BIS Papers
No 156

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April 2025

JEL classification: E42, G23, G28, O33, F38.

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The views expressed are those of the authors and not necessarily the views of the BIS.

This publication is available on the BIS website (www.bis.org).

ISSN 1682-7651 (online)
ISBN 978-92-9259-851-8 (online)

Cryptocurrencies and decentralised finance: functions and financial stability implications

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Abstract

Cryptocurrencies and decentralised finance (DeFi) aim to replicate many of the economic functions of traditional finance (TradFi), but their distinctive features introduce new financial stability risks. We analyse these features, and examine key developments, such as smart contracts, decentralised exchanges (DEXs), stablecoins and new forms of central bank money. Our findings suggest that while the underlying economic drivers are not different than in TradFi, DeFi poses significant challenges, including new forms of information asymmetries, market inefficiencies and the risk of cryptoisation in emerging markets. We propose tailored regulatory interventions, such as embedding rules within smart contracts and strengthening the oversight of stablecoins, to manage financial stability risks. Finally, we provide a framework for prudential regulation that can mitigate risks while fostering innovation in the rapidly evolving crypto ecosystem.

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Introduction

Blockchains have been hailed as a pivotal innovation in securing digital data. While the concept has existed for decades, the first public blockchain was created by Satoshi Nakamoto – a pseudonym for an individual or a group of people – in 2008.[2] The official birthday is 31 October, the date on which the Bitcoin whitepaper was originally published (Nakamoto (2008)). Bitcoin went live two months later on 3 January 2009, with the minting of the first block of its blockchain, known as the genesis block. Since then, cryptoassets have experienced multiple boom and bust cycles.[3] Some early adopters amassed significant wealth, while many retail investors faced substantial losses (Cornelli et al (2022)).

Although cryptoassets may not have achieved the level of success Satoshi Nakamoto envisioned, they have made considerable progress since their inception. New blockchains have been created, together with thousands of cryptoassets built on them. A particularly important innovation was the creation of the Ethereum blockchain in 2015, which enabled developers to deploy decentralised software applications. These applications allow users to access services – such as trading, lending and borrowing – without intermediaries. Together, these services have become known as decentralised finance (DeFi).

As cryptoassets and DeFi have evolved, policymakers in national authorities and international institutions have been grappling with the challenges posed by these innovations. Initially, their reactions were marked by a mix of curiosity, scepticism and a cautious willingness to explore the underlying characteristics of these new assets. Due to their limited size in the early years, policy actions were generally limited to issuing warnings about their speculative nature.

More recently, however, as the crypto market has grown and its connections to traditional finance (TradFi) have deepened, policy interventions have increased. Internationally, organisations such as the Bank for International Settlements (BIS), Financial Stability Board (FSB), International Monetary Fund (IMF) and International Organization of Securities Commissions (IOSCO) have produced numerous reports and, in some cases, issued recommendations or standards.[4] At the national level, regulators have become more proactive in defining policies to respond to the growth of crypto and DeFi.

This chapter presents a description of the functions that crypto and DeFi innovations aim to fulfil. It covers blockchains, cryptoassets and DeFi applications, as well as other parallel developments such as stablecoins and new forms of central bank money. The chapter then presents a conceptual framework for assessing the financial stability implications of these innovations, indicating that relatively minor adjustments to existing frameworks used in TradFi can do the job. The chapter also

[2] A blockchain can be defined as a form of permissionless (or "public") distributed ledger in which details of transactions are held in the ledger in the form of blocks of information. Distributed ledger technology, in turn, is a means of saving information through a distributed ledger, ie a repeated digital copy of data available at multiple locations.

[3] Cryptoassets (or cryptocurrencies) can be defined as a type of private sector digital asset that depends primarily on cryptography and distributed ledger or similar technology.

[4] See for instance FSB (2022, 2023a,b); IMF-FSB (2023); IOSCO (2022, 2023a,b); OECD (2022).

discusses the case for prudential regulation of cryptoassets, highlighting both their potential linkages with TradFi and instances in which regulators may need to address DeFi directly. The last section provides a forward-looking assessment of potential future research.

Crypto innovations and their financial functions

Blockchains and cryptoassets: how do they work?

Blockchains aim to reduce reliance on centralised authorities by validating transactions through a combination of cryptography and economic incentives.[5] Essentially, a blockchain is an append-only database that maintains a growing list of ordered records (blocks) and relies on a subset of network participants, such as miners or validators, to maintain the integrity of the records. It is distributed, meaning there are copies of it on each computer that is part of the network.

To understand how this technology works, consider a comparison between a blockchain transaction and a traditional bank transaction. If Alice wants to send $1,000 to Bob, she would ask her bank to initiate the transfer. Alice's bank checks her account for sufficient funds, sends a message to Bob's bank to credit his account with $1,000, and debits the same amount from Alice's account. Alice and Bob must rely on their banks (and intermediaries in between) to validate and execute the transaction.

On a blockchain, Alice submits her transaction to a pending transaction list (called a memory pool or mempool, which is a waiting area for unconfirmed transactions) that is broadcast to all the nodes in the network. The transaction would be denominated in cryptocurrency, ie a digital representation of value based on the blockchain itself. Network participants then compete to add a new block of transactions by solving a computationally intensive cryptographic problem that verifies Alice's funds.[6] The winner of this competition broadcasts the solution to the network and appends the new block to the chain. Other nodes can quickly check[7] that the solution is correct and append the new block to their own copy of the ledger. This therefore becomes the agreed *truth* among network participants. To link together blocks, each new block contains a cryptographic representation (*hash*) of the previous block. As a result, records cannot be altered retroactively without changing all subsequent blocks, which would require network consensus.

