argumentation about the direct link between limiting crypto-asset activities and promoting the smooth functioning of payment systems (Article 127(2) fourth indent of the Treaty on the Functioning of the European Union). It bears noting though that any segregation requirements emanating from TARGET2 would only apply to its direct participants, whereas the clients of participants' banks would be out of scope. Moreover, it is in any case not possible to prevent crypto-assets-related payments from being settled in TARGET2 or ancillary systems, as payment instructions in a system are disconnected from the underlying transaction, and are processed and settled regardless of the latter's legal validity.

**EU CCPs may in the future undertake clearing of crypto-asset based products, provided that (i) they are authorised to do so and (ii) regulatory requirements can be satisfied.** For the first condition to be met, crypto-asset-based products would need to be qualified as financial instruments, or at least considered "linked to clearing"[51] by the national competent authorities and ESMA. Either way, should a positive conclusion on eligibility of crypto-asset-based products for clearing by CCPs under EMIR prevail, then the (prospective) clearing of crypto-assets-based products would most likely imply an extension of CCP services and activities[52], and hence trigger a consultation of the CCP's EMIR college. Certain EMIR requirements might need consideration with regard to their applicability in light of crypto-assets-based products.

**Particularly regarding financial risk management, a CCP undertaking clearing of crypto-assets-based products would need to ensure that sufficient financial resources are available to the new clearing business.** Crypto-assets pricing uncertainties and historic volatility would be critical elements in the assessment of

49 See PFMI, 3.18.8.

50 2013/47/EU: Guideline of the ECB of 5 December 2012 on a Trans-European Automated Real-time Gross settlement Express Transfer system (TARGET2) (ECB/2012/27), OJ L 30, 30.1.2013, p. 1.

51 As in the case of the authorisation of clearing of spot commodities.

52 In accordance with EMIR Article 15.

adequacy of financial resources by the college. From a CCP credit risk management perspective, CCPs that operate multiple clearing services have the possibility to maintain separate default waterfalls for those clearing services. This means that losses incurred in one service line cannot be covered by dedicated prefunded or unfunded resources posted or committed by the clearing members and the CCP (i.e. initial margin, default fund contributions, skin-in-the-game, assessments or cash calls) to support another service line. Setting up separate default funds is entirely the choice of the CCP. A CCP employing this structure should conduct separate credit risk stress tests in order to size the different default funds. Furthermore, the separated structure also holds for the unfunded commitments (e.g. assessments or cash calls). It should be noted though that even if the CCP had separated default funds, at the end of the default waterfall (i.e. after exhausting all prefunded and unfunded resources dedicated to the relevant service line, including the part of the CCP's overall skin-in-the-game allocated to the service), the CCP's own remaining capital would be exposed to the overall loss allocation.

**Ultimately, difficulties in operationalising EMIR requirements for clearing of crypto-assets may as well prevent CCPs from offering the service in practice, or incentivise CCPs and their competent authorities to apply stricter risk management standards** than currently required by the regulatory framework, in particular to minimise the crystallisation of spill-over risk between clearing of crypto-assets-based products and other products (e.g., via separate default funds).

**On the other hand, CCPs cannot use crypto-assets as collateral under EMIR because crypto-assets do not fall within the list of eligible collateral of Commission Delegated Regulation (EU) 2016/2251.** Moreover, the use of crypto-assets would run counter to the objective to mitigate an FMI's own credit risk as crypto-assets do not have the characteristics of assets with low credit, liquidity, and market risk, as prescribed in the PFMI. Similarly, CCPs cannot use crypto-assets as investments. Permitted CCP investments under EMIR are limited to debt instruments issued or explicitly guaranteed by a government, a central bank, a multilateral development bank, the European Financial Stability Facility or the European Stability Mechanism[53]. This condition de facto excludes crypto-assets from being used by CCPs as non-cash investments[54].

