

LESSONS FROM THE CRYPTO WINTER

DeFi versus CeFi

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This paper analyses the mechanisms involved in the recent failings in crypto-asset markets, focusing on events in 2022 through September. The paper assesses the role of centralised finance (CeFi) and decentralised finance (DeFi), and the disproportionate impact the crypto market turmoil has had on retail market participants. It examines learnings of the recent crypto-asset market downturn, also known as the “crypto winter”, including high interconnectedness within the crypto-asset ecosystem; elaborate mechanisms of financial engineering that heavily use leverage and are built on the composability offered by DeFi (i.e., components of DeFi are pieced together to create new products); and increased market concentration. The paper highlights the urgency for policy action and provides policy recommendations.

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Foreword

This report analyses the recent developments in the markets for crypto-assets; examines the most prominent failures of crypto-asset firms in the first three quarters of 2022; analyses findings and learnings of these failures; and raises associated policy implications.

The report has been drafted by *Iota Kaousar Nassr* and *Ana Sasi Brodesky* under the supervision of *Robert Patalano* from the Division of Financial Markets of the OECD Directorate for Financial and Enterprise Affairs. *Liv Gudmundson* provided editorial and communication support.

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Executive summary

Crypto-asset market downturn: the “crypto winter”

Following a peak in crypto-asset valuations in November 2021, the market for crypto-assets entered a prolonged sell-off amid a broader market downturn in risky assets.¹ The price of main crypto-assets Bitcoin (BTC) and Ether (ETH) fell sharply; by mid-June the entire crypto-asset market lost USD 1.7 trillion in market value compared to its peak and DeFi protocols followed a similar pattern, with total value of crypto-assets locked in DeFi (TVL) dropping by more than 65% over a six-month period through May 2022. The decline in crypto-asset prices amid a broader market downturn for risk assets showcases the correlation of these markets with traditional risky asset classes, such as equities, which intensified during the downturn. The initial sell-off occurred against a backdrop of rising inflation expectations in late 2021 and the beginning of 2022, coinciding with a rise in gold prices, further indicating that investor perception of crypto-assets such as the Bitcoin as inflation hedges cannot be justified.

The downturn in valuations of major crypto-assets triggered failures of crypto-asset firms, which in turn further intensified and aggravated the crypto-market sell-off. The domino effect that was triggered by a combination of crypto-asset firm failures (such as the failure of the Terra’s UST so-called stablecoin) against the background of a prolonged crypto-asset market downturn (known as a “crypto winter”) in H1 2022 has had a severe impact on many retail crypto-asset market participants, who may have suffered significant loss of investment without any recourse. Retail investor losses should also be considered in light of the observation that many large crypto-asset investors (“crypto whales”) or dominant market participants reportedly appeared to close positions with limited losses or even a profit. Indicatively, based on an industry report, several large investors appeared to have exited their positions in UST much earlier than many smaller investors, while some small investors also continued buying during the collapse (Shah and Latif, 2022^[1]; Bloomberg, 2022^[2]).

It should be highlighted that the evidence in this note describing incidents occurring during the “crypto winter” is based on industry sources and the specialised media and has not been independently reviewed by the OECD. The OECD has also conducted analysis of data provided by blockchain analytics firms. Absence of transparency regarding the transactions undertaken by participants in decentralised exchanges or on a peer-to-peer basis, and the riskiness of such transactions, coupled with the pseudonymous nature of many crypto-assets transactions and the ensuing difficulty of tracing wallets to owners, the reported incidents cannot be validated with certainty.

¹ The analysis performed in this report focuses on the events that followed the spring 2022 crypto asset market turbulence and provides data as of Q3 2022 (30 September 2022). However, the report has been updated to include some preliminary analysis of FTX events that took place after deliberation of the report by the Committee on Financial Markets on 5 October 2022, and which confirmed many of the findings of the report (Section 3).

Spotlight and lessons from major failures

The rise and fall of the algorithmic “stablecoin” TerraUSD (UST) in a short time span and the consecutive failures of other crypto-asset service providers (Celsius, Three Arrows Capital and the largest failure so far, FTX) exposed the far-reaching consequences of interconnectivity within the crypto-assets space. Because stablecoins reserves include traditional financial assets, the resulting contagion could possibly also have spilled-over into traditional financial markets. UST broke its one-to-one peg with the U. Dollar and suffered a run that resulted in significant losses for UST holders. The value of UST declined from USD 0.99 to less than USD 0.13 in the course of five days. The subsequent de-pegging of the largest so-called stablecoin, Tether’s USDT, which was reportedly backed by holdings of commercial paper as part of its reserves and did not have an immediate observable contagion effect on short-term debt markets. However, it clearly highlighted the high interconnectedness within crypto-asset markets and the potential creation of transmission channels to traditional markets. The UST implosion also highlighted the central role of trust and confidence in the market for crypto-assets, similar to the importance trust has in traditional financial markets and how a sharp loss of confidence can affect the crypto-assets ecosystem. Importantly, some UST retail investors lost significant part of their investment without any recourse for compensation. For example, in the case of Terra UST’s implosion, 280 000 investors reportedly lost their investments (news1.kr, 2022^[3]) and nearly 4 400 retail investors have recently formed an association called the UST Restitution Group in pursuit of compensation by the Terra founder (FT, 2022^[4]). Such investors appear to have been drawn into UST by the unsustainably high yields offered by protocols connected to UST (e.g. through the Anchor protocol) and with little understanding of the circular and reflexive character of the so-called stablecoin, which had no tangible value; UST was drawing its value from another crypto-asset (LUNA) that did not have any value of its own (similar to other unbacked crypto-assets) and which in turn derived its value only from the promise of conversion between UST and LUNA.

Celsius Network, a crypto-asset lending platform, was the first large crypto-asset firm affected by the UST implosion and a good example of vulnerabilities related with crypto-asset activity. The Celsius model relied on a mechanism whereby the platform used customers’ deposited crypto-assets as collateral in DeFi lending protocols and for staking and contributions to liquidity pools, and then used the returns to pay the advertised 17% interest rates on new customer deposits. Crypto-asset lending products offered by Celsius have characteristics of investment contracts and could therefore be defined as securities in some jurisdictions.

The non-compliant provision of regulated financial activity by UST, Celsius and their peers and/or the fact that some of these activities may fall outside of the existing regulatory frameworks in some jurisdictions, deprived users of traditional safeguards for investor and financial consumer protection, such as registration and associated disclosures by security issuers. The recent turbulence also exposed the massive interconnectedness that exists within the crypto-asset market, which further exacerbates risks for participants and the markets in a potential future scenario of even greater activity in this sector. New and complex leveraged trading strategies have also been observed (e.g., leveraged liquid staking of ETH), which give rise to liquidity and maturity mismatches and intensify the linkages between already heavily intertwined crypto-assets and entities. The recent failures also exposed potential fragmentation and informational asymmetries between decentralised exchanges (DEXs) and centralised exchanges (CEXs), which gave an advantage to those trading on DEXs to the detriment of unsophisticated or retail investors. Operational failures, such as mal-functioning oracles or bugs were additional DeFi flaws exposed, enabling the theft of millions of dollars from investors (in so-called ‘exploits’). Weaknesses were also exposed in the use of Proof-of-Stake (PoS) as the consensus mechanism for transaction validation in times of stress, allowing for governance attacks at a very low cost when the price of the native crypto-assets drops significantly. Adoption of PoS may also contribute to accumulation of liquidity transformation risk.

A new wave of financial engineering with severe consequences for investors (particularly retail)

The recent crypto-asset market turmoil exposed new forms of financial engineering taking place in crypto-asset markets, with important repercussions for investors – particularly retail investors. Such financial engineering comprises the main ingredients of such practices in traditional finance (e.g., complexity, leverage, and related risks) and is compounded by certain novel mechanisms developed in decentralised finance (e.g., composability of DeFi). Developments such as liquid staking, creating derivatives backed by illiquid locked assets, create extreme liquidity transformation risk and maturity mismatches. Consecutive rounds of re-hypothecation of crypto-assets that are considered by platform clients to be lent and/or ‘locked’ as collateral create risks related to high leverage and liquidity mismatches in crypto-asset markets. Such activities continue despite the recent failures.

The major crypto-asset firm failures in the current downturn concern CeFi (centralised crypto-asset finance) as well as DeFi platforms that were Decentralised in Name Only (“DINO”) and exhibited centralised control attributes (e.g., over the protocols or over users’ assets). Such CeFi entities have centralised control over the operation of the firm, the management of users’ funds, and all decision-making. By contrast, many DeFi protocols worked as intended, surviving the turbulence without any major failures, despite the massive decline in the price of crypto-asset collateral pledged in these platforms. Automated mechanisms in DeFi lending protocols fulfilled their intended purpose of settling transactions without issues in H1 2022, in spite of – or perhaps due to – the wave of automated liquidations triggered by the price corrections. However, automated liquidations may risk exacerbating market volatility, depending on the size of liquidations and market conditions.

Despite differences in their business models and labelling, some firms in both CeFi and DeFi may currently operate in a non-compliant manner or outside the regulatory perimeter at this juncture. As such, they may be exposing participants to material risks in the absence of any of the traditional financial regulation safeguards for consumer and investor protection and market integrity. CeFi and DeFi players are currently heavily intertwined; CeFi is in many ways the lifeline of DeFi as the former is the primary source of funds and collateral flowing into DeFi (by means of stablecoins, as an example) and is the (more user-friendly) entry point for many users wishing to participate in DeFi. From the CeFi perspective, DeFi protocols were the ideal venue for crypto-asset trading, because DeFi protocols allowed CeFi firms to take heavily leveraged positions. At its simplest form, crypto-asset lenders would borrow crypto-assets at a certain rate and invest the borrowed assets in a DeFi protocol that provided a higher return as long as markets went up, similar to traditional carry trade strategies.

The CeFi-DeFi ecosystem is very concentrated, and is becoming increasingly so after the recent downturn, which exacerbates risks. In addition to concentration of so-called stablecoin issuers, concentration was also observed among holders of major stablecoin arrangements. Based on industry data, large crypto-asset trading firms acting as market-makers have a significant proportion of the holdings of such crypto-assets, which could give rise to market domination and other distortive effects in the wider crypto-asset markets. Issuers of major stablecoins are in some instances shareholders of crypto-asset lenders (e.g., Tether and Celsius). There have been reports of crypto-asset lenders allegedly borrowing stablecoins directly from the issuer and the issuers then possibly using such loans as part of the reserves backing the stablecoin, in a self-referential and circular manner. Furthermore, recent acquisitions by the largest players of the crypto-asset market have increased their dominance, thereby increasing further concentration and interconnectedness in an already very heavily interlinked ecosystem.

If financial stability frameworks for traditional financial systems were applied to the crypto-asset ecosystem, one might arrive at the conclusion that these markets are prone to systemic risks within the boundaries of the crypto-asset market system, due to high and increasing concentration risks, leverage, and high interconnectedness between the different players in CeFi and between CeFi and DeFi protocols. Two key

elements that are not present are the size of exposures relative to the financial system as well as the role that traditional financial activities play in the functioning of the real economy (ESRB, 2014^[5]). Nevertheless, the confidence and trust in these markets is vitally important to their functioning, similar to as in traditional financial markets, and the growing risks makes this digital ecosystem unstable. This is important to note given the possibility of growing interconnectedness between markets for crypto-assets and traditional financial markets, and the prospect for renewed growth of investor demand for crypto-assets and DeFi.

The analysis in this note provides evidence of elaborate mechanisms involving heavy use of leverage built on the composability offered by DeFi. However, growth of these mechanisms has been driven by user optimism about the value of the underlying products and the ensuing sharp rise of speculative behaviour. That led to the exploitation of customer funds through certain platforms employing mechanisms which depend on new user funds to pay unrealistic returns to existing users.

Policy considerations

The non-compliant operation of certain crypto-asset market players offering regulated financial activities and products, and/or the operation of other players outside the regulatory perimeter in some jurisdictions, exposes markets and their participants to significant risks usually addressed by consumer and investor protection rules. The absence of transparency regarding the strategies undertaken and their riskiness, the liquidity of assets subject to client transactions, the trading of client crypto-assets and the re-hypothecation of crypto-assets in DeFi platforms are just some examples of the lack of disclosures available to market participants.

The lessons from the failures of major crypto-asset market participants from the recent downturn highlights the urgent need for policy action. This is particularly true for the protection of retail investors, given the disproportionate impact that the recent downturn appears to have had on retail investors compared to certain large crypto-asset holders and/or insiders who have allegedly managed to cover some of their losses.

The importance of communication of appropriate policy frameworks and the non-compliant nature of activity of some market players is paramount to address financial consumer protection issues. This is even more the case given that the current low levels of crypto-asset prices are being marketed to new investors as a good entry point with upside opportunities.

The recent crypto-asset market turmoil has not materially affected traditional financial markets due to the former's relatively small size, and at this stage, the limited interconnectedness of crypto-asset markets and traditional financial markets. However, should conditions change, a future instance of similar turmoil in a larger crypto-asset market could have implications for financial stability. The recent turmoil in crypto-asset markets has exposed the high interconnectedness that exists within the crypto-asset ecosystem, and which may intensify following this crypto winter, because the market is concentrating in few dominant players who control even larger parts of the crypto-asset activity. This increases risks of wide-scale disruption and contagion within the crypto-asset markets if any of these dominant players faces difficulties in the future.

International co-ordination at the cross-border level is necessary because of the global nature of the crypto-asset market activity and so as to avoid regulatory arbitrage opportunities currently exploited by some non-compliant crypto-asset firms. Co-ordination among authorities at the domestic level is also important to avoid fragmentation between different authorities. Collaboration among different jurisdictions and authorities can mitigate resource and knowledge burdens by scaling solutions. The operating models of the crypto-asset market may call for an investment in upskilling to improve in-house expertise of regulatory and supervisory authorities in some jurisdictions, *inter alia* through the potential use of digital solutions for financial supervision (e.g., SupTech solutions).

1 Crypto-asset market update: the recent downturn confirms the underlying speculative drivers

The recent crypto-asset market downturn resulted in a loss of c. USD 2 trillion of market value for crypto-assets with severe repercussions for participants of those markets, while it exposed important vulnerabilities underlying such products and their issuers, as well as the broader markets for decentralised finance.

This section examines the current state of markets for crypto-assets and provides empirical evidence on the drivers of institutional participation in these markets, discussing how such drivers have evolved since the peak of this market in late 2021. It also presents and discusses liquidations of DeFi protocols as a result of the drop in the value of crypto-assets pledged as collateral in such applications.

Recent surveys from developed economies such as the US, UK, Canada, and EU member states point to an adoption rate of crypto-assets among the adult population of around 10% (see Annex A or further information from the surveys). This relates to people who affirmed that they hold or held crypto-assets, mainly BTC. Analysis of on-chain data (data retrieved from transactions performed on the blockchain) by the blockchain analytics company Chainalysis ranked the adoption of crypto-assets in 146 countries around the world based on usage of different types of cryptocurrency services (Chainalysis, 2022^[6]). According to the ranking, emerging markets dominate the index. The only two high income countries in the top 20 adopters are the US and UK. On chain data point to about a total of BTC 40 million-holding entities recognised by Chainalysis that may be classified as retail (i.e., holding up to 1 BTC).