To incentivise nodes to participate in this costly process and append the blocks, they are rewarded with new cryptocurrency or through transaction fees paid by users.

5 See Nakamoto (2008) for the technical details and Budish (2024) for a discussion of the economic incentives.

6 This mechanism is called proof-of-work given that the miners need to prove that they solved the computational problem. More modern blockchains (such as Ethereum) use a different consensus mechanism (called proof-of-stake) which involves "staking" (ie locking onto the blockchain for a given amount of time) a validator's own cryptocurrency.

7 The cryptographic problem requires substantial computing power to be solved, but once a solution is found it is trivial to check that it is the correct one.

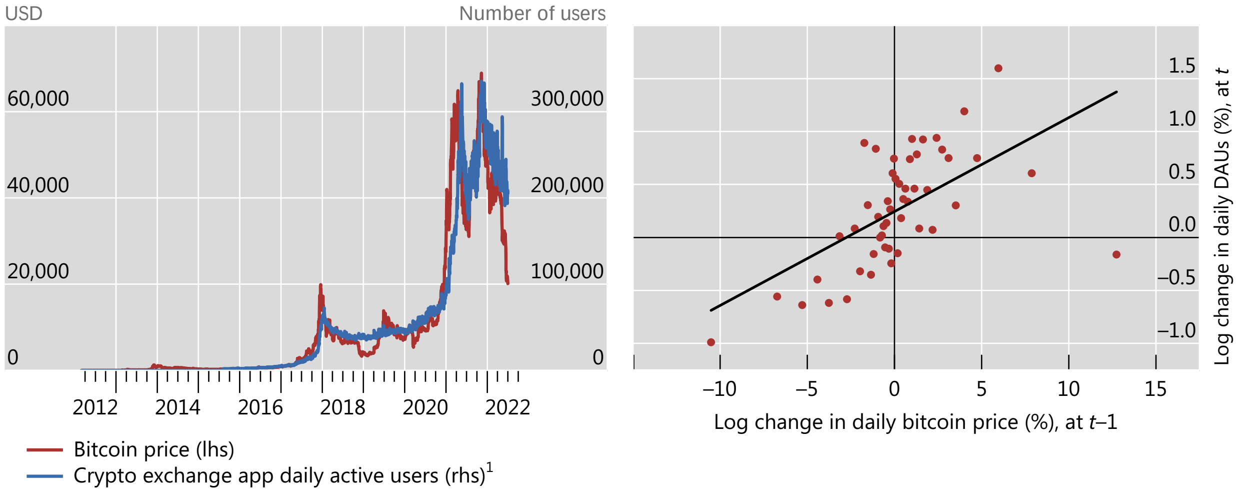
As implied by its name, the original goal of bitcoin and other cryptocurrencies was to provide payment services. However, this objective has largely not been achieved. In the crypto community, 22 May is celebrated as Bitcoin Pizza Day, commemorating one of the earliest notable bitcoin transactions. In 2010, a programmer purchased two pizzas for 10,000 bitcoin. Yet this transaction did not herald a new era for payments services. Surveys confirm that only a small percentage of households have used crypto to pay for goods or services, even though cryptocurrencies pre-date widely used technologies such as quick response (QR) codes and mobile payment apps.[8]

Where cryptocurrencies have proven to be successful is in encouraging speculation. Over the past decade, cryptocurrency prices have been extremely volatile, but have generally trended upwards for the most successful assets. This has attracted waves of investors seeking high returns. Auer et al (2022) show that, when the price of bitcoin rises, more people download and actively use crypto exchange apps (Graph 1.A). Global daily data show that the inflows of users are positively correlated with bitcoin price increases (Graph 1.B).

Chained to speculation? New users enter as the bitcoin price rises — Graph 1

A. Daily active users increase as the bitcoin price trends higher

B. Inflows of users are correlated with price increases[2]



[1] Calculated on a sample of more than 200 crypto exchange apps over 95 countries. [2] The graph shows a binned scatterplot at the country-day level. DAUs = daily active users.

Sources: Auer et al (2022); CCData; Sensor Tower.

Decentralised finance

Smart contracts, DeFi protocols and Dapps

Following the creation of the Bitcoin blockchain, various projects in the crypto space emerged. The first major development was the rise of exchanges that facilitated interactions with bitcoin. These exchanges allowed users to exchange bitcoin for fiat

[8] See for instance surveys in Australia, the United States and Sweden.

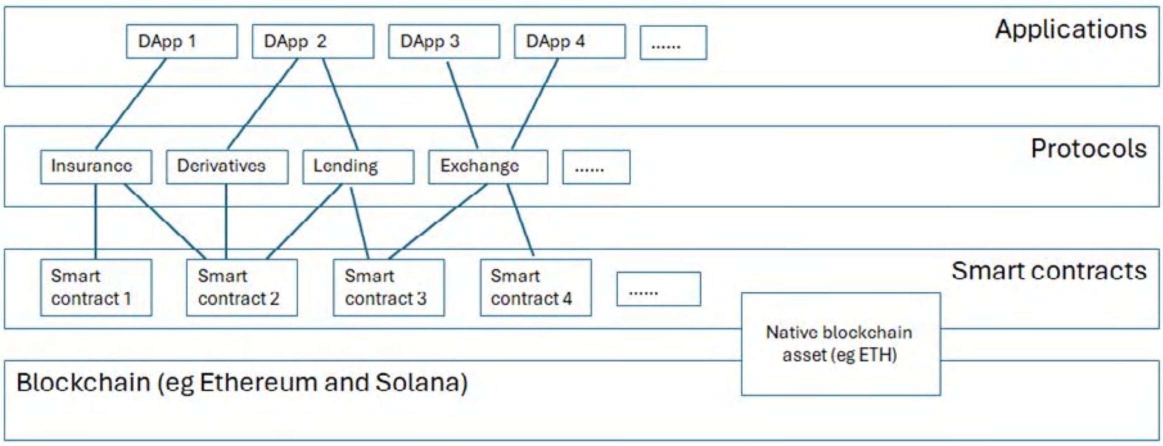
money, contributing to multiple waves of new participants entering the crypto market. These waves drove up prices but were followed by significant periods of bust.