**This analysis shows that risks arising from a scenario where crypto-assets enter FMIs could in principle be managed within the current regulatory and oversight frameworks.** That does not mean that risk-taking in relation to crypto-assets should be encouraged. From an ECB perspective, the value proposition of crypto-assets is far from clear, whereas EU FMIs would incur heightened risks and additional costs.

**It bears noting, though, that today European clearing members (CMs) and their clients can already clear crypto-asset derivatives at** third-country recognised CCPs (**TC-CCPs) without restrictions.** Where TC-CCPs are authorised by their

53 EMIR Article 47, EMIR RTS on CCP requirements Articles 43-45 and Annex II.

54 Crypto-asset derivatives may be used by the CCP only for the purpose of hedging (i) positions of defaulting members during the default management process or (ii) currency risk arising from its liquidity management.

third-country competent authority to clear crypto-asset derivatives (such as CME Clearing in the United States by the Commodity Futures Trading Commission) and these CCPs have been already recognised under EMIR, ESMA would have no power to prohibit the provision of those clearing services to EU CMs under the existing equivalence regime (currently under revision). European CMs and their clients that do not make use of such services face spill-over risks from this activity indirectly through the CCPs' default funds.

## 4.5 Regulatory issues

**At the time of writing, the legal status of crypto-assets varied among countries, absent a common taxonomy of crypto-assets, and a shared understanding of how crypto-assets should be treated from a regulatory standpoint.** Given the global dimension of the crypto-assets phenomenon, uncoordinated and/or inconsistent regulatory approaches undertaken at the country level may prove ineffective and create incentives for regulatory arbitrage. Whilst this need not pose an immediate threat to the financial system, it calls for vigilance at the level of the EU, to prevent a proliferation of national initiatives from triggering regulatory arbitrage and, ultimately, hampering the resilience of the financial system to crypto-asset market-based shocks.

**Under EU law as it stands, crypto-assets as defined in this report do not appear to fit under any of the subject matter-relevant EU legal acts (particularly PSD2 and EMD2, and MiFID as shown in Section 2).** As a consequence, crypto-assets as defined in this report and related activities are unregulated, with the exception of anti-money laundering following the adoption of the fifth Anti Money Laundering Directive (AMLD5)[55], which envisages extending the scope of AMLD4[56] to providers engaged in exchange services between virtual currencies and fiat currencies and custodian wallet providers[57]. For completeness, the Settlement Finality Directive (SFD) – predating the advent of crypto-assets – is not applicable to crypto-asset networks or intermediaries[58].

**Given the current state of law, there is limited scope for public authorities to intervene;** moreover, regulatory intervention would be further complicated by the lack of governance and distributed architecture of crypto-assets. Finally, the cross-border

55 Directive (EU) 2018/843 of the European Parliament and of the Council of 30 May 2018 amending Directive (EU) 2015/849 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing, and amending Directives 2009/138/EC and 2013/36/EU (OJ L 156, 19.6.2018, p. 43).

56 Directive (EU) 2015/849 of the European Parliament and of the Council of 20 May 2015 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing, amending Regulation (EU) No 648/2012 of the European Parliament and of the Council, and repealing Directive 2005/60/EC of the European Parliament and of the Council and Commission Directive 2006/70/EC (OJ L 141, 5.6.2015, p. 73).

57 In AMLD5, custodian wallet providers are defined as entities that provide services to safeguard private cryptographic keys on behalf of their customers, to hold, store and transfer virtual currencies.

58 The SFD seeks to regulate the finality of transfer orders, defined as instructions to place at the disposal of a recipient "an amount of *money* by means of a book entry on the accounts of a credit institution, a central bank or a settlement agent, or any instruction which results in the assumption or discharge of a payment obligation as defined by the rules of the system", or "to transfer the title to, or interest in, a *security or securities* by means of a book entry on a register, or otherwise" [emphasis added].

dimension of this phenomenon challenges the effectiveness of (uncoordinated) interventions at the domestic level.