DeFi platforms have attracted much interest and transaction volume in crypto-assets in the past year and a half; total value locked (TVL) in DeFi was estimated at USD 53 billion in September, accounting for 5% of the entire crypto-assets market value at the time. Inflows into DeFi from the US are the highest among OECD member countries in 2022, at a scale much higher than other countries (see Annex A). Forty-two percent of OECD member countries are ranked in the top quartile of retail transactions in DeFi according to Chainalysis (2022^[6]) (see Annex A for additional analysis on usage of DeFi services).

1.1. Current state of crypto-asset markets

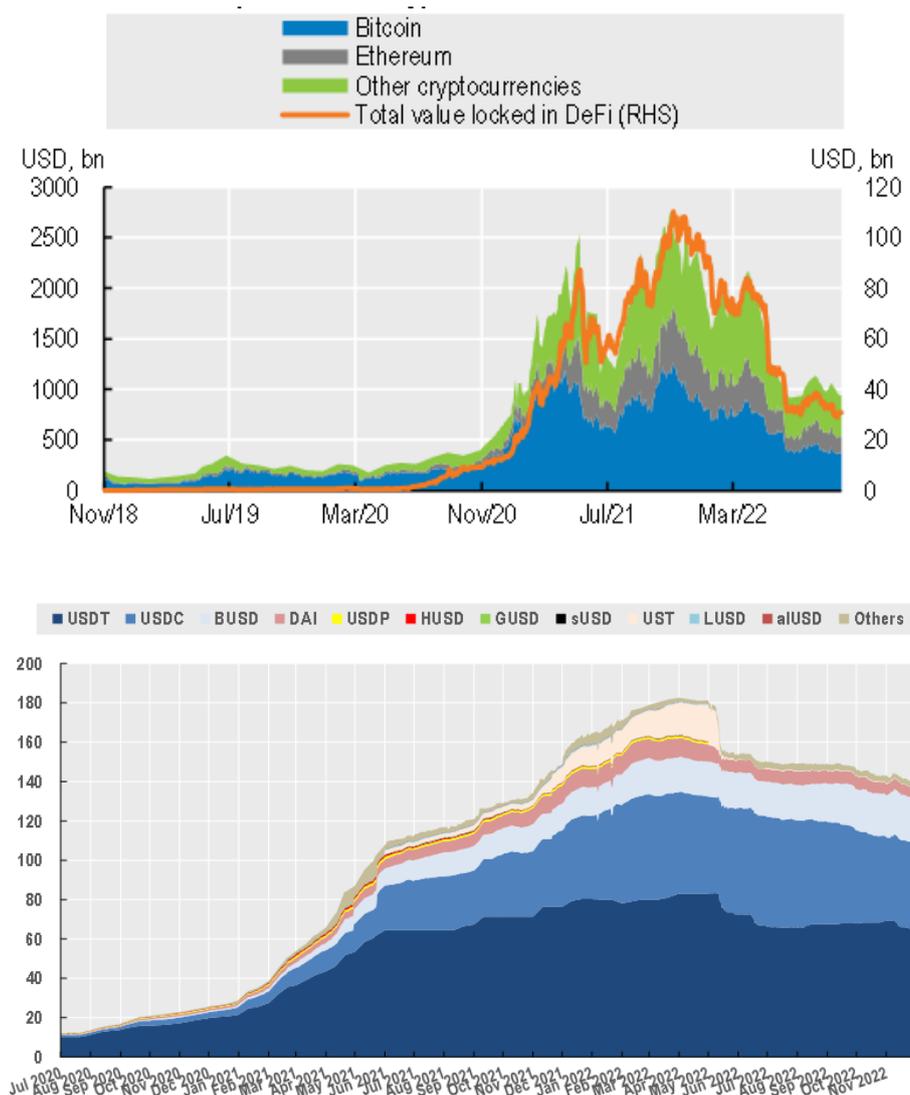
Following a peak in crypto-asset market prices in November 2021, the market for crypto-assets entered a prolonged sell-off amid a broader market downturn in risky assets. As of 30 September 2022, the price of main crypto-assets BTC and ETH fell sharply, with BTC losing 70.8% and ETH 71.4% of its value from its November peak. The entire crypto-asset market lost USD 1.8 trillion of market value compared to its peak (Figure 3.1).

DeFi markets followed a similar pattern, with TVL dropping by 65% over the same 6-month period, reaching USD 53 billion of crypto-assets reportedly locked in ETH-based protocols (as of 8 September) (Figure 3.1).

Subsequently, ETH and to a lesser extent BTC recovered slightly, but as discussed briefly at Section 3, later events post the timing of writing of this report caused values to fall further.

Figure 1.1. Market value of crypto-assets, Total Value Locked (TVL) in DeFi [RHS] and market value of major stablecoins [LHS]

In USD billion, as of 30 September 2022



Source: CoinMarketCap, DeFiLlama, CoinMetrics.

The drop in crypto-asset valuations amid a broader downturn in financial markets for risk assets showcases the correlation of these markets with traditional risk asset classes, such as equities (OECD, 2022^[7]). In fact, the correlation of crypto-asset prices with equities has increased (see Section 1.2). The initial sell-off occurred against a backdrop of rising inflation expectations in late 2021 and a rise in gold prices, further indicating that investor perception of crypto-assets such as BTC as inflation hedges is not supported.

The broader fragile investor risk sentiment in financial markets in Q1-Q2 2022 contributed to the increased volatility in traditional markets and heightened risk aversion, which drove a parallel crypto-asset sell-off.

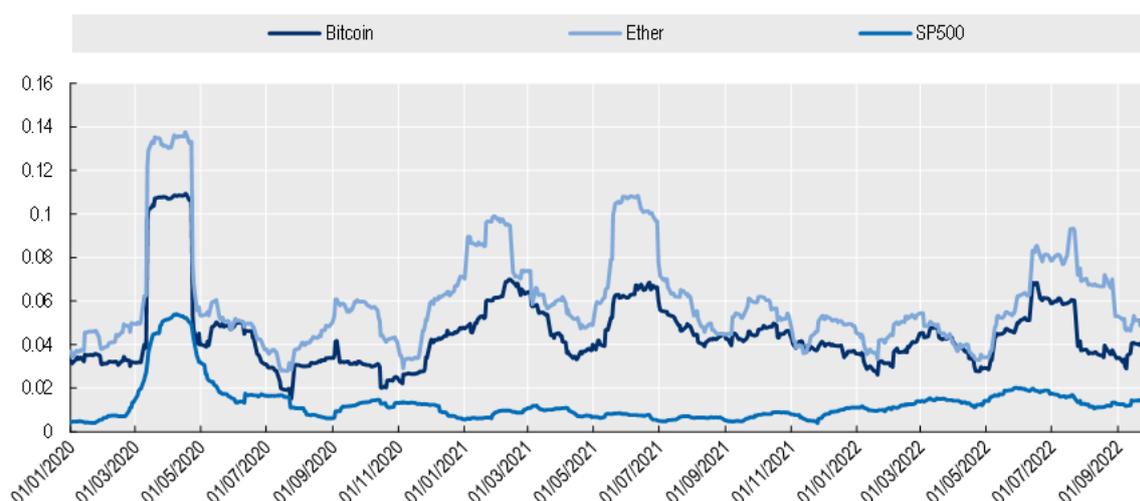
The downturn in valuations of major crypto-assets triggered failures of crypto-asset firms (see Section 2), which in turn further intensified and aggravated the sell-off.

When compared to the last crypto-asset downturn, the cumulative decline from the peak of the market is broadly in line with historical relative performance in the 2017-18 crypto-asset bear market. The previous peak of the BTC price in December 2017 represented a 2 500% y-o-y increase. In the first few days of the downturn following this peak, the price of BTC fell by over 50% in just a few days and continued to decline with a peak-to-trough decline of c.85% for BTC. It took almost three years to regain the previous peak since the market bottomed out in December 2018. The recent downturn reflects also the broader environment of risk-off investment sentiment, although the rapid growth of crypto-asset prices, stablecoin and DeFi market activity have intensified the recent crash.

Crypto-assets price volatility increased during the first half of 2022, particularly in June, corresponding to failures in some crypto-asset service providers, but overall remained close to its average in recent years. When compared to the volatility of the S&P, BTC daily returns have portrayed volatility about four times higher than the daily S&P500 index returns during 2020-21 (4.6% and 1.2%, respectively). During the market downturn since the beginning of 2022, BTC volatility decreased to 4.2%, while that of S&P increased to 1.4% (Figure 1.2).

Figure 1.2. 30-day moving volatility

BTC, ETH and S&P 500, as of 30 September 2022



Source: Refinitiv and OECD calculation.

Furthermore, reflecting high correlations among crypto-assets, all major coins experienced sell-offs similar to BTC and ETH. Overall, some of the crypto-assets with the largest appreciations in 2021 experienced the largest drops in 2022.

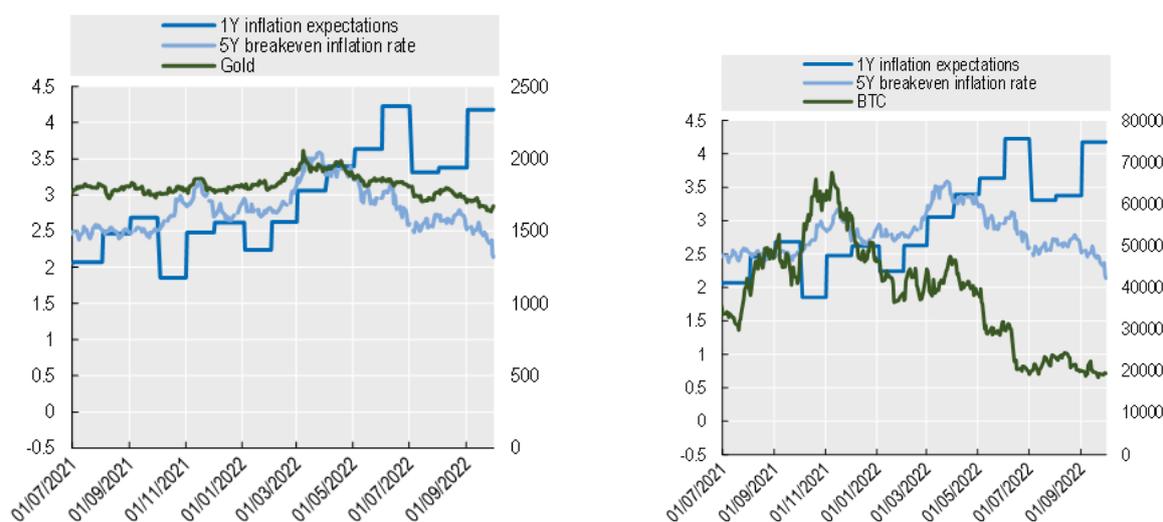
1.2. Update of empirical evidence on drivers of institutional investor adoption of crypto-assets

During the end of 2021 and into the first quarter of 2022, inflation expectations rose for both short- and medium-term horizons (one and five years). Medium term inflation expectations then began to decline in the second and third quarters of 2022, while expectations for short term inflation remained elevated.

Returns on BTC did not provide investors with protection against rising expectations for inflation during the beginning of 2022, as BTC prices were already declining during the period inflation expectations were rising. This was in contrast to gold price, which has followed quite closely the medium-term inflation expectations for the entire period. For the year that ended on 30 September 2022, the correlation between the price of BTC and the five-year breakeven inflation expectations derived from market prices was 0.4, while that of the price of gold and inflation expectations was 0.9 (Figure 1.3).

Figure 1.3. BTC, gold and inflation expectations

As of 30 September 2022



Note: The 1Y inflation expectations are calculated by Federal Reserve Bank of Cleveland estimated by a model that uses Treasury yields, inflation data, inflation swaps, and survey-based measures of inflation expectations. The 5Y breakeven inflation rate represents a measure of expected inflation derived from 5-Year Treasury Constant Maturity Securities and 5-Year Treasury Inflation-Indexed Constant Maturity Securities.

Source: Refinitiv and FRED.

1.2.1. Updated correlations of main crypto-assets with traditional asset classes and comparison with last report

In an OECD publication of May 2022 (OECD, 2022^[7]), the analysis demonstrated that the short-term correlation of returns of BTC and ETH has been close to one ever since ETH was launched. The short-term correlation of BTC returns with that of equity markets seemed to increase during general market downturn periods, for example during Q1 2020, the first COVID-19 wave of infections, and again at the end of 2021 during a period of equity turbulence. In addition, the correlation of BTC with equity markets has been increasing over time.

Figure 1.4. Short-term correlation of BTC and other assets

30 days moving correlation of daily return – BTC versus other assets, As of 30 September 2022



Source: Refinitiv and OECD calculations.

The summer turmoil in the crypto-asset market has only reinforced the trends identified in the previous OECD publication. Future analysis may be merited to examine the effect of the FTX bankruptcy that occurred after the time of writing this report.

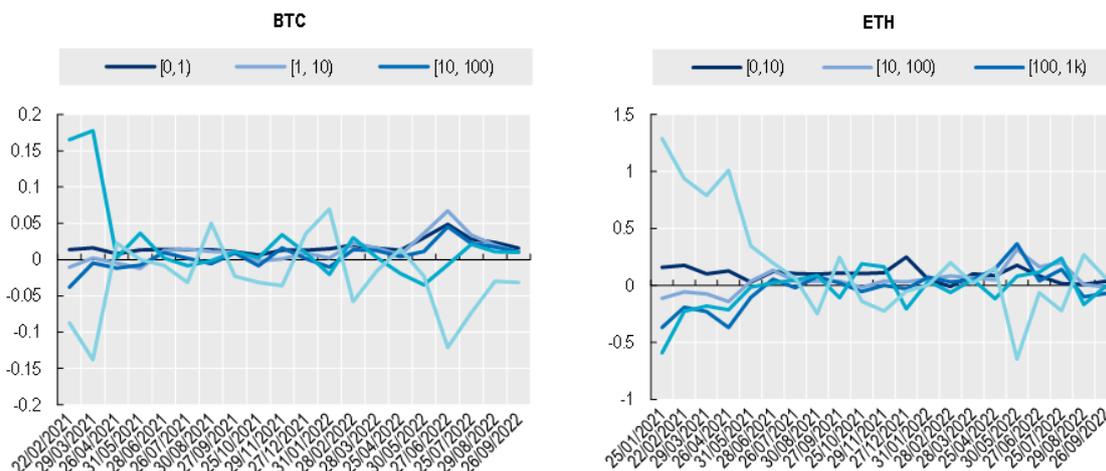
1.2.2. Impact of the market downturn on demand for crypto assets and regulated products linked to the BTC

The OECD publication of May 2022 identified a divergence in the type of investors holding BTC and ETH, with retail investors prevailing in BTC and larger investors dominating ETH holdings (OECD, 2022^[7]).² Large investors decreased their holdings in BTC further at the expense of smaller retail investors following the past few months' price declines. After the large accumulations of ETH by institutional investors during 2021, these investors were too on the selling side during Q2 and Q3 of 2022, and perhaps fearing the effects of the transition of the Ethereum blockchain to Proof-of-Stake consensus mechanism (the so-called "Merge") on the price of the underlying crypto-asset (Figure 1.5).