At the same time, computer scientists saw an opportunity in blockchain technology and they developed a number of competing blockchains. Arguably the most important was Ethereum, launched in 2015. The main innovation of Ethereum was its ability to allow developers to build software applications that could interact with its blockchain. These "smart contracts", as they have come to be known, allowed developers to add functionality beyond simple peer-to-peer transfers, like those in the Bitcoin network. Specifically, they enable users to transfer funds contingent on pre-specified conditions, with the outcome of the transaction being automatically executed by the contract.[9] This functionality opened up the development of an entirely new ecosystem of decentralised intermediation services, now known as decentralised finance (DeFi) (Zetzsche et al (2020); Aramonte et al (2022); Makarov and Schär (2022)).

Schär (2021) highlights that DeFi can be thought of as comprising five main layers: blockchains, assets, protocols, applications and aggregators. We think that a slightly modified version of the asset stack is easier to understand and should include blockchains, smart contracts, protocols and DeFi applications (Dapps). These are illustrated in Graph 2. Blockchains and smart contracts have already been discussed, so what remains is a description of the two other layers.

The different layers of decentralised finance

Graph 2



Source: authors' elaboration adapted from Schär (2021).

DeFi protocols are essentially combinations of smart contracts designed for specific use cases. These use cases include decentralised exchanges (DEXs), lending platforms or on-chain asset management. Due to the permissionless nature of blockchains, protocols can be accessed by any user and indeed by any application, allowing new products to be built on their foundations. In some sense, protocols can be viewed as collections of more complex smart contracts.

9 More precisely, they can be certain of the outcome when a new block is added to the chain, which takes approximately 12 seconds.

Dapps provide graphical interfaces that allow users to easily interact with the underlying DeFi protocols, rather than dealing directly with the smart contracts themselves. For all but the most sophisticated users, Dapps serve as the primary gateway to DeFi protocols, typically through computers or smartphones. Despite DeFi's aim to remain fully decentralised, Dapps function as de facto centralisation vectors (Schuler et al (2024)), enabling the development of intermediaries within the DeFi ecosystem.

What DeFi attempts to do and what it does (at least for now)

Since the launch of the Ethereum blockchain, a number of DeFi protocols have been created by various teams of developers. Many of these protocols are based on Ethereum, which remains the dominant platform for DeFi. Other blockchains such as Binance Smart Chain, Solana, Tron, Arbitrum and Avalanche have also emerged. These protocols fall into a few main categories, which largely mimic services provided by intermediaries in the traditional financial sector.

Before describing what DeFi attempts to do, it is worth briefly recalling the key economic functions performed by the financial system. We rely on the classification by Merton (1995), which highlights six functions (see the first column of Table 1):

1. Provision of clearing and settlement for payments to facilitate the exchange of goods and services (eg deposit accounts, credit and debit cards, and e-money)
2. Development of mechanisms for the pooling funds to undertake large-scale enterprises and/or subdividing shares in enterprises to facilitate diversification (eg stocks and bonds mutual funds)
3. Transfer of resources through time, across regions and across industries (eg loans, mortgages and pension funds)
4. Management of uncertainty and control of risk (eg insurance contracts and derivatives)
5. Aggregation of price information to help coordinate decentralised decision-making (eg exchanges and trading activity)
6. Addressing incentive problems when one party to a transaction has information that the other does not have, or where one party acts as an agent for others (eg risk management activities).

Blockchains were explicitly created with the intention to perform function 1 – clearing and settling payments – even though this has not been their key use case in practice. Stablecoins (discussed further below) represent another attempt to fulfil this function. Other DeFi protocols have been developed to address the remaining functions (summarised in the third column of Table 1).

DEXs are arguably the most successful type of DeFi protocols. They allow users to exchange cryptoassets for one another or for stablecoins directly on the blockchain, without relying on centralised crypto exchanges. Early DEX protocols required liquidity providers to offer liquidity across all price ranges, regardless of market conditions. More modern versions of DEXs allow for much more sophisticated strategies for liquidity provision (Lehar and Parlour (2021); Aquilina, Foley, Gambacorta and Krekel (2024)). These protocols mimic function 5, which involves providing price information to coordinate decentralised decision-making.

Economic functions and activities in TradFi and DeFi Table 1

Function		TradFi examples	DeFi examples
1.	Clearing and settling payments to facilitate trade	Payment systems, deposit accounts, e-money, cards, central counterparties	Blockchains, stablecoins
2.	Pooling of funds to undertake large-scale enterprises	Stocks, bonds, mutual funds, exchange-traded funds (ETFs)	Asset management protocols, crypto tokens, governance tokens
3.	Transfer economic resources through time and space	Loans, mortgages, pension funds, mutual funds	Lending protocols, asset management protocols, smart contracts
4.	Manage uncertainty and control risk	Loans, insurance contracts, derivatives, hedging strategies	DeFi insurance, derivatives, hedging strategies, smart contracts
5.	Provide price information to coordinate decentralised decision-making	Exchanges, trading activities, derivatives	DEXs, crypto derivatives
6.	Deal with incentive problems	Risk management, repeated interactions with the same known counterparties	Smart contracts, over-collateralisation

Sources: authors' elaboration, adapted from Aquilina, Frost and Schrimpf (2024a).