**Still, there could be avenues for the regulation, at EU level, of crypto-assets business at the intersection with the regulated financial system, i.e. aimed at crypto-asset "gatekeeping" services, namely crypto-assets custody and trading/exchange services.** This would allow risks to be addressed at the point where they enter and propagate into the regulated financial sector, and to protect users of these services. Moreover, regulating the gatekeepers would facilitate monitoring of crypto-assets via transparency and reporting obligations that would otherwise not be possible to impose/enforce on unregulated activities. Importantly, EU regulation in this area would prevent diverging approaches at the Member State level from proliferating thus leading to fragmentation.

**In a context where a large part of crypto-asset-related activity is carried out by centralised service providers, this set-up is no different from the traditional financial intermediation business, hence a similar framework could be used to regulate and authorise the activities of (centralised) crypto-asset gatekeepers.** While investors in crypto-assets can hold and trade units with their peers by using any personal device with an internet connection, they are more likely to rely on third party service providers or gatekeepers (e.g. custodian wallet providers, trading platforms and exchanges)[59]. Gatekeepers participate in the networks where crypto-asset transactions are instructed and validated to hold, buy and sell crypto-assets on behalf of their clients[60].

**However, the above regulatory approach is not suited to decentralised gatekeeping activities that do not foresee the involvement of an identifiable intermediary[61]; in this case, a principles-based approach, complemented by a formal mechanism to validate the observance of such principles, could be considered.** A way to (indirectly) regulate crypto-asset gatekeeping services and, at the same time, safeguard the regulated intermediaries/infrastructures with which those decentralised networks may interact, would be to (at least) subject decentralised networks (and the cryptographic algorithms and protocols they are built upon) to a minimum set of principles, such as: (i) technological integrity, meaning, inter alia, no back doors/loopholes or hidden functionalities, no white listing of malware, no fraudulent collusion, responsible cryptographic key management, and the pursuit of the state of the art; (ii) algorithms/protocol service performance and transparency so

59 Crypto-asset trading platforms enable users to buy and sell crypto-assets in exchange for either fiat currencies or other crypto-assets. Some may publish market quotes based on their clients' trading activity and, by doing so, facilitate price formation. Operators of crypto-asset trading platforms may act as the counterparty to users wishing to acquire and/or sell crypto-assets and provide in this case exchange services. See ECB, (2015).

60 As an example, in centralised crypto-asset trading platforms, the operator is de facto entrusted by traders with their crypto-assets and expected to transfer them between individual accounts it provides to them, settling such trades "off-chain" (i.e. out of the distributed ledger) in its own books. Operators of centralised crypto-asset trading platforms may also act as the counterparty to users wishing to acquire and/or sell crypto-assets and provide in this case exchange services.

61 An example is decentralised trading platforms that do not rely on an operator to hold users' funds and internalise transfers in crypto-assets. All individual trades settle in the distributed ledger. Crypto-assets are therefore transferred on a peer-to-peer basis, among possibly unauthenticated users. The main benefit of decentralised trading platforms from a user perspective is that investors do not entrust a third party to hold their assets. Low volumes and slow execution of trades compared to centralised services currently limit the use of decentralised trading platforms to a niche user base.

as to ensure the correct performance of the service and facilitate any necessary audit; (iii) stress-tested operational security and cyber-resilience; (iv) regulatory compliance intended as audibility by users and supervisors in line with the regulatory obligations/requirements that may be triggered by participation in or use of the network.

**It cannot be excluded that regulation of crypto-asset gatekeepers could have an unintended impact on the market.** First, because centralised gatekeeping services will be held to a greater level of scrutiny than decentralised services (which cannot be as effectively supervised), there is a risk of an uneven playing field and a shift from centralised to decentralised services. Furthermore, regulating and supervising gatekeepers entails significant resources on the side of public authorities, particularly with regard to the mechanisms to ensure compliance. Finally, regulation could be perceived as (unintentionally) legitimising crypto-assets business[62].