² The distinction between investors' size is based on the value of their overall holdings in a particular crypto-asset. We assume that holders of more than 1 000 BTC or 10 000 ETH are more likely to be professional or institutional investors. For more details on holder distribution of the main crypto-assets see Annex A.

Figure 1.5. The selling and buying characteristics of investors during the latest downturn

Charts present change in holdings of crypto-assets by number of crypto-assets held by the entity at the last week for each month. Change in holdings for a size category is expressed in millions of assets. As of end September 2022

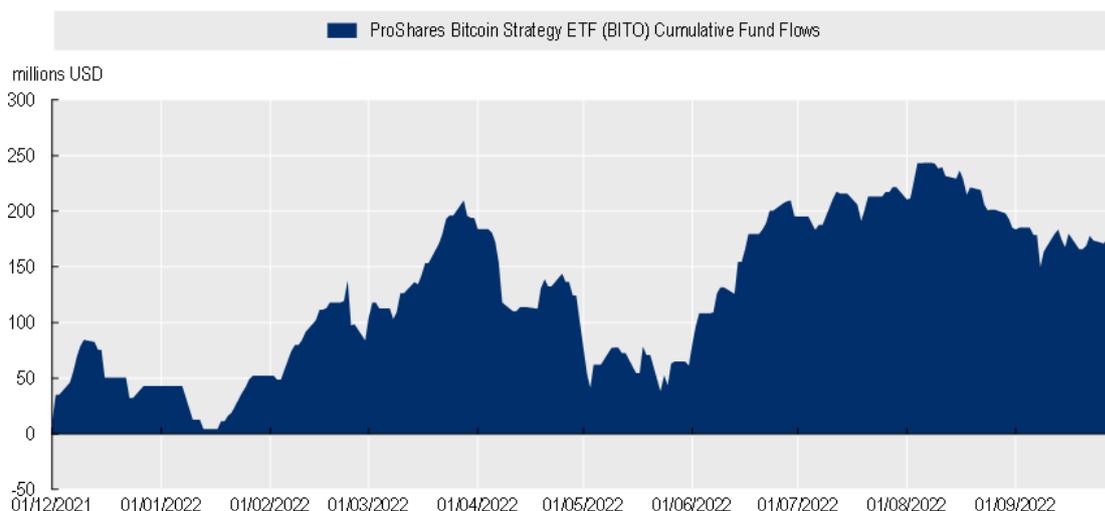


Source: OECD, based on data from Chainalysis.

Despite price declines, investors in ETFs tracking the crypto-asset market were not quick to withdraw funds, perhaps with an expectation for recuperation as occurred after previous “crypto winters”. Cumulative flows from the beginning of 2022 into the ProShares Bitcoin Strategy ETF (BITO), the first BTC Futures ETF introduced to the US market in October 2021 indicate that net flows into the fund remained positive throughout the first half of 2022 and continuing to grow in Q3 2022 (Figure 1.6). A set of ETFs that follow an investment strategy benchmarked to developments in the crypto-asset market have not experienced declines in market cap more than can be expected due to the BTC price declines (Figure 1.7), meaning, there is no indication that large-scale withdrawals took place.

Figure 1.6. Fund Flows to BITO ETF

Cumulative flow in millions USD between 01 December 2021 and 30 September 2022



Source: etfdb.com.

Figure 1.7. Change in market cap of crypto-related ETFs versus the price of BTC

Change in % starting from 01 December 2021 until 30 September 2022



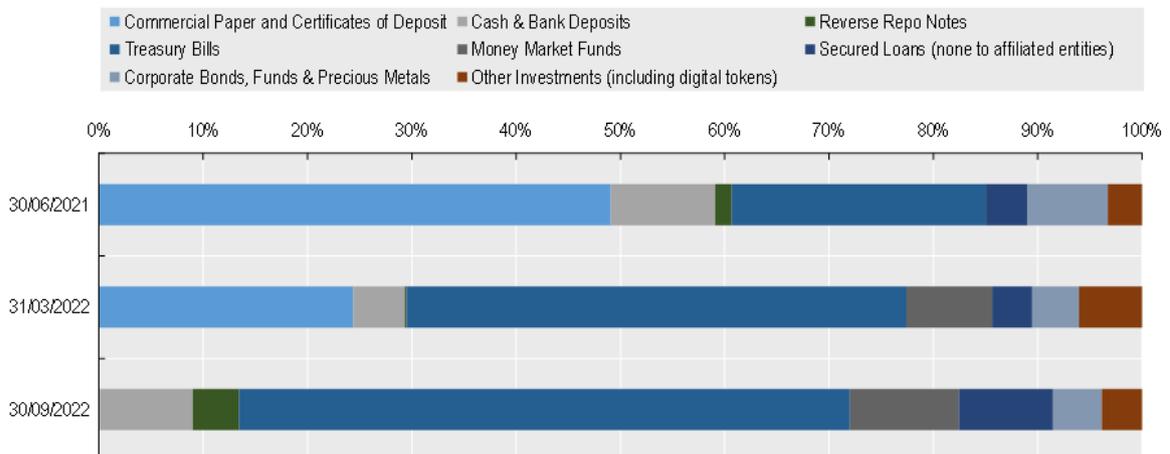
Source: Refinitiv and OECD calculations.

1.2.3. Possible impact of stablecoin spillovers into commercial paper markets

The rise in interest rates has allowed the issuers of stablecoins backed by reserve assets to reportedly reallocate their reserves to government bonds, replacing riskier assets, without having to cut return on assets as much as would have been the case under previous interest rates environment. Tether, the issuer of the largest stablecoin USDT, reported that it was gradually decreasing its holdings of commercial paper (CP) (US and non-US CP) and at the same time increasing its holdings of US Treasury bills and money market funds (MMFs) (Figure 1.8). As of September 2022, Tether reported that it was holding about USD 40 billion in Treasury bills and an additional USD 7 billion in MMFs. Tether’s holding of CP declined from USD 30 billion in June 2021 to USD 50 million in September 2022. Importantly, the Treasury market is much deeper than the estimated global CP market and is therefore less prone to liquidity squeezes.

Figure 1.8. Tether assets breakdown

As reported by Tether



Source: Tether assurance opinions: <https://tether.to/en/transparency/#reports>; (BDO, 2022^[8]).

1.3. DeFi liquidations

During the 2022 downturn in crypto assets, there were no reports of DeFi protocols collapsing and repayment of loans in lending platforms continued (Kaiko, 2022^[9]). However, occasionally, the fear of a crash has prompted actions in DeFi lending protocols that stand in contrast to the idea of decentralisation and automation and highlight existing centralisation in governance in self-proclaimed DeFi structures that are 'Decentralised in Name Only' ('DINO'). In fact, currently the vast majority (if not all) DeFi protocols are DINO. Such was the case in the (eventually unsuccessful) attempt of token holders of the Solend protocol to take over a large account that was facing liquidation. In another incident, MakerDAO, an app that supports stablecoin DAI, suspended the token from being deposited in Aave's crypto lending platform against another asset called stETH due to the latter's illiquidity (Bloomberg, 2022^[2]). The proper functioning of DeFi lending protocols relies on the ability to smoothly carry out liquidations when asset prices decline, and liquidations are automatically triggered. A simultaneous and severe decline in crypto-asset prices as occurred in May/June 2022 can result in congestion of transactions on a specific platform and in additional downward pressure on asset prices due to protocols trying to execute many liquidations simultaneously, leading to more liquidations. Therefore, maintaining sufficient liquidity is imperative.

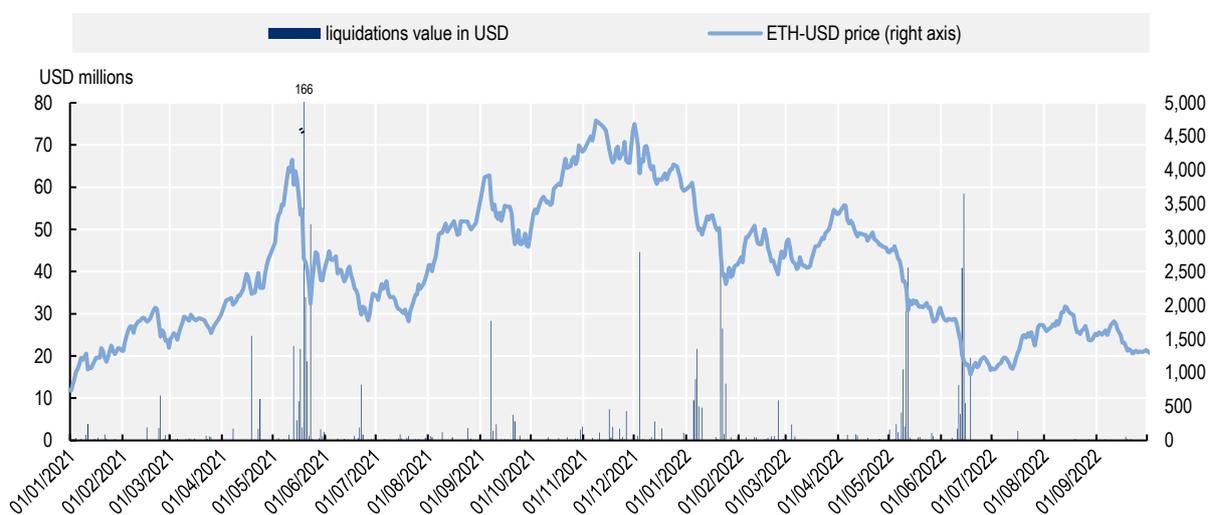
Indicatively, and based on available on-chain data, this note analyses liquidations on the Aave V2 lending pool by way of an example (based on on-chain data provided by Kaiko). Aave is a decentralised lending protocol that allows users to lend or borrow crypto-assets and has been one of the top ten DeFi protocols in terms of TVL since the early stages of development of this market. As of 30 September 2022, TVL in all Aave's liquidity pools amounted to c. USD 5.5 billion.³ Liquidation data concerning Aave's V2 liquidity pools show that c. USD 450 million value of crypto assets have been liquidated in the period 1 January 2022 – 30 September 2022, with c. USD 300 million worth of liquidations of ETH and additional USD 80 million worth of liquidations of BTC. Rest of liquidated collateral was of various other crypto-assets (see Figure 1.9).⁴ The peaks in liquidations tended to coincide with incidents of large downward price movements.

³ Includes all Aave versions across seven chains including Ethereum, Avalanche, Optimism, Polygon, Arbitrum, Fantom, Harmony.

⁴ Liquidations data was provided by Kaiko.

Figure 1.9. Liquidations in AAVE lending pools

Liquidations for collateral pledged in different crypto assets in AAVE V2 pool, in million USD



Source: OECD calculations, based on on-chain data by Kaiko.

Although liquidation mechanisms of lending DeFi protocols performed as intended, research suggests an inherent fragility of such liquidations mechanisms. Empirical evidence points to a lasting price impact of trades on exchanges carried out by arbitrageurs acting to repay DeFi loans under liquidation in return for the collateral (Lehar and Parlour, 2022^[10]). The price impact is registered not only on the exchange where the arbitrageur trades but spreads to other exchanges as well. Because prices across various decentralised exchanges are aggregated and used in return to determine the collateralisation value of other loans, this price impact may lead to more liquidations. In DeFi, the price impact is related to liquidators having financial incentive to maximise the number of positions that they liquidate. In addition, price arbitrageurs in decentralised exchanges might also be the liquidators of collateral, making their incentives to restore prices to their “true” value unclear (Lehar and Parlour, 2022^[10]). It should be noted that although the current liquidation of collateral mechanism has enabled DeFi platforms to withstand crypto-asset price volatility, it could be contributing to volatility spikes in the market, exacerbating market stress. Further analysis needs to be undertaken to test the effect that liquidations have had on market volatility.

2 Major crypto-asset failures in 2022

The onset of the “crypto winter” led to the failure of Terra’s dominant stablecoin UST, which created contagion and had a domino effect in the broader crypto-asset market leading to the failure and bankruptcy of other crypto-asset firms. This section discusses important factors that contributed to, and intensified these failures, focusing on the Terra UST implosion, Celsius Network bankruptcy and contagion to the wider crypto-asset ecosystem.

2.1. The Terra UST implosion

The rise and fall of TerraUSD (UST) in a short time span is a useful case study exposing the risks involved in so-called stablecoin arrangements, and which extend to other crypto-assets and could possibly spill-over to traditional markets, too. UST issuance grew exponentially from inception in 2020, capturing 2% of the total stablecoin market in May 2021 and representing the third largest stablecoin with a 10% market share in May 2022 with an USD 18 billion issuance volume. Ironically, the growth of UST was seen as beneficial to the broader market for so-called stablecoin arrangements, as it decreased concentration (the top four stablecoins accounted for 90% of total stablecoin supply of USD 180 billion as of February 2022).

On 7 May 2022, UST broke its peg and experienced a run that resulted in significant losses for holders, becoming a valueless stablecoin in less than a week despite many reported attempts by the Terra-connected Luna Foundation Council to defend the peg. The price of LUNA dropped to USD 0.1 from USD 31.0 in the course of that week, with a corresponding USD 41 billion loss of market value compared to early April when the crypto-asset was trading at around USD 110. The collapse of UST reportedly was triggered by two large trades that resulted in the de-pegging of UST (Chainalysis, 2022^[11]). Although initially UST re-pegged due to USD 2 billion UST purchases by Terralabs, the sell-off continued given a loss of market confidence in the UST and LUNA crypto-assets, resulting in massive deposit withdrawals from the associated Anchor protocol, heavy redemptions of UST, and in the total loss of any presumed value for both tokens.

Box 2.1. The arbitrage mechanism underlying Terra USD (UST)

Stablecoins backed by fiat currencies or similar liquid reserves are in theory fully collateralised, although in practice the composition and riskiness of the collateral is unclear. Algorithmic stablecoins are by design under-collateralised and aim to maintain their peg by providing arbitrage incentives to users. While all types of stablecoins could be prone to runs due to the nature of their collaterals, algorithmic stablecoins appear to be particularly fragile (Adams and Ibert, 2022^[12]) especially during market downturns.

UST was an algorithmic stablecoin based on a stabilising mechanism involving the creation (“minting”) and destruction (“burning”) of the LUNA crypto-asset. Both UST and LUNA are crypto-assets native to the Terra blockchain. The issuer of UST promised that any UST is redeemable for USD 1 worth of LUNA at all times.

Theoretically, when UST traded below its peg, users could burn UST and mint USD 1 worth of LUNA, making a return equal to the difference. The destruction of UST would then push the price of UST upwards as supply would decrease.

Equally, when the price of UST exceeded the USD 1, users could burn LUNA in exchange for newly minted UST, profiting from the difference. The arbitrage opportunities arising from any de-pegging of UST for users who could trade it for and against USD 1 worth of LUNA is what maintained the peg until its failure.