Decentralised lending and borrowing protocols are also common. These allow users to lend and borrow cryptoassets against interest. The anonymity of the blockchain implies that standard creditworthiness assessments are impossible and therefore loans are collateralised – and usually, in fact, over-collateralised. Staking is a type of lending that is specific to DeFi and entails lending cryptocurrency to the underlying blockchain to facilitate its functioning by validating transactions. These protocols mimic function 3 above, while over-collateralisation mimics function 6.

Asset management and yield farming apps enable users to pool cryptoassets with others and allocate their funds to portfolios of cryptoassets. The code embedded in the smart contract makes sure that funds adhere to a predefined investment strategy. Yield farming is a strategy that seeks to maximise returns by lending or borrowing cryptoassets across various DeFi platforms. These protocols mimic functions 2 and 3. Every crypto token can also be seen as a way of mimicking function 2, as it allows users to participate in the success of a protocol.

Derivatives and synthetic asset protocols let users execute transactions similar to derivatives in traditional finance. These transactions link different types of cryptoassets, and smart contracts govern the management and maintenance of collateral. These protocols mimic function 4. Meanwhile, *decentralised insurance* protocols fall into two main segments. The first type protects users from risks that are specific to DeFi, such as hacking. The second type automates the payment of claims based on predefined events, covering risks similar to those in traditional finance. These protocols also mimic function 4.

While DeFi protocols mimic the functions of intermediaries in TradFi, it should be noted that, to date, they play little to no role in supporting the financing needs of the real economy. No household can rely on a DeFi protocol to obtain a mortgage and buy a house, no company can hedge a real-world risk using a DEX, and no innovator has yet managed to use crypto or DeFi to commercialise a product outside the crypto or DeFi ecosystem. This may change in the future, but for now DeFi remains almost exclusively self-referential, serving the crypto and DeFi ecosystems without extending its services to the real economy.

So far, DeFi has mainly been used for speculation on the value of the token issued with new protocols. Participants typically trade tokens hoping for future appreciation and profits.

Stablecoins

Stablecoins are crypto tokens that, unlike traditional cryptocurrencies, aim to maintain a value of one dollar, providing par convertibility on demand. Due to this feature, stablecoins are considered safer than unbacked cryptocurrencies and are presented by proponents as the key medium of exchange in the crypto ecosystem (Arner et al (2020)).

There are three types of stablecoins, categorised by the mechanism they use to maintain par convertibility. The first type is "fiat-backed" stablecoins, such as Tether and USD Coin, which represent the lion's share of the market in terms of capitalisation. In this model, stablecoin issuers hold fiat-denominated short-term assets, such as US Treasuries, high-quality commercial paper, repurchase agreements and bank deposits, to stabilise the token's value. The balance sheet structure of fiat-backed stablecoins closely resembles that of money market funds (MMFs) (Aldasoro et al (2024)). The second type is "crypto-backed" stablecoin, like Dai, which offers par convertibility by holding crypto collateral instead of fiat collateral, as used by fiat-backed stablecoins. A special type of crypto-backed stablecoins are decentralised stablecoins, which rely on smart contracts and cryptocurrency collateral to maintain a target price. Finally, the third type is "algorithmically backed" stablecoins, such as the infamous TerraUSD, which collapsed in May 2022 after losing its peg to the US dollar. This last type of stablecoins maintain their value through algorithms that mint or burn tokens and adjust their supply based on market demand.

Beyond serving as a medium of exchange, stablecoins are promoted as a way to facilitate cross-border payments, promising to bypass the high transaction fees applied by traditional payment systems. However, in practice, stablecoins typically play the role of gateways to access DeFi/crypto ecosystems. Moreover, the widely touted role of stablecoins as a safe haven during market turbulence is far from certain, at least for now. Recent research shows that fiat-backed stablecoins, which account for more than 90% of total stablecoin market capitalisation, are significantly affected by both crypto-specific and US monetary policy shocks. Specifically, both types of shocks lead to outflows from stablecoins, suggesting that stablecoins as a whole do not act as a safe haven against either crypto or traditional financial shocks (Aldasoro et al (2024)).