[62] EBA and ESMA in their advices to the EC on crypto-assets suggest that the EC conduct a holistic cost-benefit analysis to assess whether EU level action is needed (EBA, 2019, §72) and that EU policymakers consider implement a bespoke regime for crypto-assets (that do not qualify as financial instruments) (ESMA, 2019, §182-187).

# 5 Conclusions and future directions

**In conclusion, in the present market conditions, crypto-assets risks/implications for financial stability, monetary policy, and payments and market infrastructures are limited and/or manageable within the current framework.** Even at their peak in early 2018 the outstanding value of crypto-assets was too small to give rise to concerns for the EU financial system and the economy. The regulatory framework for FMIs allows risks arising from crypto-assets specific features to be managed and effectively constrains their use. With regard to supervised institutions, while the CRR is unsuited to deal with crypto-assets risks, deducting these items from CET1 would overcome this issue; otherwise Pillar 2 could be leveraged.

**The current assessment does not prevent the ECB from analysing the resilience of the financial system to possible future developments, and from identifying gaps to be filled.** Crypto-assets market developments are dynamic and links to the financial sector and the economy may increase in the future. Greater direct and/or indirect exposures to crypto-assets may result from many factors, from market developments to unintended "legitimising" effects of clarifying the application of standards (e.g. accounting standards) or regulating crypto-asset activities. Depending on how they are regulated, crypto-assets may more easily enter the FMI environment, and deteriorate the FMI risk profile.

**It is therefore important that the ECB continue to monitor the crypto-assets phenomenon, raise awareness and develop preparedness for any adverse scenarios, in cooperation with other relevant authorities.** Financial institutions investing directly or indirectly in crypto-assets should have in place relevant governance arrangements, also in line with the licensing criteria, and commensurate to the materiality of investments in crypto-assets and/or crypto-assets-related activities. Any risks relating to crypto-assets not covered by Pillar 1 (i.e. should CET1 deductions not apply to crypto-assets) should be addressed via supervisory assessment. With regard to market infrastructures, the ECB is in a position to impose ring-fencing segregation for the FMIs it owns and controls, subject to risk considerations. FMI oversight has an important role in ensuring that evolution of business models in crypto-assets does not result in circumventing the regulatory framework or compromising its effectiveness, including by urging from FMIs stricter risk management standards as appropriate.

# Annex 1: The case for central bank digital currency in the European Union

The relentless digitalisation of the economy has raised questions as to the suitability of existing forms of money for meeting the new and emerging needs of economic actors. The advent of crypto-assets has fuelled this debate, and it has been suggested that the technology underlying crypto-assets (distributed ledger technology or "DLT") should prompt central banks to issue their own "digital currencies". However, issuing a central bank digital currency (CBDC) is not contingent upon the use of a specific technology such as DLT. Moreover, CBDC would not constitute a new asset type (see Section 2 of this paper). From this perspective, CBDC needs to be analysed separately from crypto-assets.

Central banks provide widely accessible physical money in the form of cash and digital money in the form of reserves. Access to the latter, however, is more restricted as it is only available to commercial banks and other selected institutions (e.g. governments and financial market infrastructures) that hold accounts at the central bank. Digital central bank money for use by the general public currently does not exist.

Like other central banks, the ECB undertakes analysis of the opportunities and challenges associated with providing direct claims in digital form to the general public. This analysis aims to assess whether citizens and firms require digital payment services in central bank money or whether a central bank can satisfy the economy's need for safe and efficient payment services by acting within its traditional roles as operator of wholesale payment systems, as overseer of payment systems and instruments, and as catalyst in the area of payments more broadly.

The status of the euro as the single currency of 19 EU Member States is not under discussion. Hence, the ECB's analysis is premised on the notion of CBDC as a potential new form of the euro that is complementary to euro banknotes, coins, and wholesale deposits provided by the central bank, and to commercial bank deposits and electronic money provided by private entities under the relevant licensing regimes.