Figure 2.1. The ill-conceived UST design was discussed by Terra before its implosion



Source: Twitter.

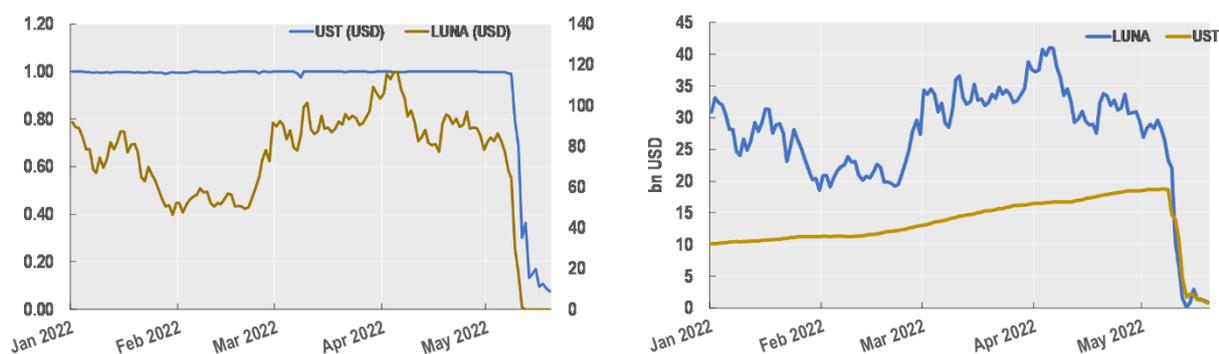
The initial success of UST was built to a large extent on users’ trust that they could exchange 1 UST for USD 1 worth of LUNA at any time. Nevertheless, the reflexive nature of UST and the risk of a run, which materialised in May 2022, was mentioned by the founders even before the de-peg and the subsequent implosion of UST (Terra Powered by LUNA, 2022^[13]). This was described as possible imbalances in demand and supply forces that would outstrip value from both Terra native tokens.

The broad discussion about UST’s design flaws did not prevent massive inflows of funds and crypto-assets in the Terra products, and the complete loss of c USD 40 billion of investor funds, including those of many retail participants (FT, 2022^[4]).

The Terra UST example highlights the urgent need to address the specific risks arising from so-called stablecoins, particularly given their instrumental place within the crypto-asset markets and their role as one of the main bridges that link the crypto-asset ecosystem with traditional financial markets (OECD, 2022^[7]). The EU’s proposed Markets in Crypto Assets (MiCA) framework, prohibits an algorithmic stablecoin which is not fully collateralised by suitable reserve assets; such a coin would fall under the general crypto-asset category but not be able to claim to be stable (Council of the European Union, 2022^[14]).

Many factors may have contributed to the recent UST collapse. These include possible faults in the design model backing the algorithmic stablecoin, speculation about possible attempts of crypto-asset whales to manipulate the market (Kaiko, 2022^[15]), oracles reported to have failed to update the price (see Section 3.3) and a sharp loss of confidence in the stablecoin (ESMA, 2022^[16]; Nassr, 2022^[17]). The outcome is a loss of investment for the average small UST holder, without any recourse for compensation.

Figure 2.2. Luna and UST price (LHS), Luna and UST Market Value (RHS)



Source: messari.io, Nassr (2022^[17]), Not-so-stable coins: a double-edged sword for decentralised finance and the key bridge linking DeFi to TradFi, <https://oecdonthellevel.com/2022/05/30/not-so-stable-coins-a-double-edged-sword-for-decentralised-finance-and-the-key-bridge-linking-defi-to-tradfi/>.

UST's design was ill-conceived in many ways, and one of the most obvious design flaws was the circularity and reflexive nature of this stabilisation mechanism. USTs were effectively collateralised by LUNA and LUNA had no value of its own and derived any possible value from the promise of conversion of UST for LUNA and vice versa. The claim that it was a stablecoin pegged to the USD can be described by a lengthy path of a crypto-asset (UST) created without any identifiable source of value, and whose price was based on another crypto-asset (LUNA) that had no use other than to stabilise the UST. The latter was, in turn, priced in ETH, which is priced in USD.

The growth of UST was driven to a large extent by the unsustainable high yields offered by protocols connected to UST holders, and which was subsidised by the founding entity Terralabs in order to create demand for LUNA. The UST yield reserve held by Terralabs was created to ensure pay-outs were possible when inflows were lower than outflows. Terra's Anchor protocol, a "decentralised money market" purported to offer 19.46% annual yield for lending of UST, with the interest paid also in UST.⁵ In 2021, under 20% of circulating UST was deposited in the Anchor protocol, but towards the end of the stablecoin's life, more than 50% of UST was lent on Anchor (Kaiko, 2022^[15]).

The main use case of UST was to generate returns on the Anchor protocol, which in turn was sustained only through the spending of the Terralabs yield reserves. These were reserves of UST intended to ensure pay-outs to depositors when incoming cash flow was less than outgoing cash flow. The 'real yield' generated by Anchor was estimated at 5.81% in April 2022, with the shortfall covered by said reserve (Greythorn Research, 2022^[18]). Anchor's viability depended on the sustainability of the reserves which were used to pay out the extra yield provided to borrowers. As such, the Terra founding team kept

⁵ Following a governance proposal that passed on 24 March 2021, Anchor decided to implement a more sustainable semi-dynamic earn rate. Under the new system, the earn rate will adjust monthly by a maximum of 1.5% when the yield reserve appreciates or depreciates by 5% or greater. Therefore, if the yield reserve decreases by at least 5% a month, the deposit rate will drop to 18%, then 16.5%, 15%, until the yield reserve stabilises (Greythorn Research, 2022^[18]).

subsidising demand for their two native tokens, UST and LUNA, and the design of the UST arrangement was unsustainable from scratch.

Some observers have compared Anchor to MMFs, where participants can lend and borrow from each other via well-collateralised short-term loans. The issuers of MMFs pool deposits and lend in the money market (among other similar investments), and Anchor shares some similarities with such structures in theory (Wong R., 2022^[19]).

Anchor's unsustainable economic model were discussed at the Anchor community forum as early as in 2021; the steady depletion rate of the yield reserve threatened the UST model (Anchor Protocol Community Forum, 2021^[20]). However, despite the upfront realisation of the flaws of UST's design and unsustainable nature of the Anchor protocol, the opportunity for excessive yield and leverage lured in users. This highlights that, as the OECD has found in earlier reports, the single most important driver of activity in the markets for crypto-assets is currently speculation (OECD, 2022^[7]).

The underlying mechanics of some crypto-asset ventures relied on the creation of a critical mass of people participating in the project to keep it alive. For example, in the case of UST – LUNA, the value of LUNA depended on securing a sufficient mass of people believing that Luna is valuable, in order to maintain the UST peg. The founders, through the Anchor protocol, subsidised users willing to lend this crypto-asset to drive demand for UST and LUNA until enough people trusted its value without subsidisation.

2.1.1. Contagion to USDT and other crypto-assets

Following the UST collapse, the stress was transmitted to other major crypto-assets and most importantly to Tether's USDT stablecoin which subsequently de-pegged. On 12 May, Tether traded at USD 0.95 to the dollar and the stablecoin suffered USD 7 billion of redemptions (Tether is allegedly backed by real-asset reserves, in contrast to algorithmic stablecoin UST). In fact, Tether de-pegged more than once before the Terra implosion. In future, such fire sales could disrupt critical funding markets with potential impact on financial stability overall (FSOC, 2021^[21]) especially given that traditional financial institutions may hold assets of stablecoins' reserves (IOSCO, 2022^[22]).

Although the price of Tether's stablecoin quickly recovered peg, the incident highlighted the important risk of contagion to traditional financial markets. First, the vulnerabilities related to stablecoin arrangements have the potential to affect the stability of broader short-term credit markets.⁶ The massive redemptions that Tether experienced in May did not have a visible effect on CP markets, although it is difficult to observe and quantify the impact given the size of the broader short-term credit markets and the lack of transparency and reliability of Tethers' reserves.

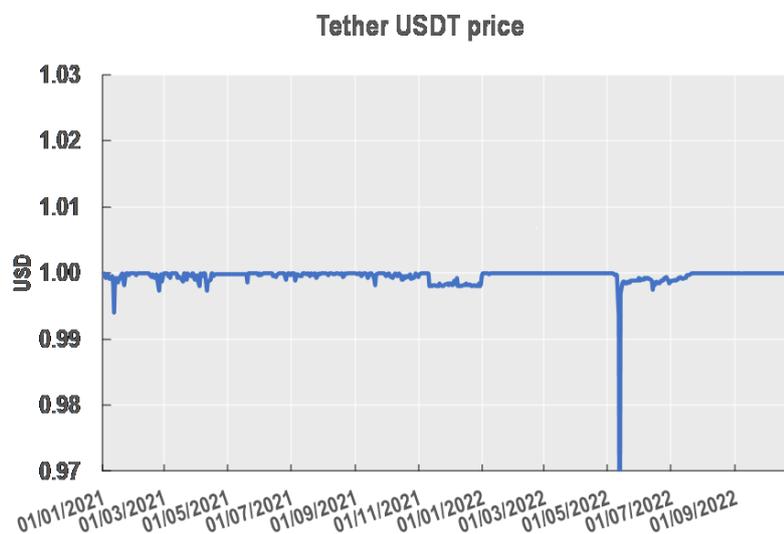
In addition to the concentration of stablecoin issuers, concentration is also observed in the holders of major stablecoins such as Tether. Large crypto-trading firms acting as market-makers seem to have correspondingly very significant holdings of such crypto-assets, which could give rise to market domination and other distortive effects in the wider crypto-asset markets (Figure 3.1). Such concentration among holders of Tether intensifies the interconnectedness of the crypto-asset ecosystem and may be one of the reasons driving previous 'bail-out' efforts by dominant players. Concentration on the issuers' side could lead to excessive concentration of power to the detriment of market competition and with potential anti-competitive effects, especially in the absence of interoperability (FSOC, 2021^[21]). Other previously discussed vulnerabilities of stablecoins like Tether give rise to investor protection and market integrity risks,

⁶ Until recently, major so-called stablecoins reported to have significant holdings of commercial paper as part of their reserves (e.g., Tether). Possible vulnerabilities arise if and when such reserve holdings are much larger relative to short term credit markets and there are no regulations on reserve asset quality. It should be noted, however, that in November 2022, Tether reported a sharp reduction in its reserves holdings of commercial paper (Tether, 2022^[61]).

prudential concerns related to the potential for runs, payment system risks and the possibility to rapidly scale (PWG, FDIC and OCC, 2021^[23]) as well as potential concerns under securities laws (OECD, 2022^[7]).

Figure 2.3. Tether USDT losing its peg

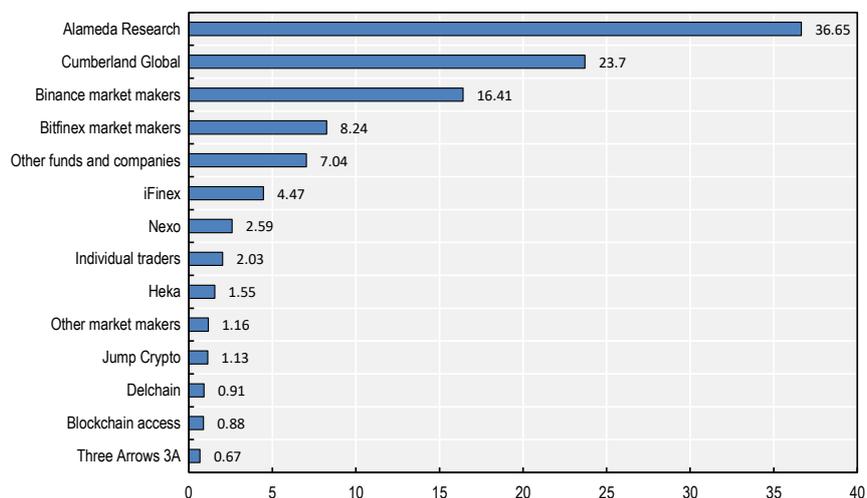
In USD, lows as of 24 October 2022



Source: OECD, coinmarketcap, based on 24hr low on a daily basis.

Figure 2.4. Tether USDT holders prior to the FTX collapse

As of November 2021, USD billion



Source: Protos (2021^[24]), Tether Papers: This is exactly who acquired 70% of all USDT ever issued, <https://protos.com/tether-papers-crypto-stablecoin-usdt-investigation-analysis/>; Protos (2021^[25]), Tether minted most USDT to just 2 firms — Alameda and Cumberland, <https://protos.com/tether-minted-usdt-stablecoin-crypto-two-alameda-cumberland/>.

Vulnerabilities in so-called stablecoin arrangements also have spill-over effects within the crypto-asset market ecosystem. The UST implosion highlighted the important role of trust and confidence in the market

for crypto-assets, similar to the importance it has in traditional financial markets and how confidence effects can affect the crypto-asset ecosystem (Nassr, 2022^[17]). This was particularly critical amid the broader market sell-off of mainstream crypto-assets and has intensified the risk-off sentiment of traditional and specialised investors with investments in crypto-asset markets.

Over and above negative sentiment following the UST collapse, BTC may have also received downward pressure given the large amounts of BTC that have been converted into UST by Terra founders, to support UST's peg, and the limited liquidity of crypto-asset markets. BTC dropped from USD 35 857 on 7 May to USD 25 500 on 12 May. The Luna Foundation Guard⁷ purchased 80 394 BTC (worth circa USD 3.5 billion) to support UST between January and May 2022. An additional USD 500 million worth of BTC was purchased via Three Arrows Capital (3AC) after the de-peg in an effort to re-stabilise UST by converting BTC into UST. Importantly, over the course of the days following the de-peg, the BTC addresses holding the Foundation's reserves were emptied.

2.1.2. DEX – CEX Information asymmetries, oracle failures and other flaws of decentralised finance observed in the UST failure

The Terra UST failure provided evidence of potential fragmentation between decentralised exchanges (DEXs) and centralised exchanges (CEXs) (Melachrinou, 2022^[26]). In the Terra failure, UST holders that traded on CEXs reacted one-two days after UST holders trading on DEXs, and after the price had already de-pegged to USD 0.8, therefore suffering greater losses. DEX data may have provided clearer warning signals that led UST holders trading in decentralised pools to react earlier.

In particular, the UST sell-off on decentralised exchange Curve UST/3CRV meta liquidity pool started on 7 May, when traders performed a USD 85 million arbitrage transaction to benefit from a price discrepancy between UST and other USD-denominated stablecoins, followed by other similar swaps which led to a broader UST sell-off. This, in turn, led to an increase in UST's share in the liquidity pool and an imbalance that was later reflected in UST's trading price (Melachrinou, 2022^[26]).