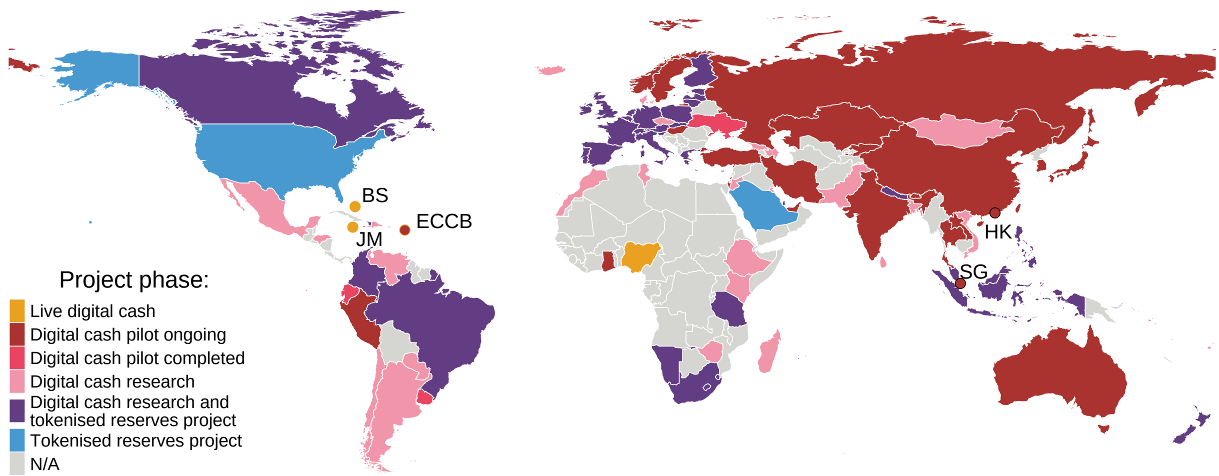
New forms of central bank money

Beyond stablecoins, but potentially with some similar functions, are new forms of central bank money, such as central bank digital currencies (CBDCs). CBDCs are defined as digital payment instruments that are denominated in the national unit of account and are a direct liability of the central bank (BIS (2020, 2021); Group of Central Banks (2020)). In other words, CBDCs can be seen as a digital representation of physical cash, or of commercial bank reserves.

There are two types of CBDCs, namely wholesale and retail. The former are used exclusively for transactions between financial institutions, providing new ways for central bank money to be accessible to regulated financial institutions. Those using distributed ledger technology (DLT) and tokenisation can be considered tokenised central bank reserves.[10] Retail CBDCs are available to the general public, ie households and businesses, and can be seen as a form of digital cash. They may resemble current electronic money but there is one key feature on which these two fundamentally differ. While current forms of electronic money that are accessible to households and non-financial corporations represent a liability of a financial institution, retail CBDCs constitute a direct claim on the central bank, in a similar way to physical cash.

There is a lot of heterogeneity when looking at the development stage and the design features of CBDC projects. In terms of development stage, at the time of writing, there are three live retail CBDCs (digital cash systems) in the world – in The Bahamas, Nigeria and Jamaica. At least 25 jurisdictions have reached a pilot stage for retail CBDC and nearly as many have conducted wholesale CBDC (tokenised reserve) pilots (Graph 3). Auer et al (2023) documented the status, policy approaches and technical design of the various projects, and the cross-country economic and institutional factors that correlate with the stage of advancement of CBDC projects. Specifically, both retail and wholesale CBDC projects are more advanced in economies with high mobile phone use and a high capacity for innovation. Furthermore, retail CBDC work has progressed more where the informal economy is larger and wholesale

Digital cash and tokenised reserves projects around the world — Graph 3



BS = The Bahamas; ECCB = Eastern Caribbean Central Bank; HK = Hong Kong SAR; JM = Jamaica; SG = Singapore.

Updated as of September 2024.

The use of this map does not constitute, and should not be construed as constituting, an expression of a position by the BIS regarding the legal status of, or sovereignty of any territory or its authorities, to the delimitation of international frontiers and boundaries and/or to the name and designation of any territory, city or area.

Source: Auer et al (2023).

[10] Many central banks are using permissioned DLT, in which access to the network and validation are restricted to known parties with permission. This contrasts with permissionless blockchains.

CBDC work is positively correlated with financial development, consistent with the focus of such projects on improving the efficiency of wholesale settlement.

Retail CBDC projects are characterised by different design features (Auer and Böhme (2020)). The first and foundational design choice is the *architecture*, which characterises the operational role of the central bank and of the private intermediaries in a CBDC. While the majority of central banks did not state publicly which architecture model they envisage for their retail CBDC project, among the ones that did, there is notable preference for the *hybrid* or *intermediated* model encompassing a two-tier architecture in which the central bank directly issues the CBDC and maintains a central ledger of the transactions, while (private) intermediaries run all customer facing relationships. Interestingly, a few central banks explored the *direct* architecture model in which the central bank is in charge of issuing the CBDC, maintaining the ledger of transactions and offering payments services. Typically, this model has been considered in combination with other models and in order to explicitly pursue social objectives like financially including citizens without a bank account.

The second technical design choice is in respect of the *infrastructure*. This layer can be based on a conventional centralised database or instead on DLT. Among the central banks that publicly communicated their choice on this design feature, the majority are considering solutions that balance efficiency with protection from single points of failure.

The third choice concerns the way in which consumers can *access* the CBDC. Identification is a key feature of *account*-based CBDCs and can serve as the basis for well functioning payments with sound law enforcement. Conversely, the *token*-based model, like physical cash, prioritises privacy and allows access to CBDC anonymously. On this dimension, a majority of central banks have explored the account-based model or models featuring a tiering of both account- and token-based access. In the latter, anonymous access is typically permitted for transactions of small amounts and additional identification requirements are introduced as the amount grows.

Finally, the fourth design choice is the use of CBDC for cross-border payments. This relates to international interlinkages in a CBDC's design and its accessibility for residents versus non-residents. Interestingly, while many of the retail CBDC projects were initially focused on domestic use, a growing number explicitly target use by non-residents or the potential of CBDCs to facilitate cross-border payments.

The rationale for the prudential regulation of crypto and DeFi

The textbook rationale for the economic regulation of markets in general and financial markets in particular is the presence of market failures, ie characteristics of the market which can – in principle – be improved upon with a policy intervention.[11] The same rationale can be applied to the innovative ways of intermediating markets

[11] See Goodhart et al (1998) for an in-depth discussion of the rationale for the regulation of financial markets, and Aquilina, Frost and Schrimpf (2024a) for an application to DeFi. We use a similar approach in this section.

that characterise DeFi. Market failures can be characterised by externalities, which are typically the focus of information problems and prudential regulation.