Research suggests that any hypothetical CBDC would come with both benefits and costs and would have manifold implications, ranging from its impact on financial stability to its interaction with the transmission of monetary policy and the operational efficiency of payment systems. Further analysis suggests that the actual costs and benefits of CBDC would ultimately depend on its specific design features.

In principle, a CBDC could be designed as a user-friendly risk-free asset that meets the public's demand for an economy that is both digitalised and safe. By potentially providing an alternative to some types of bank deposit, CBDC could induce its holders to withdraw a substantial amount of liquidity from the banking system, thereby influencing its ability to finance economic activity in normal times. During economic downturns in particular, it could facilitate bank runs in response to possibly unjustified

rumours regarding the insolvency of some market participants. Limiting the amount of CBDC injected into the economy would mitigate the above-mentioned risks, but it needs to be done in a way that ensures that it is fungible with any other form of the euro, as is the case for cash and commercial bank money, for example.

Depending on its specific features, CBDC could either allow monetary policy to reach a wider range of economic actors more directly or weaken the tools available to the issuing central bank for the conduct of its monetary policy. When assessing the features and implications of CBDC as a complement to cash, it is important to identify possible means of ensuring that CBDC is a neutral factor for monetary policy, just as cash is.

In this context, it should also be noted that physical cash provides a level of privacy that may prove difficult to replicate in its digital version (CBDC) from a technical perspective. If it were replicated, however, it would raise issues with respect to the enforcement of laws against money laundering and the financing of illegal activities.

From a demand side perspective, the business case for issuing CBDC in the euro area is currently not a compelling one. Looking at the current use of payment instruments i the EU, while non-cash payments in the EU continue to grow, the demand for euro banknotes has been sustained, and cash is generally still a popular means of payment across the euro area. Besides cash, European citizens and firms have access to a wide range of electronic payment instruments underpinned by sound clearing and settlement infrastructure. More recently, instant payments have allowed the immediacy of cash transactions to be matched in the digital economy and, since November 2018, the TIPS (TARGET Instant Payments Settlement) service has enabled real-time settlement in central bank money to be provided on a 24/7/365 basis.

This analysis suggests that current conditions do not warrant the issuance of CBDC in the euro area. Nonetheless, rapid developments are possible in the constantly evolving digital economy. These may range from changes in the needs of EU citizens, channelled by EU authorities as a public interest, to a considerable decline in the use of cash, or the unprecedented event of another central bank issuing a CBDC that is available cross-border. Therefore, the ECB and the broader community of euro area central banks will continue evaluating the case for making a digital version of euro central bank money available to the public on the basis of evolving requirements and global developments.

Furthermore, the European central bank community is conducting additional exploration and research into the functional and technical feasibility of implementing CBDC, coordinated by the ECB under the so-called “Eurochain” initiative, which aims to assess whether and how the use of new tools made possible by technological innovations such as DLT could change the implications of CBDC for the European economy and the fulfilment of the central bank mandate.

As a member of the Bank for International Settlements’ Markets Committee and the Committee on Payments and Market Infrastructures (CPMI), the ECB has channelled its input into the joint analysis of CBDC conducted by these two groups. Their joint

report of March 2018 concluded that any steps towards the possible launch of CBDC should be subject to careful and thorough consideration. While broad monitoring of digital innovations should continue, further research on the possible effects of the issuance of CBDC on interest rates, as well as exchange rates and other asset prices, as well as on the structure of intermediation, financial stability and financial supervision is warranted.