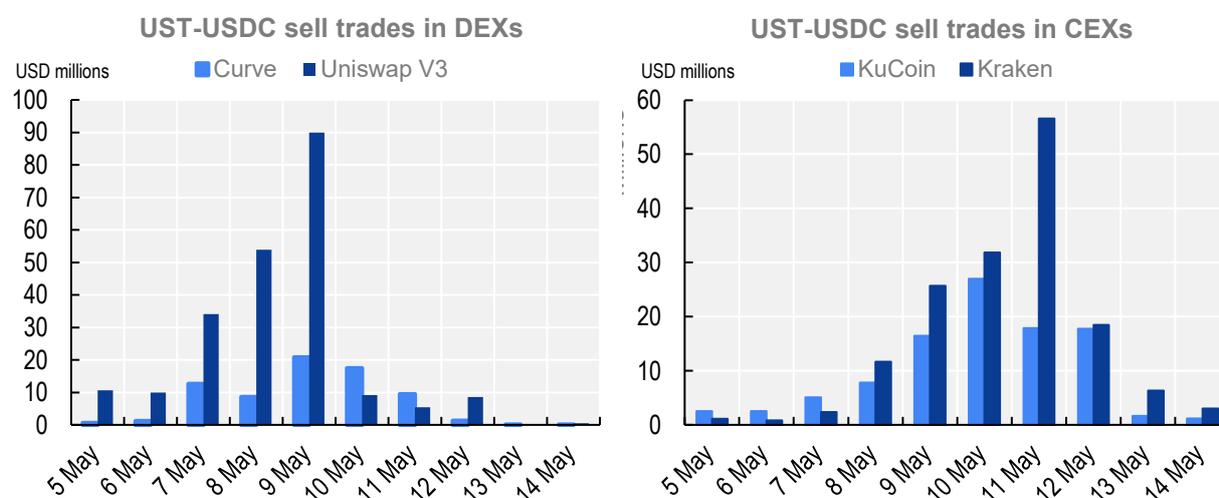
The above example underlines potential market inefficiencies in markets for crypto-assets and the possibility of information asymmetries arising in the wider decentralised finance ecosystem. In the case of UST, it appears that users trading on DEXs had a clear advantage over those trading on CEXs and the time-lag difference in the reaction of the centralised trading venues for crypto-assets led to a relative concentration of losses among participants trading solely on CEXs (Melachrinou, 2022^[26]).

Mal-functioning oracles⁸ are another of DeFi's flaws exposed during the UST failure. The Chainlink oracle, which was feeding LUNA's price on chain, with the price feeds used to value LUNA collateral pledged on DeFi platforms, hardcoded the price of LUNA at USD 0.10 and stopped updating LUNA's price when the Terra ecosystem was suspended. The price of LUNA dropped below the hardcoded USD 0.10 to USD 0.01 and eventually to zero, but this was not reflected on platforms such as Blizz Finance. As such, people who noticed the flaw were able to buy large amounts of LUNA at the market price (USD 0.01), post it as collateral and borrow funds from Blizz at a value of USD 0.10. The Mirror Protocol suffered similar market abuse due to an oracle bug.

⁷ Allegedly a non-for-profit organisation formed to support the growth of the Terra ecosystem.

⁸ Oracles are automated service providers 'oracles' feeding external data into a blockchain network, in this case live price feeds on the basis of which smart contracts are triggered (or not) (OECD, 2020^[62]).

Figure 2.5. Information asymmetries between CEXs and DEXs evidenced by time lag in market reaction



Source: Kaiko.

Weaknesses were also exposed in the use of Proof-of-Stake (PoS) as the consensus mechanism for transaction validation in times of stress. When the price of the crypto-asset staked by validators dropped significantly, the required amount of crypto-asset needed for validators dropped, too, allowing for governance attacks at a low cost. In the Terra example, when the price of LUNA started collapsing, the value of validators' staked LUNA fell to almost zero, which meant malign actors could have acquired a large amount of LUNA at almost no cost and possibly take control of the blockchain (Wong R., 2022^[19]). Terra halted its blockchain in order to reduce the risk of such attack, and the halt further pressured its peg mechanism (Wong R., 2022^[19]).

2.2. Celsius Network

Celsius was a self-proclaimed crypto-asset lending platform, allowing users to borrow USD against their crypto-asset holdings which were used as collateral, or lend their crypto-assets to the platform and earn up to 17% APY on their deposited crypto-assets (Celsius, 2018^[27]). Interest was paid in the platform's reward Celsius token (CEL). Celsius was also active in crypto-asset mining and was also involved in proprietary 'discretionary' trading of digital assets, as well as in DeFi lending protocols⁹ (Celsius, 2018^[27]), likely involving customers' crypto-assets. It also offered custody services. By July 2022, the company claimed 1.7 million registered users and circa 300 000 active users with account balances of more than USD 100, and approximately USD 6.0 billion in assets (Kirkland and Ellis LLP, 2022^[28]).

The Celsius model relied on a mechanism wherein the platform borrowed customer crypto-assets and used them as collateral to borrow against other crypto-assets in DeFi lending protocols and liquidity pools, so as to pay 17% rates to new customer deposits. Celsius may have been engaged in non-compliant

⁹ As of 27 June 2022, Celsius had approximately USD 648 m in DeFi borrows collateralised by approximately USD 1.61 bn in digital assets based on a market valuation of 27 June 2022. These DeFi loans were held on four different DeFi protocols: (i) Maker (MKR) (USD 225 m loan collateralised by USD 499 m in digital assets); (ii) AAVE (USD 263 m loan collateralised by USD 708 m in digital assets); (iii) Compound (USD 157 million loan collateralised by USD 409 m in digital assets); and (iv) Notional Finance (USD 3.2 m loan collateralised by USD 6.6 million in digital assets). As of the Petition Date, substantially all of these DeFi loans were repaid by the Company and the collateral was returned.

provision of financial services with minimal risk management in place and in non-compliance with regulations. Crypto-asset lending products offered by Celsius have characteristics of investment contracts in some jurisdictions, and could therefore be defined as securities (Office of the Attorney General, 2021^[29]) (Texas State Securities Board, 2021^[30]). The potentially non-compliant provision of regulated financial activity deprived users of traditional safeguards for investor and financial consumer protection, such as registration and associated disclosures by security issuers.

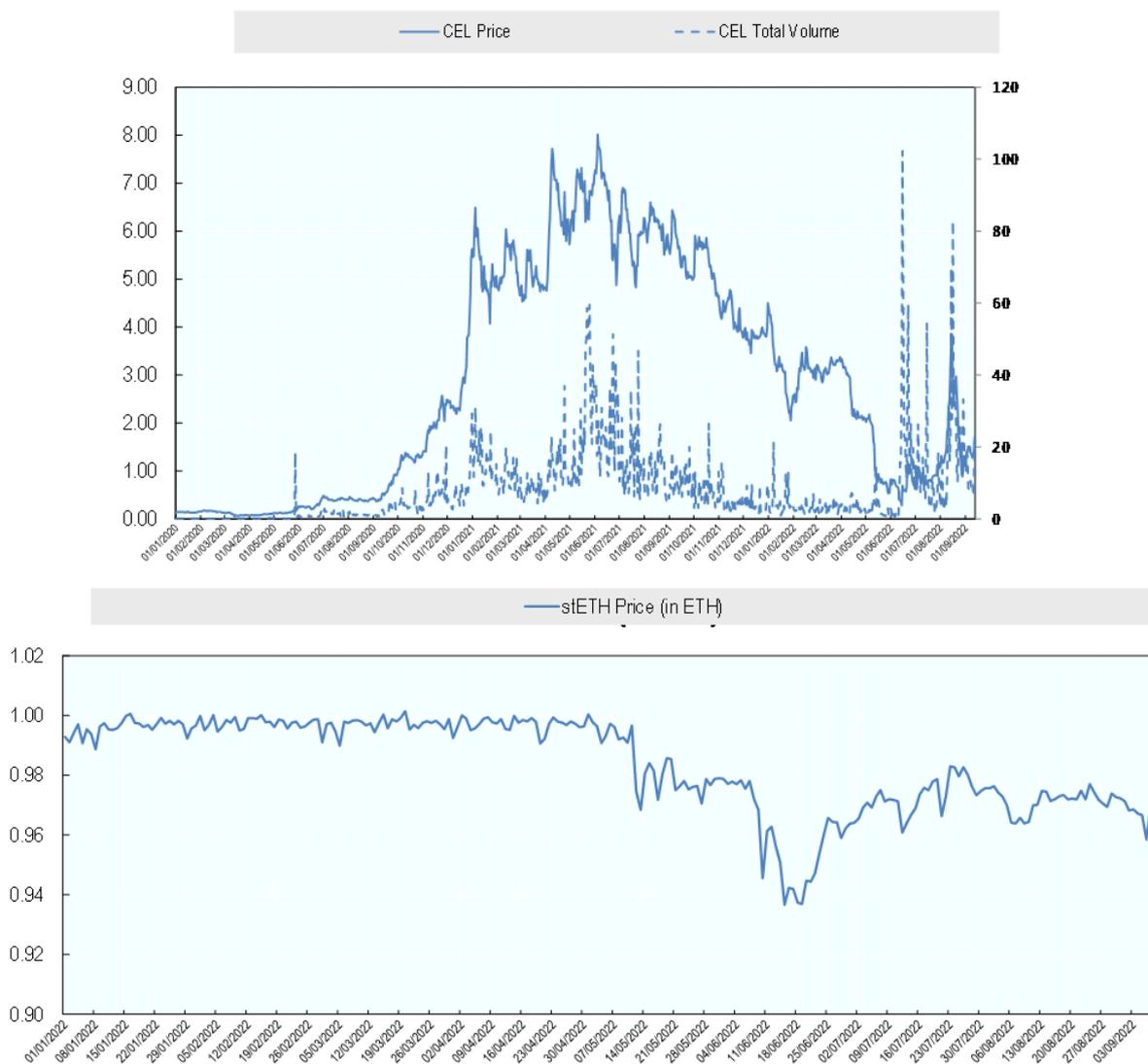
The intensification of the crypto-asset downturn following the UST implosion in H1 2022 was naturally reflected in the value of Celsius crypto-asset collateral: USD 12 billion of assets as of 17 May compared to USD 24 billion in late December 2021. Celsius suffered a classic run with USD 750 million of outflows between 6 May and 14 May, concurrently with the UST failure, and total net outflows of USD 1.1 billion between 1 March and 20 May 2022 (FT, 2022^[31]). The price of the native token CEL dropped from USD 8 in June 2021 to USD 0.80 a year later, although similar to most crypto-assets it did not have any underlying value that would justify a positive valuation (Figure 2.6)). Celsius became effectively insolvent and stopped its client withdrawals on 13 June, and subsequently filed for Chapter 11 bankruptcy relief (Celsius, 2022^[32]).

Celsius had UST deployed on Terra and was one of the large crypto-asset players who managed to withdraw deployed UST and funds at the early stages of the UST implosion, therefore suffering only a relatively minor loss of USD 15.8 million on all activity related to Luna or UST (Kirkland and Ellis LLP, 2022^[28]). The withdrawal of the activity (estimated at USD 500m) by Celsius intensified the UST run and accelerated its failure (TheBlock, 2022^[33]). This was an example of so-called ‘whales’ exiting Terra almost unscathed in the midst of the UST collapse, while retail investors may have suffered a significant loss of their investment.

Celsius’ shareholders included Tether, the issuer of USDT stablecoin (Crunchbase, 2022^[34]). In addition to this shareholding relationship between Celsius and Tether, the two entities had credit arrangements involving crypto-assets: Celsius was allowed to borrow USDT directly from Tether under a 130% over-collateralised facility by pledging BTC as collateral. Such transactions are recorded by Tether as secured lending in their reported reserves (accounting for 9.02% of USDT reserves as of 30 September 2022) (Tether, 2022^[35]; 2022^[36]). However, this is effectively a circular transaction, whereby Tether issues USDT on the basis of collateral securing USDT loans to other entities. This amounts to the issuance of USDT through the unregulated expansion of credit.

The Celsius USDT loan was liquidated shortly after the UST implosion, because the level of over-collateralisation was not sufficient to cover for the drop in the value of BTC. Once the loan was covered, Tether returned the remaining part to Celsius as per its agreement. Celsius’ position was liquidated with no losses to Tether (Tether, 2022^[37]).

Figure 2.6. CEL price performance (LHS) and stETH de-pegging (stETH to ETH)



Source: CoinGecko.

Celsius was also actively involved in leveraged ETH staking in exchange for passive interest backed by locked ETH. The platform was borrowing ETH and locking it for staking in the new version of the Ethereum 2.0 blockchain that is based on Proof-of-Stake and where consensus is now reached through validation by nodes holding ETH.¹⁰ Staking involved the locking of ETH until (i) the so-called ‘Merge’ was effected and Ethereum transitioned to a PoS consensus mechanism, and (ii) the future Ethereum ‘Shanghai’ upgrade enables the “unstaking” of ETH (Ethereum.org, 2022^[38]; Github, 2022^[39]). Prior to the Merge, Celsius was involved in what is called as “Liquid staking” for the ETH it staked, by using a crypto-asset

¹⁰ On 15 September Ethereum performed a software update, known as the Merge, where it altered its’ proofing mechanism of transactions from the high energy consuming mechanism of proof-of-work to the less energy consuming proof-of-stake. It is worth noting that the upgrade went on smoothly with no spikes in volatility in the spot markets. Proof-of-stake can be performed by validators who have stacked a minimum of 32 ETH (staking can also be performed through intermediaries for smaller holdings). Such participation is rewarded.

service provider (e.g. Lido) that transformed staked (locked) ETH to liquid ETH by issuing a derivative on the back of the locked staked ETH.¹¹ Instead of resolving the illiquidity of staked ETH, Celsius created a liquidity mismatch between the borrowed ETH, which was subject to margin calls, and the stETH. stETH could then be pledged to DeFi lending protocols, further interlinking the different parts, and major players, of the crypto-asset ecosystem. Indeed, Celsius had pledged USD 400m of stETH on Aave DeFi lending protocol (FT, 2022^[40])

Delays in the ‘Merge’, coupled with the downturn and the increased need of crypto-asset investors for liquidity to cover for margin calls, led to increased demand for selling stETH for ETH.¹² This, in turn, led to massive imbalances of the secondary market DeFi automated market-maker pools hosting stETH (such as Curve) with ETH liquidity scarce given significant supply of stETH for sale (against ETH). Subsequently, stETH’s de-pegged from its 1:1 ratio with ETH in mid-May (2-3% price gap) and the gap widened in June (5-6%). Massive sales of stETH by Alameda Research,¹³ a crypto-asset trading company owned by FTX’s founder, intensified the pressure on stETH and widened its de-pegging. Following that, users of large crypto-lenders such as Celsius sought to withdraw ETH from the platform, and Celsius was forced to sell its own stETH to meet the demand for ETH. This activity further exacerbated pressure on stETH as Celsius held a large percent of stETH overall market supply.¹⁴

2.3. The wider crypto-asset dominos: Three Arrows Capital, Voyager Digital, BlockFi

Crypto-asset market instability spread to many other crypto-asset market participants and created a domino effect with immediate impact on several sizeable crypto-asset market participants that subsequently failed. These include Hong Kong China-based Babel crypto-lender and crypto-exchange Hoo which also paused customer withdrawals; Voyager Digital; Vault; and BlockFi, among others. Some of these companies filed for bankruptcy protection, others paused operations, limited withdrawals or sought bailouts by other crypto-asset market participants.