Externalities

Externalities are costs (or benefits) that impact a party other than those involved in a transaction. In financial markets, negative externalities can be so severe that the process of intermediation can break down completely. Information problems arise either when the available information is not adequate for market participants to make informed decisions or when one party to a transaction has access to a different set of information either before or after the transaction has been completed.

Typically, externalities in financial markets are associated with the so-called cascade of defaults: a party defaulting on its obligations causes losses to its counterparties that are then unable to make good on their obligations, thereby resulting in instability for the system as a whole (Battiston et al (2012)). Given the role played by finance, such a cascade of events could result in effects for the economy as a whole, for instance in the substantial reduction of credit provision, thereby impacting economic growth. Indeed, the firms that are then denied credit are completely unrelated to the initial transaction and only pay the cost. The underlying problem is that the default of an institution imposes costs on others and hence, these institutions have an incentive to behave in a riskier way than if they were bearing those costs themselves.

As has become clear in recent stress episodes, a cascade of defaults is by no means the only source of externalities. Many non-bank financial intermediaries can be a source of financial instability, through the pecuniary externalities created by deleveraging pressures (Aramonte et al (2021)). Mechanisms put in place to align the private and public costs of default can result in better market outcomes compared with a counterfactual in which these mechanisms are not implemented.

Systemic externalities are present across all functions of the financial system. Yet they are particularly important in the clearing and settlement function – as a failure there may have substantial ripple effects on other functions – and in the transfer of resources through space and time, as the network of credit exposures inherent in this function gives rise to the network of exposures that can break down following a default. In DeFi, the presence of smart contracts and atomic settlement makes some of these externalities less likely. But there are systemic players (eg stablecoins and their issuers) which give rise to similar issues.

Information problems

Inadequate information

One type of information problem relates to the fact that market participants may not have the relevant information necessary to make rational decisions. This can be because firms do not have an incentive to highlight the specific characteristic of their products[12] or it may simply be due to the characteristics of financial products. Many

12 For instance, Gabaix and Laibson (2006) show that firms have no incentive to disclose their prices in the presence of myopic consumers.

products are complex as they typically have multiple attributes and their true quality is often revealed only a long time after purchase.

Many of these issues are clearly present in crypto and DeFi. For instance, a smart contract will behave in different ways as the underlying economic situation evolves and its inputs change, and consumers may have a hard time predicting how the behaviour will change. More generally, an investor does not know much about the development team behind a new Dapp and even if the information is disclosed voluntarily, it is difficult to judge its quality.

Another issue relates to the use of "oracles" in DeFi, which import real-world data into blockchain environments for use in smart contracts. Whether oracles can truly adhere to the decentralisation ethos of crypto is debatable. Even if complete decentralisation is feasible, striving for it often leads to increasingly complex consensus protocols, which reduce blockchain efficiency by increasing computational costs and slowing transaction speeds (Duley et al (, 2023)).

Information asymmetry

In the presence of information asymmetry, markets lead to suboptimal outcomes such as lower quantity being produced and average quality deteriorating. In the extreme, markets could completely collapse.[13]

Given the novelty of crypto and DeFi, it is complex for consumers to differentiate across products on the basis of their quality in the DeFi space. Low-quality products can therefore remain in the market for very long periods of time. Indeed, outright scams can persist (and have persisted) for long periods in crypto and DeFi. While key price information and transactions are available on-chain, consumers have little history available on the reputation of the developers, no access to detailed, high-quality disclosures that take their biases into account and very little chance to compare different providers in the market. Furthermore, the structure of decentralised autonomous organisations (DAOs),[14] which underpin many Dapps, makes it difficult to understand where the decision-making power resides, who is responsible for the consequences of such decisions, and which individuals de facto have access to superior information.

Mitigating market failures

Even if a market failure is present, regulation is not always necessary. The market may change and adapt to mitigate the failure by itself, or the failure may not be large enough to warrant an intervention. Table 2 summarises which market failures are more prevalent across the various economic functions described above as well which mitigants are present. It also compares DeFi with TradFi. We discuss these below.

[13] Many of the original models of information asymmetries were developed with financial markets in mind. Rothschild and Stiglitz (1976) focus on insurance markets and Grossman and Stiglitz (1980) on the investment market. Akerlof (1970) shows that a market can completely collapse due to adverse selection in markets with asymmetric information, and the paper includes descriptions of insurance and other markets in which honesty matters.

[14] A DAO is an organisation that should be entirely governed by its community on the basis of holdings of so-called governance tokens whose acquisition and distribution vary. For instance, in some cases some token holders maintain a right to veto decisions and in others different quorums are required for changes to go through.