# Annex 2: List of acronyms

| | |
|---|---|
| **AMLD4** | Fourth Anti-Money Laundering Directive |
| **AMLD5** | Fifth Anti-Money Laundering Directive |
| **BCBS** | Basel Committee on Banking Supervision |
| **BRRD** | Bank Recovery and Resolution Directive |
| **CBDC** | Central bank digital currency |
| **CBOE** | Chicago Board Options Exchange |
| **CCP** | Central counterparty |
| **CeBM** | Digital central bank money |
| **CET1** | Common Equity Tier 1 |
| **CFD** | Contract for difference |
| **CFE** | CBOE Futures Exchange |
| **CFTC** | US Commodity Futures Trading Commission |
| **CM** | Clearing member |
| **CME** | Chicago Mercantile Exchange |
| **CoBM** | Digital commercial bank money |
| **CPMI** | Committee on Payments and Market Infrastructures |
| **CRR** | Capital Requirements Regulation |
| **CSD** | Central securities depository |
| **CSDR** | Central Securities Depositories Regulation |
| **DLT** | Distributed ledger technology |
| **EBA** | European Banking Authority |
| **ECB** | European Central Bank |
| **EMD2** | Second Electronic Money Directive |
| **EMIR** | European Market Infrastructure Regulation |
| **ESA** | European Supervisory Authority |
| **ESCB** | European System of Central Banks |
| **ESMA** | European Securities and Markets Authority |
| **ETF** | Exchange traded fund |
| **ETN** | Exchange traded note |
| **EU** | European Union |
| **FAANG** | Facebook, Apple, Amazon, Netflix and Google |
| **FATF** | Financial Action Task Force |
| **FMI** | Financial market infrastructure |
| **FSB** | Financial Stability Board |
| **G7** | Group of Seven |
| **G20** | Group of Twenty |
| **GDP** | Gross Domestic Product |
| **ICA-TF** | (ECB) Internal Crypto-Assets Task Force |
| **ICO** | Initial coin offering |
| **IFRS** | International Financial Reporting Standards |

| | |
|---|---|
| **IOSCO** | International Organisation of Securities Commissions |
| **LCR** | Liquidity coverage ratio |
| **LCR DR** | Commission Delegated Regulation on the Liquidity Coverage Ratio |
| **MiFID** | Markets in Financial Instruments Directive |
| **NSFR** | Net stable funding ratio |
| **ORPS** | Other retail payment system |
| **PFMI** | Principles for Financial Market Infrastructures |
| **PIRPS** | Prominently important retail payment system |
| **PSD2** | Revised Payment Services Directive |
| **SEC** | US Securities and Exchange Commission |
| **SFD** | Settlement Finality Directive |
| **SIPS** | Systemically important payment system |
| **SREP** | Supervisory review and evaluation process |
| **SSB** | Standard setting body |
| **TC-CCP** | Third-country recognised CCPs |
| **TIPS** | TARGET Instant Payments Settlement |

# References


Committee on Payments and Market Infrastructures, Board of the International Organisation of Securities Commissions (2017), Resilience of central counterparties (CCPs): Further guidance on the PFMI – Final report, July.

Committee on Payments and Market Infrastructures, International Organisation of Securities Commissions (2012), Principles for financial market infrastructures, April.

Committee on Payments and Market Infrastructures, Markets Committee (2018), Central bank digital currencies, March.

European Banking Authority (2019), Report with advice for the European Commission on crypto-assets, January.

European Central Bank (2018), Financial Stability Review, Frankfurt am Main, May.

European Central Bank (2015), "Virtual currency schemes – a further analysis", February.

European Central Bank (2012), "Virtual currency schemes", October.

European Securities and Markets Authority (2019), Advice. Initial Coin Offerings and Crypto-Assets, January.

Ernst & Young (2018), "Big vs. agile: what happened in the global IPO market in Q4 2018", December.

Financial Times (2018a), "The rise and fall of ethereum", published online, 19 October. Last accessed 12 February 2019.

Financial Times (2018b), "Auditors grapple with crypto and blockchain", published online, October 28. Last accessed 12 February 2019.

Financial Stability Board (2018), Crypto-asset markets / Potential channels for future financial stability implications, October.

Mersch, Y. (2018a), Virtual or virtueless? The evolution of money in the digital age, lecture given at the Official Monetary and Financial Institutions Forum, London, 8 February.