Singapore-based crypto-asset hedge fund Three Arrows Capital (3AC) incurred losses from its LUNA positions and announced liquidity issues a few weeks after the UST implosion. It commenced liquidation proceedings on 27 June (Coindesk, 2022^[41]). Celsius had extended two loans totalling USD 75 million to 3AC and was left with a USD 40 million claim against 3AC following liquidation of collateral pledged by 3AC. Other failing crypto-asset companies had even greater claims (e.g., Voyager, BlockFi). The collapse of 3AC therefore had a direct impact on Celsius and Voyager, with the latter having lent 3AC 15 250 BTC and USDC 350 million worth of USDC. 3AC’s inability to repay its loans to Voyager contributed to Voyager filing for bankruptcy in July 2022 (Voyager, 2022^[42]).

Interestingly, some major crypto-asset market participants made acquisition offers to some of the failing companies, or extended bailout loans, increasing consolidation and concentration in this market. Crypto-asset players extending credit lines (akin to lenders of last resort) or making acquisition offers had an economic interest in the acquisition of assets at huge discounts, while also needing the crypto-asset ecosystem to survive for their benefit. For example, crypto-asset lender BlockFi agreed to a rescue deal by the FTX crypto-asset platform on 1 July that valued the lender at USD 240 million, a very low price

¹¹ Lido describes liquid staking those protocols that allow users to earn staking rewards without locking assets or maintaining staking infrastructure. For more see <https://stake.lido.fi/>

¹² Redemptions by lido will be enabled only when “unstaking” is enabled (Lido, 2022^[58]).

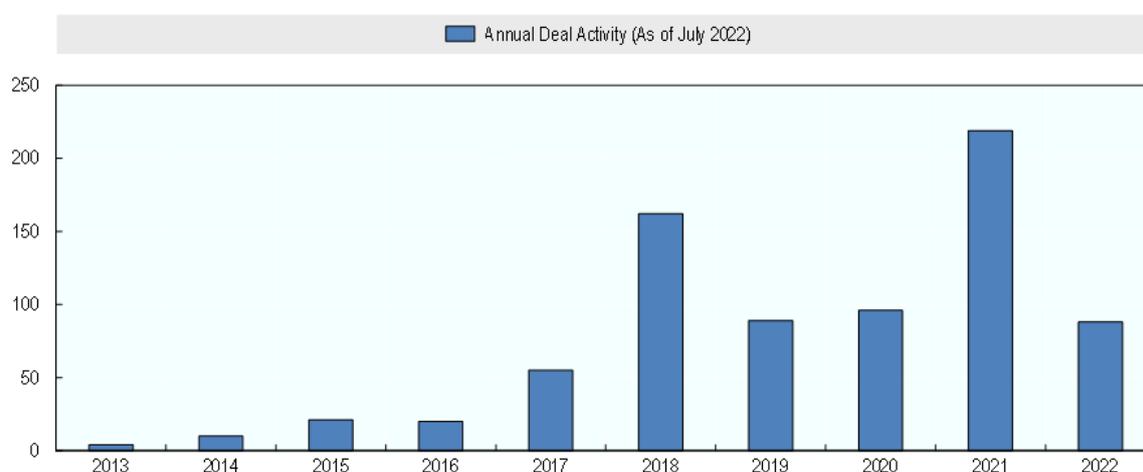
¹³ Market sources report 50 000 stETH sold on 9 June by addresses linked to Alameda Research.

¹⁴ Market sources report Celsius having staked 8 000 of stETH on Aave DeFi lending protocol, corresponding to 10% of the total supply.

compared to the earlier valuation of the company at USD 4 billion (FT, 2022^[43]). FTX earmarked USD 1 billion for acquisitions of failing players and associated rescue efforts (Bloomberg, 2022^[44]). Similar consolidation was observed in the last cycle of the crypto-asset market in 2018 (Figure 2.7). At the same time, increasing concentration risks may accelerate and intensify domino effects in future downturns. Such risks are important given the possible financial stability considerations involved if the market for crypto-assets becomes larger than it was at its November 2021 peak, and noting the growing possibility of interconnectedness, and spillovers, between DeFi and the traditional financial system (OECD, 2022^[7]).

The domino effect that was triggered by the UST failure against the background of a prolonged “crypto winter” in H1 2022 had a catastrophic impact on retail crypto-asset market participants, some of whom suffered total loss of investment without any recourse. Retail investor losses are perhaps even more concerning when considering that certain crypto-asset whales or dominant market participants managed to exit failing platforms with limited losses or unscathed.

Figure 2.7. Crypto-asset mergers and acquisitions: 2022 and 2021



Source: Tokendata.io.

2.4. The FTX bankruptcy

FTX.com (“FTX”), the fourth largest crypto-asset trading firm prior to its collapse, and numerous affiliated firms filed for bankruptcy on 11 November 2022, following reports by crypto-asset industry media about the solvency of its associated entity Alameda Research (Coindesk, 2022^[45]).¹⁵ According to media reports, FTX’s native crypto-asset FTT comprised a significant portion of Alameda’s balance sheet. Of the USD 14.6 billion alleged worth of the total assets on Alameda’s balance sheet, FTT made up USD 5.8 billion. FTT was used by FTX’s clients as the platform’s currency for trading on FTX, and its price was supported by FTX through weekly buybacks. According to industry reports, the FTT held by Alameda was in turn pledged as collateral to FTX against further lending. This suggested a much closer funding relationship between FTX and Alameda than the market had understood and also suggested that the solvency of both FTX and Alameda was dependent on the value of FTX’s native token.

Following the revelations, Binance announced it was selling its FTT holdings, which triggered a sharp sell-off of FTT in the market. The subsequent sharp decline in the price of FTT translated into losses on the

¹⁵ This section was added to the report post its deliberation at the October Committee meetings (see Footnote 1).

balance sheets of FTX and Alameda and led to their respective bankruptcies. The collapse of FTX triggered a further sell-off in broader crypto-asset markets.

One significant contributing factor in FTX's inability to meet redemption requests, which came to light following the bankruptcy filing, was that it had loaned certain customer assets to Alameda to help meet its liabilities, taking FTT as collateral. More fundamentally, there were an array of governance failures at FTX – including mishandling of customer funds, failure to conduct transactions with an affiliate at arms-length, and deficient record keeping and accounting.

Based on reporting, FTX's collapse appears to confirm the lessons from other recent crypto-asset firm failures identified in this report and the concerns raised herein about profound vulnerabilities in this market. These include concentration risk, leverage, interconnectedness, and opacity. As of the time of publication, more information continues to emerge about FTX's collapse. It is therefore premature to examine the implications of this failure in full.

3 Findings and policy implications

The summer 2022 downturn and the numerous subsequent failures of crypto-asset firms offer various lessons about the nature of crypto-asset markets and their risks. Crypto-asset firms bring financial engineering to a new level, by deploying mechanisms composed of all the main ingredients of such practices in traditional finance (e.g., complexity, leverage) and the innovation characteristics of decentralised finance (e.g., composability of DeFi as observed in the example of liquid staking strategies) compound the risks.

This section discusses some of the learnings of the recent failures, highlighting the fact that all reported recent failures were related to CeFi (centralised players). DeFi intensified the turmoil in crypto-asset markets due to its own inherent weaknesses and the leverage it facilitated. In addition, DeFi relies on CeFi activity for its survival and/or growth. The analysis also points to the fact that the crypto-asset ecosystem is extensively interlinked, and such interconnectedness could lead to even greater and speedier domino effects in the future. Concentration in these markets is also increasing, with large players becoming even more dominant; any loss of confidence in those dominant firms could set in motion a new round of classic runs and redemptions which would result in even more failures and loss of funds for investors. The section also offers some policy considerations to address the risks of non-compliant operation of crypto-asset market firms, in particular related to consumer and investor protection.

3.1. DeFi vs. CeFi: Recent failures happened in centralised entities

The major crypto-asset firm failures in the current downturn concern CeFi with clear centralised control over the activity, governance or user assets. This has material implications for misled investors who may have been lured into such activity thinking that they participate in decentralised crypto-asset activity over which individuals do not have control. Contrary to what DeFi conceptually represents, these CeFi firms had very clear centralised control over the operation of the firm and the management of users' funds, and all decisions were made by a handful of people or a single person with direct impacts on investors – retail in particular.

The misconception that failures were DeFi-related was mainly driven by Terra UST's assertion that it was a DeFi project as well as an industry effort prior to the market disruption to benefit from the hype and exuberance around DeFi.¹⁶ Ironically, even DeFi structures themselves are not truly decentralised, as there are pockets of centralisation in almost all self-proclaimed DeFi protocols (OECD, 2022^[46]; 2022^[7]). Certain major DeFi protocols with dominant positions in this market appeared to have survived the downturn without any major failures and despite the massive decline in the price of crypto-asset collateral pledged in these platforms. Automated mechanisms in DeFi lending protocols performed their intended purpose of settling transactions without issues in H1 2022 (see Section 2.3). From the point of view of infrastructure and automated mechanisms underlying DeFi protocols, particularly when it comes to lending, these proved to work sufficiently well so as not to trigger any failure of the large DeFi protocols. At the same time, automated liquidations are expected to accelerate runs and intensify volatility spikes in markets for

¹⁶ It should be highlighted that currently the vast majority (if not all) DeFi protocols are Decentralised in Name Only ('DINO'). Terra UST was self-proclaimed as DeFi but had clear centralised characteristics and was DINO.

crypto-assets, further intensifying crises. In other words, automated liquidations could act as a pro-cyclical force that could aggravate market downturns.

Although there are indeed differences in their business models and labelling, both CeFi and DeFi currently operate in a non-compliant manner and/or outside the regulatory perimeter in an unregulated manner in many jurisdictions. Both CeFi and DeFi therefore expose their participants to material risks in the absence of any of the traditional financial regulation safeguards for consumer and investor protection and market integrity.

3.2. CeFi is currently the lifeline of DeFi and the two are heavily intertwined

CeFi is in many ways the lifeline of DeFi as the former is the primary source of funds flowing into DeFi and is the (more user-friendly) entry point for many users wishing to participate in DeFi. In practice, CeFi is perhaps the main client of DeFi, as was evidenced by the weight of crypto-lender Celsius in DeFi lending markets before its failure.

From the CeFi perspective, DeFi protocols were the preferred venue for unrestricted¹⁷ leveraged crypto-asset trading and re-hypothecation of collateral that could allow such firms to increase their returns. The opportunities for unrestricted leverage that DeFi protocols provide was the key driver for such strategies, as crypto-assets could be re-hypothecated numerous times, exacerbating the risk in times of a downturn.

The Celsius example is noteworthy in regards to its stETH strategy, because this demonstrates the level of complexity introduced in DeFi.¹⁸ This strategy is a clear example of the level of interconnectedness between CeFi – DeFi and of the crypto-asset ecosystem overall. It also highlights the level of unrestricted leverage existing in the crypto-asset ecosystem. Strategies premised on the re-hypothecation of customer assets in DeFi stopped working when the value of crypto-assets dropped, because crypto-asset lenders were unable to both meet user demand for withdrawals while also pledging additional collateral to avoid automatic liquidation by DeFi protocols. Lastly, it provides an example of the risks related to the novel characteristics of DeFi, such as composability – in this case through the creation of maturity and liquidity mismatches.

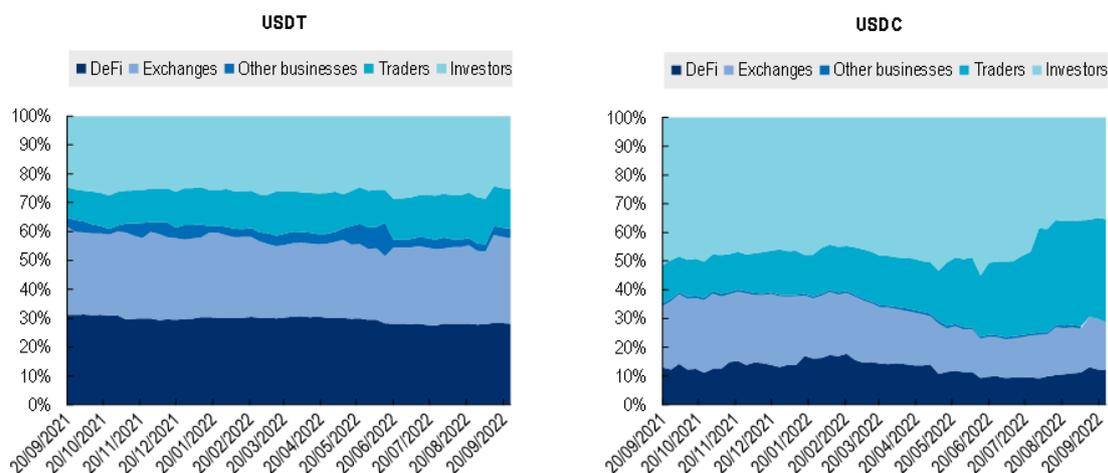
In addition to the concentration of stablecoin issuers (see Section 2.1), concentration is also observed among the holders of major stablecoins. Large crypto-asset trading firms acting as market-makers hold correspondingly large proportions of stablecoins, especially USDC, which could give rise to market domination and other perverse effects in the wider crypto-asset markets.

Certain issuers of major stablecoins were reportedly shareholders of crypto-asset firms (e.g., Tether and Celsius). As described earlier, Tether and Celsius also had an extensive commercial relationship that facilitated rapid, stablecoin-based credit creation.

¹⁷ Restricted only by the level of over-collateralisation which still gives ample space for leveraging up.

¹⁸ Celsius used borrowed ETH for staking at the Ethereum blockchain (locking the borrowed ETH so as to participate as a validator in the consensus mechanism) and in turn transformed the locked borrowed ETH into stETH derivatives. These stETH were then pledged on DeFi lending protocols to lever up even further, receiving new crypto assets backed by these stETH. Indicatively, in the period 1–13 July Celsius paid back USD 223m to Maker, USD 235m to Aave and USD 258m to Compound (Coindesk, 2022^[56]). These loans were covered by crypto-asset collateral whose value exceeded USD 700m (given over-collateralisation in all these three DeFi lending protocols).

Figure 3.1. Holding distribution of so-called stablecoins by type of entity



Source: Chainalysis.

The CeFi-DeFi ecosystem is a very heavily intertwined and concentrated market, and is becoming increasingly so after the recent downturn, which exacerbates risks. DeFi protocol activity is concentrated in the largest protocols (OECD, 2022^[46]), while CeFi seems to have large dominant players heavily interconnected among each other and with major DeFi protocols. Evidence of such interconnectedness within the crypto-asset and decentralised finance ecosystem was observed in the links between major firms during the recent “crypto winter” (Figure 3.2). Recent mergers and acquisitions and bailouts (see Section 2.3) increase the dominance of the largest players of the crypto-asset market, further increasing concentration in this market.