Economic functions, rationales for regulation and mitigants in TradFi and DeFi				Table 2
Function	Rationale for regulation in TradFi and examples	Mitigants in TradFi	Rationale for regulation in DeFi and examples	Mitigants in DeFi
1. Clearing and settling payments to facilitate trade	Systemic externalities (eg for deposit-taking institutions and central counterparties).	Prudential regulation; risk management requirements; deposit insurance; central bank as lender or liquidity provider of last resort.	Systemic externalities (eg for stablecoins); inadequate information and information asymmetries (contents of smart contracts are difficult to assess for consumers).	Clearing is instantaneous in many instances. Yet, no mitigants for stablecoins or other systemic players.
2. Pooling of funds to undertake large-scale enterprises	Information problems; inadequate information and information asymmetries (eg managers know more about their actions than investors and have little incentive to disclose it); economies of scale in monitoring; consumer demand for regulation.	Disclosure requirements (eg prospectuses); minimum standards for product approval; trusted intermediaries.	Information problems; inadequate information and information asymmetries (founders/developers know more about their actions than investors and have very little incentive to disclose it); economies of scale in monitoring; consumer demand for regulation (if the sector grows).	Smart contracts (but quality control lacking); voluntary disclosure (which is likely to be selective) eg white papers.
3. Transfer economic resources through time and space	Systemic externalities; information problems; inadequate information and information asymmetries (eg creditworthiness of counterparty); economies of scale in monitoring; consumer demand for regulation.	Prudential regulation; risk management requirements; repeated interactions; supervision by authorities; central bank as lender or liquidity provider of last resort.	Systemic externalities; information asymmetries (lack of trusted third party requires alternative mechanism); economies of scale in monitoring; consumer demand for regulation.	Smart contracts (but quality control lacking); over-collateralisation; private actors acting as lender or liquidity provider of last resort (but liquidity is finite).
4. Manage uncertainty and control risk	Information problems; inadequate information and information asymmetries (eg credit worthiness of counterparty); economies of scale in monitoring; consumer demand for regulation.	Prudential regulation; risk management requirements; repeated interactions; supervision by authorities.	Information problems; inadequate information and information asymmetries (eg credit worthiness of counterparty); economies of scale in monitoring; consumer demand for regulation.	Smart contracts (but quality control lacking); voluntary disclosure (which is likely to be selective) eg white papers.
5. Provide price information to coordinate decentralised decision-making	Information problems; inadequate information and information asymmetries (eg information about the fundamental value of an asset); economies of scale in monitoring; consumer demand for regulation.	Prudential regulation; risk management requirements; disclosure requirements (eg prospectuses); minimum standards for product approval (eg listing rules).	Information problems; inadequate information and information asymmetries (eg information of fundamental value of an asset); economies of scale in monitoring; consumer demand for regulation.	Smart contracts (but quality control lacking); voluntary disclosure (which is likely to be selective) eg white papers.
6. Deal with incentive problems	Information problems; inadequate information and information asymmetries (eg information about the fundamental value of an asset).	Prudential regulation; risk management requirements; disclosure requirements (eg prospectuses); imposition of minimum standards on people and products.	Information problems; inadequate information and information asymmetries (founders/developers know more about their actions than investors and have very little incentive to disclose it); economies of scale in monitoring; consumer demand for regulation.	Smart contracts (but quality control lacking); voluntary disclosure (which is likely to be selective) eg white papers; over-collateralisation.

Source: Aquilina, Frost and Schrimpf (2024a).

Externalities

While markets can sometimes address information problems through mechanisms that align private incentives with disclosure, they are – almost by definition – less capable of correcting externalities. When private incentives do not align with public objectives, there is little the market can do on its own. As a result, in TradFi systemic externalities are typically mitigated through public interventions. These usually take the form of: (i) the prudential regulation and supervision of financial institutions; (ii) the imposition of risk-management requirements; (iii) deposit insurance for deposit-taking institutions; and (iv) in extreme cases, central banks acting as lenders (or dealers) of last resort.

There is no reason to believe that the dynamics present in TradFi would not apply to DeFi. While DeFi has some risk mitigants embedded in the system – for example, atomic settlement removes the need for separate transaction clearing – there are many areas in which such mitigants are lacking. For instance, certain types of stablecoins used for settling payments in DeFi, particularly algorithmic stablecoins, have proven to be highly unstable. Their failure could have systemic effects within DeFi.[15]

In fact, there are several reasons to believe that some risks are more pervasive in DeFi than in TradFi. The anonymous nature of the blockchain reduces reputational risk, as participants' actions are not linked to real world identities, increasing the incentive to take larger risks. Furthermore, as DeFi loans rely on (typically highly volatile) collateral – and there are no other mechanisms to monitor borrowers or enforce payment – this makes the system inherently less stable. Since wallets are anonymous and cannot be linked to physical or legal entities, loans must be over-collateralised. This creates a pecuniary externality, where any price decline triggers the liquidation of collateral, further depressing the value of tokens used as collateral in other lending applications. As a result, systemic risk is propagated through the system (Chiu et al (2022); Aramonte et al (2021)).

Finally, the interoperability of components within DeFi (the "composability" feature) creates multiple layers of interdependent networks (Kitzler et al (2021)) that are more fragile than isolated networks. In such interdependent networks, the failure of a node in one network can lead to the failure of dependent nodes in other networks. As a result, the failure of a small fraction of nodes in a single network, may have catastrophic effects across multiple networks (Buldyrev et al (2010)).

Information problems

In TradFi, the imposition of minimum standards, the use of intermediaries trusted by consumers (eg financial advisers), mandatory disclosures and supervisory reporting are the typical solutions to problems of inadequate and asymmetric information.

[15] Ahmed et al (2024) present a global games framework to examine how the promise of par convertibility by various stablecoins can fail. They find that increased reserve transparency can heighten run risk if stablecoin holders believe the reserves are of low quality or if conversion to fiat money is inexpensive. Conversely, transparency can reduce run risk when confidence in reserve quality is high or conversion costs are significant. For highly volatile reserve assets, like many crypto-backed stablecoins, par convertibility withstands minor shocks but collapses under substantial negative shocks, even with high initial reserve values.