Mersch, Y. (2018b), Virtual currencies ante portas, speech given at the 39th meeting of the Governor's Club Bodrum, Turkey, 14 May.

Pinna, A. and Ruttenberg, W. (2016), "Distributed ledger technologies in securities post-trading. Revolution or Evolution?", Occasional Paper Series, No 176, European Central Bank, Frankfurt am Main, April.

Satis Group (2018), "Crypto-asset market coverage initiation: network creation", July.

**Acknowledgements**
This paper was prepared under the aegis of the ECB Internal Crypto-Assets Task Force (ICA-TF). It benefited from contributions by: Dirk Bullmann, Ludovico Cardone, Adrien Delcroix, Daniele Fornaro, Christoph Kaufmann, Gera Kiewiet, Urszula Kochanska, Emilia Kondracka, Simon Kördel, Jenny Körner, Klaus Löber, Markus Mayers, Andrea Pinna, Spyros Palligkinis, Aleksander Tracz, and Angelos Vouldis.

**Chair of the ICA-TF**

**Mehdi Manaa**
European Central Bank, Frankfurt am Main, Germany; email: mehdi.manaa@ecb.europa.eu

**Secretariat of the ICA-TF**

**Maria Teresa Chimienti**
European Central Bank, Frankfurt am Main, Germany; email: maria_teresa.chimienti@ecb.europa.eu

**Members of the ICA-TF**

**Mitsutoshi Adachi**
European Central Bank, Frankfurt am Main, Germany; email: mitsutoshi.adachi@ecb.europa.eu

**Phoebus Athanassiou**
European Central Bank, Frankfurt am Main, Germany; email: phoebus.athanassiou@ecb.europa.eu

**Irina Balteanu** (from September 2018)
European Central Bank, Frankfurt am Main, Germany; email: irina.balteanu@ecb.europa.eu

**Alessandro Calza**
European Central Bank, Frankfurt am Main, Germany; email: alessandro.calza@ecb.europa.eu

**Conall Devaney**
European Central Bank, Frankfurt am Main, Germany; email: conall.devaney@ecb.europa.eu

**Ester Diaz Fernandez**
European Central Bank, Frankfurt am Main, Germany; email: ester.diaz@ecb.europa.eu

**Fabian Eser**
European Central Bank, Frankfurt am Main, Germany; email: fabian.eser@ecb.europa.eu

**Ioannis Ganoulis**
European Central Bank, Frankfurt am Main, Germany, email: ioannis.ganoulis@ecb.europa.eu

**Maxime Laot**
European Central Bank, Frankfurt am Main, Germany, email: maxime.laot@ecb.europa.eu

**Günther Philipp**
European Central Bank, Frankfurt am Main, Germany; email: guenther.philipp@ecb.europa.eu

**Raphael Poignet**
European Central Bank, Frankfurt am Main, Germany, email: raphael.poignet@ecb.europa.eu

**Stephan Sauer**
European Central Bank, Frankfurt am Main, Germany, email: stephan.sauer@ecb.europa.eu

**Doris Schneeberger**
European Central Bank, Frankfurt am Main, Germany, email: doris.schneeberger@ecb.europa.eu

**Livio Stracca** (until July 2018)
European Central Bank, Frankfurt am Main, Germany; email: livio.stracca@ecb.europa.eu

**Jens Tapking**
European Central Bank, Frankfurt am Main, Germany; email: jens.tapking@ecb.europa.eu

**Colm Toolin**
European Central Bank, Frankfurt am Main, Germany; email: colm.toolin@ecb.europa.eu

**Carolyn Tyler**
European Central Bank, Frankfurt am Main, Germany; email: carolyn.tyler@ecb.europa.eu

**Helmut Wacket**
European Central Bank, Frankfurt am Main, Germany; email: helmut.wacket@ecb.europa.eu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu



PDF ISBN 978-92-899-3688-0, ISSN 1725-6534, doi:10.2866/162, QB-AQ-19-006-EN-N