If traditional financial stability analysis were applied to the crypto-asset ecosystem, it might indicate that these markets have particular systemic risks within their boundaries. These are driven by high and increasing concentration risks, coupled with high interconnectedness between the different players in CeFi and between CeFi and DeFi protocols, as well as the level of complexity and the intensive use of leverage in these markets. Knowing also the importance of confidence and trust in these markets, similar to in traditional financial markets, the ecosystem on a standalone basis appears unstable. This is important to note given the possibility of growing interconnectedness between markets for crypto-assets and traditional financial markets in future (OECD, 2022^[7]).

3.4. The overall crypto-asset market can only produce positive yield when markets for crypto-assets go up

CeFi and DeFi markets work better in bull markets. For DeFi, procyclicality of lending protocols brings more lending and borrowing as the price of the collateral pledged increases (OECD, 2022^[46]). Market uptrends incentivised investors to increase leverage, while they also allowed potential crypto-asset Ponzi schemes to survive as long as the uptrend persisted. This dynamic may have been evident in Terra's Anchor protocol, which managed to earn part of the unrealistic yield it was paying out to investors just by benefiting from the positive dynamic of the crypto-asset market before the market downturn.

In the last crypto-asset cycle, investors were drawn into crypto-assets for speculation and looking for yield amid a prolonged low interest rate environment. This is no longer as strong an incentive given a rising rates environment. The dynamics between borrowers and lenders is also affected, with a smaller number of willing lenders than during the market uptrend.

The problem of unsustainable business models also affects stablecoin issuers who do not earn any margin from their activity or charge any fees. Instead, they rely on the yield of their reserves which could allow for some profits in the current environment but may fare less well under a low interest rate environment.

3.5. Policy considerations

The recent crypto-asset market turmoil exposed a new wave of financial engineering taking place in crypto-asset markets, with important repercussions for investors – particularly retail investors. Such financial engineering comprises many of the main ingredients of such practices in traditional finance (e.g., complexity, leverage) and ensuing risks. The innovative characteristics of decentralised finance (e.g., composability of DeFi) compound the risks. Innovations such as liquid staking, creating derivatives backed by illiquid locked assets, is extremely dangerous. Consecutive rounds of re-hypothecation of crypto-assets that are considered by their clients to be lent and/or 'locked' as collateral and liquidity mismatches continue despite the recent failures.

The analysis in this note provides evidence of elaborate mechanisms involving heavy use of leverage and built on the composability offered by DeFi. However, the most important ingredient for the growth of these mechanisms has been user optimism about the value of the underlying products.

Importantly, the lessons of the summer 2022 failures in crypto-asset markets exposed the significant interconnectedness that exists within the crypto-asset ecosystem. This is expected to only intensify following this crypto winter, as the market is concentrating in few dominant players that control even larger parts of crypto-asset activity than previously. This increases future risks of wide-scale disruption and contagion within the crypto-asset markets if any of these dominant players faces difficulties in the future, and risks accelerating and intensifying domino effects, such as the one observed currently, in future downturns.

The non-compliant operation of crypto-asset market players offering regulated financial activities and products exposes market participants and the markets to significant risks usually addressed by consumer and investor protections. Lack of transparency regarding the strategies undertaken and their riskiness, the liquidity of assets subject to client transactions, the trading of client crypto-assets and the re-hypothecation of crypto-assets in DeFi platforms are just some examples of the lack of critical disclosures for market participants.

The recent downturn and the lessons from the failings of major crypto-asset market participants highlight the urgency of policy action. This is particularly true for retail investors, given the disproportionate impact that the recent downturn appears to have had on retail investors compared to crypto-asset whales and insiders who managed to cover some of their losses.

The importance of communication of appropriate policy frameworks and the non-compliant nature of activity of some market players is paramount to address consumer protection issues. This is even more the case given that the current low levels of crypto-asset prices are being marketed to new investors as a good entry point with upside opportunities for future earnings. When appropriate disclosure about risks is not provided by market participants, policy makers could provide warnings to investors, and in particular to retail investors, about the increased risks of such activities. Such warnings will have a better effect if coupled with intensive financial education efforts to improve investor and financial consumer understanding about the risks involved in crypto-asset markets.

The recent crypto-asset market turmoil has not spilled over to traditional markets, and reasons for this include the relatively small size of the market for crypto-assets, and limited interconnectedness with traditional markets at this stage. A future scenario of similar turmoil in a larger crypto-asset market could have implications for financial stability. Negative impact on investor confidence and losses in crypto-assets markets that could affect overall positions of investors in traditional markets, especially given increased involvement of institutional investors in such markets underline such future risk.

Crypto-asset market concentration and the intertwined nature of crypto-asset activities exacerbate the effects of any loss of confidence, triggering classic runs and domino effects within the crypto-ecosystem. Where such runs involve crypto-assets backed by debt assets as reserves, such as some stablecoin arrangements, spike in demand for redemptions or fire sales could disrupt critical funding markets with potential impact on financial stability, especially given that traditional financial institutions may hold assets of stablecoin reserves (OECD, 2022^[7]).

International co-ordination at the cross-border level is necessary because of the global nature of the crypto-asset market activity and to avoid regulatory arbitrage opportunities currently exploited by some non-compliant crypto-asset firms. Co-ordination within authorities at the domestic level is also important to avoid fragmentation between different authorities. The operating models of the crypto-asset market may call for an investment in upskilling to improve in-house expertise of regulatory and supervisory authorities in some jurisdictions, *inter alia* through the potential use of digital solutions for financial supervision (e.g., SupTech solutions).

Possible benefits of select technologies associated with decentralised finance may need to be further explored given the high level of innovation in these markets. Policymakers may consider ways to allow for the safe and responsible innovation, anticipating and addressing emerging risks for participants and the markets. Traditional financial market participants may adopt decentralised finance technologies and practices (e.g., atomic settlement of securities or post-trade/clearing disintermediation) to capture potential efficiencies and productivity gains in financial market infrastructure.

Annex A. Trends in crypto-assets and DeFi adoption

A data paradox exists in market for crypto-assets and decentralised finance: while some distributed ledger technologies (DLTs) claim to offer full transparency, there may be limited information about the types of investors involved in such activity, their profiles and their locations. Crypto-asset markets offer transparency with regard to trades taking place on chain, but the information available includes no more than the asset that was transferred, the amount of the asset and the corresponding price, and, where applicable, the terms of the smart contract for the transaction. The pseudonymous nature of markets for crypto-assets render these significantly cumbersome for people to gather credible and reliable statistics about market activities. The issues related to data analytics for these markets are multiple: the limited credibility and reliability of data reported by the industry; the difficulty of aggregating holdings of single users who may hold multiple wallets; or the use of mixers that make it difficult to trace transactions. An additional impediment to clear understanding of activity in crypto-assets markets is that many transactions take place off-chain in centralised exchanges and other centralised services because of considerable transaction costs associated with P2P activity.

Substantial analysis of adoption and usage patterns across countries and investors are, as a consequence, based either on surveys, or on indirect information regarding trades and ownership that are provided by blockchain data analytics companies. These may base their assessments on the amount held per address, or on web traffic data for the geographical breakdown of such activity.

The Bank of Canada has been studying Bitcoin (BTC) adoption since 2016, using surveys to understand Canadians' relationship with this crypto-asset. Bank of Canada's Bitcoin Omnibus Survey (BTCOS) was most recently performed in 2021, before the 2022 downturn in crypto-assets prices (Balutel et al., 2022^[47]). The survey shows very high and consistent awareness by consumers of BTC in the past several years, but quite low investment ratios. An increase was observed during the COVID-19 crisis; ownership between 2020 and 2021 increased from 5% to 13% of the general population. Recent investors interviewed say that they largely see BTC as an investment. The median holding of BTC by survey respondents declined from CAD 500 in 2018 to CAD 250 in 2019, and it increased to CAD 503 in 2021. These fluctuations are the result of both changes in ownership pattern and movements in the price of BTC over time. Importantly, half of survey respondents were unfamiliar with any other crypto-asset besides BTC. In 2021, only 26% of respondents were aware of ETH, the second largest coin in terms of market value. The most well-known so-called stablecoin was USD Coin (USDC), at 12% of respondents. Reported ownership of ETH and USDC was 7% and 1.5%, respectively (Balutel et al., 2022^[47]).

Importantly, most Canadian BTC owners hold small amounts; in 2021, the median amount of BTC held was equivalent to CAD 500 worth, and 70% of BTC owners held the equivalent of CAD 5 000 or less (Balutel et al., 2022^[47]). In terms of drivers of such participation, the increase observed in crypto-asset holdings among Canadians in 2021 occurred following widespread increases in savings and wealth during the pandemic. At the same time, some fintech companies began to offer cryptocurrencies alongside traditional investment products, providing consumers with a wider range of accessible and user-friendly platforms to buy BTC (Balutel et al., 2022^[47]).

A survey of crypto-assets take-up also took place among UK consumers between February and June 2021 (HMRC, 2022^[48]). A total of 8% of UK adults reported that they hold crypto-assets. Out of these, 53% of owners had holdings of up to GBP 1 000, with 7% holding more than GBP 5 000 in value. The most frequently mentioned method of acquisition (68% of respondents owning crypto-assets) was through a 'centralised exchange'. Similar to the findings of Canada's BTCOS, UK crypto-asset owners tended to be younger than the general population (HMRC, 2022^[48]).

Box A.1. UK steps to support safe innovation while addressing risks in crypto-asset markets

The UK, like a growing number of other OECD member jurisdictions, has taken and is undertaking a number of steps to support safe innovation and address consumer and stability risks in crypto-asset markets as part of an incremental and risk-based approach to regulating the sector:

- Bringing custodian wallets providers and crypto-asset exchange providers into anti-money laundering (AML) and counter-terrorist financing (CTF) regulation to address illicit finance risks.
- Putting in place a targeted measure to bring certain cryptoassets within the Financial Conduct Authority (FCA) financial promotions regime to improve consumer understanding: once legislation has been laid, this will apply to the promotion of certain crypto-assets and provides the FCA with powers to regulate the marketing and retail interaction with crypto-assets. The FCA have proposed that crypto-assets would be treated as high-risk investments, meaning that investors will be subject to positive frictions, warnings and restrictions on investments, among other measures.
- Legislating to bring certain stablecoins within the payments regulatory perimeter, to provide effective regulatory oversight of issuers and service providers and ensure stablecoins can be used safely by consumers. This is being taken forward as part of the Financial Services and Markets Bill (FS&M Bill) which is currently passing through Parliament.
- Issuing an HM Treasury consultation later this year on comprehensive regulation of crypto-asset activities in the investment and trading space; the government is seeking to ensure, as part of the FS&M Bill, that crypto-assets can be regulated within the existing financial services framework in the same way as other financial services activities.

Source: UK HM Treasury, as of October 2022.

Results from the European Central Bank's Consumer Expectation Survey (CES) for six large euro area countries indicate that as many as 10% of households may own crypto-assets (ECB, 2022^[49]) (ESMA, 2022^[16]). Most crypto-asset owners reported holding less than EUR 5 000 in crypto-assets, with a slight predominance of smaller holdings (below EUR 1 000), while only 6% of crypto-asset owners confirmed that they held more than EUR 30 000 in crypto-assets (Hermans et al., 2022^[50]). Interestingly, the results of the study present a U-shaped pattern, and the higher a household's income, the more likely it is to hold crypto-assets, with lower-income households more likely to hold crypto-assets than middle-income households. On average, young adult males and highly educated respondents were more likely than other respondents to invest in crypto-assets in the countries surveyed by the ECB. With regard to financial literacy, respondents who scored either at the top or the bottom levels in terms of financial literacy were most likely to hold crypto-assets (Hermans et al., 2022^[50]).

National country studies in the EU show similar trends. In France, for example, based on the Autorité des Marchés Financiers Savings and Investment Barometer, 8% of respondents declared that at least one person in their household held crypto-assets, 40% of them for less than a year (AMF, 2022^[51]). Among respondents under 35 years-old, the rate of participation was 19%, equivalent to 60% of all crypto-asset

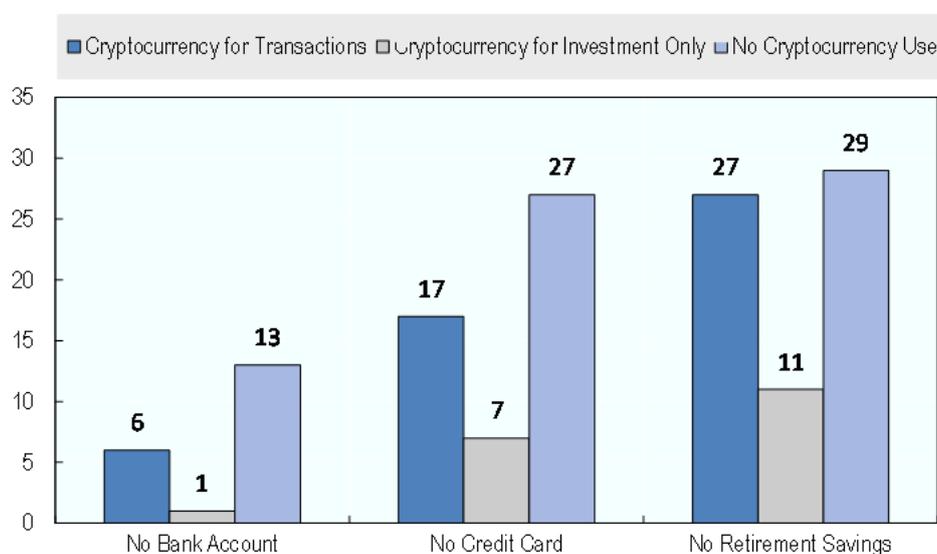
holders. Similarly, 6% of the Slovak Republic and 8% of Dutch people own crypto-assets based on 2021 survey results (Ross, 2022^[52]).

In Italy, on the basis of CONSOB Observatory on 'The approach to finance and investment of Italian households', householders owing crypto-currencies correspond to 8% of retail investors in 2022 (3% in 2021). Crypto-currency holders are mainly young; only 11% are above 55 years old. 65% of investors have between EUR 50 000 and EUR 250 000, while 18% have more than that and 17% have wealth below EUR 50 000. In addition, crypto-currency holders display a financial literacy above the average (in terms of knowledge of both basic notions and financial products) (CONSOB Report on financial investments of Italian households, 2022). Finally, 55% of Italian retail investors declare an interest in crypto-currencies.

In the US, crypto-assets were included in the Federal Reserve's *Economic Well-being of Households* survey for the first time in 2021 (Board of Directors of the Federal Reserve System, 2022^[53]). 12% of adults in the survey held or had used crypto-assets in the prior year. Eleven percent of adults had held crypto-assets as an investment, while a far smaller 2% of adults said that they used crypto-assets for purchases or make a payment in the prior 12 months, and 1% used it to send money to friends or family.¹⁹ Those using crypto-assets for purchases rather than as investments frequently lacked traditional bank and credit card accounts. Among the 3% of transactional users of crypto-assets, 13% did not have a bank account (Board of Directors of the Federal Reserve System, 2022^[53]).

Figure 3.3. Breakdown of crypto-asset use cases in the United States

In percentage



Note: Among all adults surveyed in the US Key identifies bars in order from left to right. Based on results of a survey.

Source: Board of Directors of the Federal Reserve System (2022^[53]), *Economic Well-Being of U.S. Households in 2021*, <https://www.federalreserve.gov/publications/files/2021-report-economic-well-being-us-households-202205.pdf>.

A recent report by the blockchain analytics company Chainalysis, ranked the adoption of crypto-assets in 146 countries around the world based on usage of different types of cryptocurrency services (Chainalysis, 2022^[6]). Importantly, the ranking of countries is adjusted to account for their purchasing power parity (PPP) per capita, so theoretically, a high ranking should not be the result of a country being more populated or

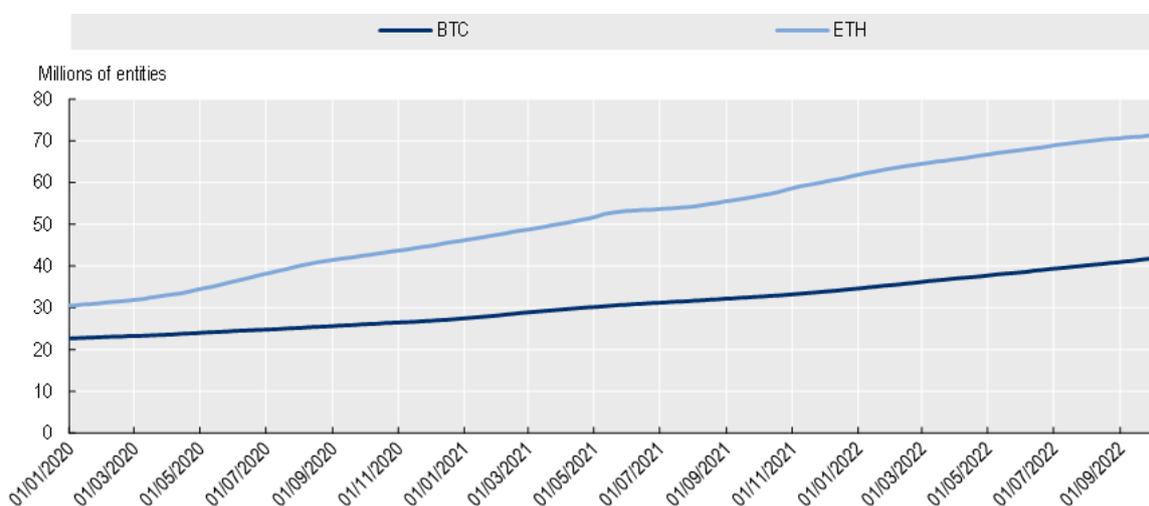
¹⁹ The total exceeds 12% because of double-counting of respondents who used crypto-assets for multiple purposes.

its residents being wealthier but rather reflect the relative transaction volume in crypto-assets in that country compared to other countries. According to the ranking, emerging markets dominate the index. The only two high income countries in the top 20 adopters are the US and UK. In emerging economies, users hold BTC and stablecoins more than other countries, perhaps desiring to protect their wealth against volatility in their domestic fiat currencies.

On-chain data on entities holding small amounts in the two leading crypto-assets, BTC and ETH, which can be used as a proxy for the number of retail investors, show a somewhat different global picture than might be extrapolated from the surveys mentioned earlier relating to developed markets. Based on information from Chainalysis, the number of entities holding up, but not more than 1 BTC increased 79% between January 2020 and October 2022 to 41 million; number of entities holding up, but not more than 10 ETH increased during the same period by 132% to 71 million (Figure 3.4). These numbers point to a much lower global adoption rate among consumers compared with developed countries.

Figure 3.4. Number of retail investors holding BTC and ETH

As of 10 October 2022, presuming a retail investor holds a maximum of 1 BTC or 10 ETH



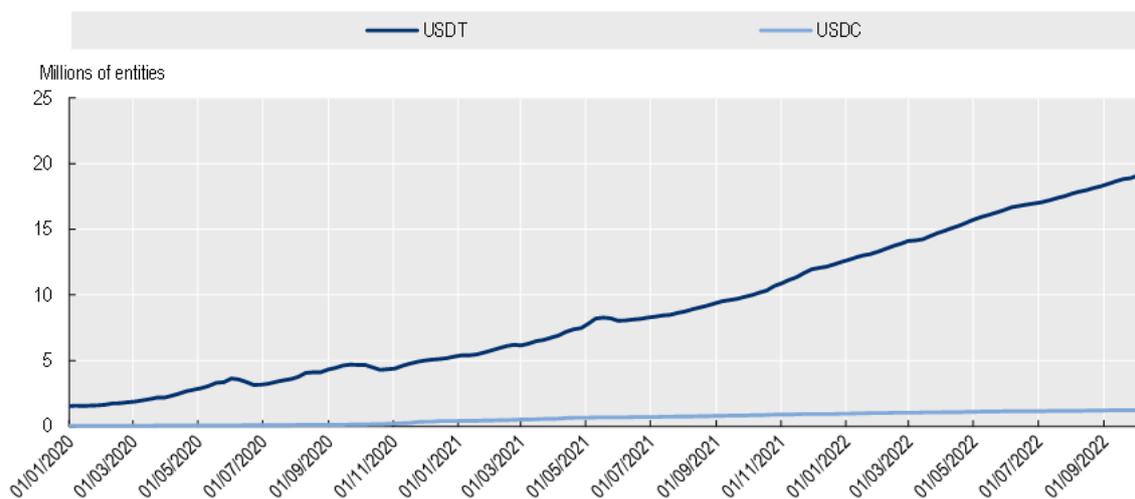
Note: Retail investors presumed to be entities that have a balance of up to 1 BTC or 10 ETH.

Source: OECD based on data by Chainalysis.

If retail holders are instead defined as market participants holding up to USD 10,000 worth of a so-called stablecoin, there are 20 million such accounts holding USDT and USDC (Figure 3.5). Retail accounts represent 97.9% of BTC holders and 99.5% of ETH holders among all accounts holding these assets. The ratio of retail accounts among all account is 99% for USDT, and 94% for USDC (Figure 3.6). Despite the dominance of retail accounts in terms of their quantity compared with accounts belonging to large investors, their share in the overall mined or minted assets outstanding is very small, about 5% for BTC and ETH and only 1-2% for each of USDC and USDT.

Figure 3.5. Number of retail investors holding USDT and USDC

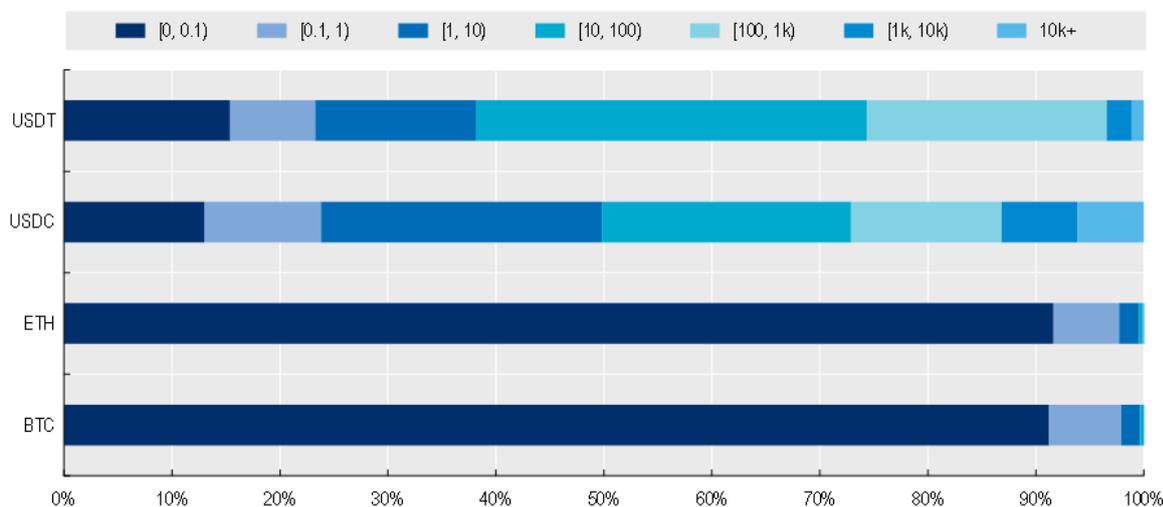
As of 10 October 2022, presuming retail investors hold balances valued at no more than USD 10 000



Note: Retail investors presumed to be entities (wallets) that have a balance of up to USD 10 000 equivalent of USDC or USDT.
Source: OECD based on data by Chainalysis.

Figure 3.6. Number of entities holding crypto-assets by number of asset held by the entity

As of 26 September 2022



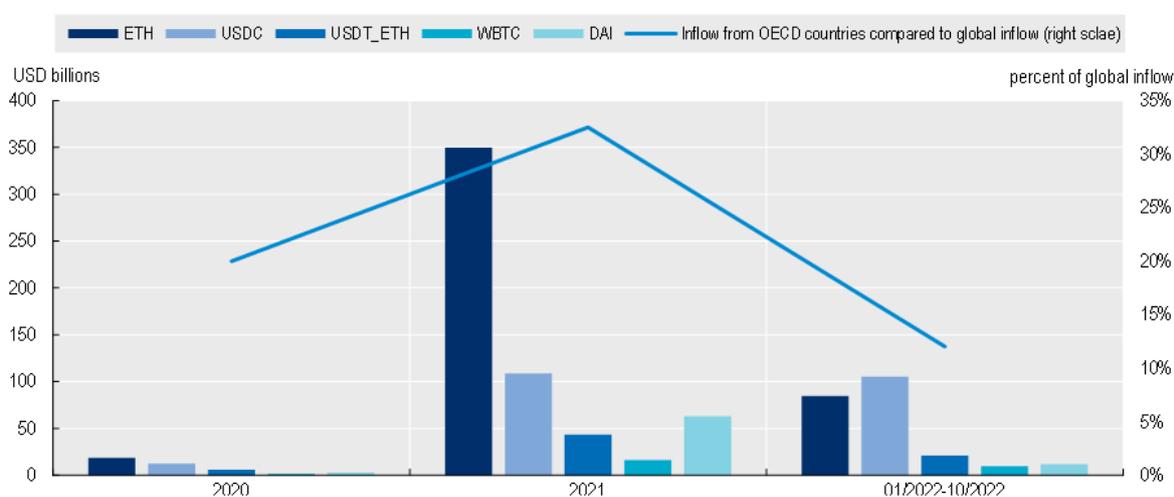
Source: Chainalysis

Chainalysis performed a geographical analysis of on-chain transaction volumes in crypto-assets in 2022 (Chainalysis, 2022^[6]). Regional transaction volume by transfer size between summer 2021 and summer 2022 show that a similar distribution between large and retail investors is observed in different regions,

with small and large retail investors²⁰ accounting for about 5% of transaction volume in crypto-assets, and institutional investors²¹ accounting for roughly 60-65% of transactions.

DeFi platforms have attracted much interest and transaction volume in crypto-assets in the past year and a half; total value locked (TVL) in DeFi was estimated at USD 53 billion in September, accounting for 5% of the entire crypto-assets market value at the time (see Section 1.1). The total flow²² of crypto-asset into DeFi during the first nine months of 2022 amounted to USD 1.9 trillion (based on Chainalysis data). Despite the market downturn, this number is higher than for the full year 2021 (USD 1.8 trillion). For comparison, equity trading volume on NYSE for the first nine months of 2022 amounted to USD 2.7 trillion (NYSE, 2022^[54]). Inflows from OECD countries represented more than 30% of total inflows to DeFi in 2021, but that ratio has declined by half in 2022 (Figure 3.7).

Figure 3.7. Inflow to DeFi from OECD countries in USD and as a ratio of global inflow



Note: Inflow is the sum of inflow in ETH, USDC, USDT (on Ethereum network), WBTC and DAI, as a proxy estimation of inflow into DeFi.
Source: OECD, based on data by Chainalysis.

Inflows into DeFi from US have been the highest among OECD countries in 2022, at a scale much higher than other countries, followed by the UK and Canada (Figure 3.8).

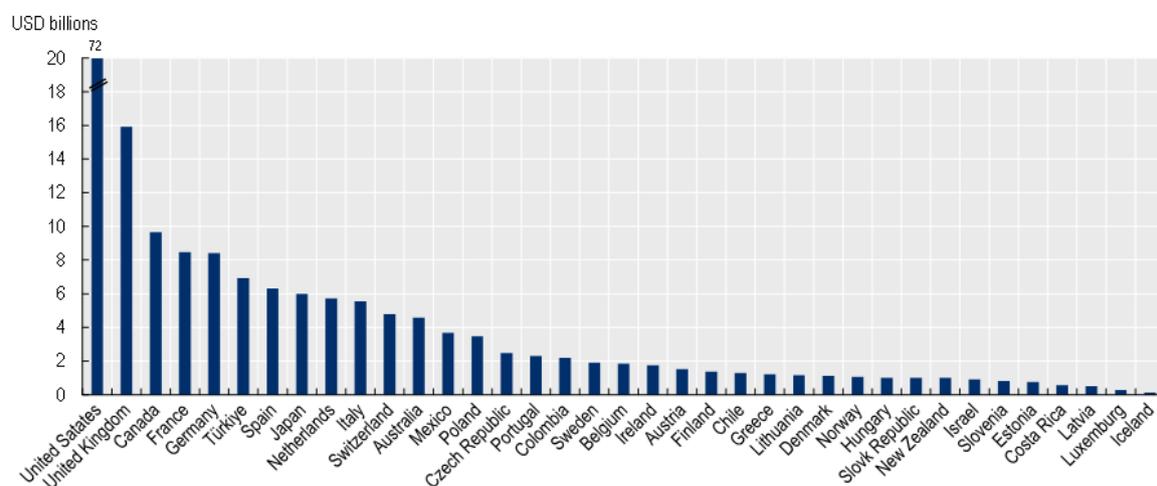
²⁰ With transaction value up to USD 10 000.

²¹ With transaction value above USD 1 million.

²² Sum of inflow into DeFi platforms composed of the crypto-assets ETH, USDC, USDT, WBTC and DAI, accounting for the majority of all-crypto-assets used as inflow into DeFi. WETH is ETH that was wrapped by a smart contract; the smart contract has locked received ETH and credited the sender with WETH in return, visible on the blockchain. WETH allows for more compatibility with smart contracts and decentralised applications than ETH. The DAI “stablecoin” is minted and destroyed by the Maker Protocol running on the Ethereum network. It attempts to maintain a one-to-one peg with the US dollar by locking other crypto assets in smart contracts.

Figure 3.8. Inflow to DeFi of ETH and USDC by country

In USD billions, period from 1 January – 24 October 2022



Note: No data on Korean inflows was available.

Source: OECD based on data by Chainalysis.

Two sub-indices of the geographical adoption index constructed by Chainalysis (Chainalysis, 2022^[6]) of interest are retail activity through CeFi services and through DeFi services. OECD members' ranking is high in both categories; 34% and 42% of OECD countries are ranked in the top quartile of retail transactions in CeFi and in DeFi, respectively. The US is ranked first in retail DeFi transactions.

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