In crypto and DeFi, part of the system is considerably more transparent given the public nature of the blockchain and smart contracts. But it would be wrong to conclude that information problems are not present. First, the availability of information is not a sufficient condition for its use by consumers and the proper functioning of markets. Information needs to be disclosed in a way that can be processed by consumers and focuses attention on the more important aspects of products and services.[16] Indeed, even TradFi disclosures for retail consumers have focused on providing the information in a manner that makes it more likely that they will act upon it (Smart (2016)). And even in those cases it is not a panacea that will solve all problems. Second, there are very important parts of the ecosystem that are not on-chain and would therefore require similar disclosures to TradFi. The true identity of Dapps developers is often not disclosed so that it is impossible to know what their knowledge and expertise is, whether they have a successful track record or if they have been subject to regulatory action. Similarly, while developers often publish white papers before launching a new project, there is no way to compare the information in multiple white papers, nor is there a way to ascertain the veracity of the information they contain. There is also plenty of evidence that what developers disclose on their websites when marketing their tokens is often not aligned with the specific terms and conditions that purchasers accept when purchasing one.[17]

Furthermore, there are instances in which no amount of disclosure will fully bridge the gap in the information available to different parties to a transaction. A typical example in the DeFi space is rug pulls.[18] Once the developers of a new DeFi project have obtained funds from investors through the issuance of tokens, it is essentially impossible to monitor their behaviour. There is a chance that they will not put enough effort into building the Dapp, or even worse, they may simply disappear with the money raised. The anonymous nature of DeFi increases incentives to do so, given the lack of reputational damage. This problem is present in TradFi, but in that case consumers can at least try to pursue managers through the courts (see Budish (2024)), as they know who they are. In DeFi this is much more difficult.

A conceptual framework for financial stability implications

In the previous section we highlighted that the rationale for the regulation of TradFi applies to DeFi. However, there is an active debate on how to tackle the challenges brought about by crypto. The issue is to correct market failures so as not to choke-off potentially useful innovations, while at the same time reducing risks for market participants and the financial system as a whole.

Aquilina, Frost and Schrimpf (2024b) summarise the ongoing debate by highlighting three high-level strategies that can be adopted which they label “ban”, “contain” and “regulate”. Outright bans are being advocated mainly by those

16 See Brummer (2022) for a discussion of how disclosure could be embedded in DeFi regulation.

17 Bruce et al (2022) highlight substantial misalignment, and in some cases outright contradictions, between what stablecoin issuers state on their front-facing materials (websites, blogs and FAQs) and the legal terms and conditions.

18 A *rug pull* is a scam that is typical of crypto and occurs when a team of developers disappears with the funds after promoting their token, leaving token holders with an asset that has no value.

commentators that believe that crypto and DeFi add little to no value while posing a substantial risk to the financial system and to consumers.

The “contain” approach aims at isolating TradFi from the risks in crypto. Some of the proponents of this approach argue that authorities should “let crypto burn”, and avoid that any regulation could be seen as conferring legitimacy to the sector (Cecchetti and Schoenholtz (2022a)). Others, such as the Basel Committee on Banking Supervision (BCBS (2022)) are more concerned with isolating TradFi from any potential spillover caused by the crypto ecosystem. The “regulate” approach (Makarov and Schär (2022)) typically involves addressing the specific market failures described above in a manner comparable to the regulation of TradFi.

In this section, we focus on the “contain” and “regulate” strategies. This is because we do not believe that a ban would be either desirable or feasible. It would not be desirable because there are indeed aspects of crypto and DeFi that represent useful innovation, shedding light on possible applications and functionalities that could be useful in the future. And it would not be feasible because given its global nature, the industry would easily relocate to jurisdictions that do not impose a ban.

To ascertain how containment and regulation could be deployed, it is useful to start from the four transmission channels from DeFi to the real economy identified by the Financial Stability Board (FSB (2023a)). These are: (i) financial institutions’ exposures to crypto assets, related financial products and entities that are financially impacted by cryptoassets; (ii) confidence effects; (iii) wealth effects stemming from fluctuations in the market capitalisation of cryptoassets; and (iv) the extent of cryptoasset use in payment and settlement. Our view is that are other aspects that are relevant, namely the potential use of smart contracts in TradFi, the risk of so-called cryptoisation for emerging market and developing economies (EMDEs), and the need to safeguard the interest of market participants in DeFi even in the absence of any (significant) spillover into TradFi and the real economy.

Links with TradFi and the real economy

The links between crypto and DeFi on one side and TradFi and the real economy on the other are currently still very limited. However, they have grown in recent years, notwithstanding the numerous booms and busts that the ecosystem has experienced. And if current trends continue, it is likely that they will continue to grow in the future.

A clear example of the increase in such a link is the approval by the US Securities and Exchange Commission (SEC) of exchange-traded funds (ETFs) with underlying assets of bitcoin or ether, in 2024. But crypto-based ETFs are now available in many jurisdictions. This makes it much easier for households to gain exposure to crypto and DeFi and also reinforces the link between the banks and brokers that would sell these products to their clients.

Another element that will drive increased connections between TradFi and DeFi is the tokenisation of real-world assets. Tokenisation is the act of creating a digital representation of an asset and placing it on a distributed ledger (FSB (2023b)). If more assets become tokenised – as seems likely in the future – then the variety of assets that could potentially be traded in the DeFi ecosystem will increase substantially, and the self-referential nature of DeFi will become a characteristic of the past. A much larger set of institutions could start participating and a number of infrastructures that are currently specific to DeFi, such as DEXs, will become part of the mainstream.

As a result of these changes, not only will the existing connections grow in size, but they will evolve in ways that are difficult to predict. There may already be connections in areas that are not immediately obvious. For instance, the drivers of the March 2023 banking stress are difficult to pinpoint exactly. But the indirect exposure of US banks to depositors with large stakes in crypto markets was a contributing factor which took many policymakers and supervisors by surprise.

In terms of prudential regulation, the objective is to make sure that the risks that may be generated by crypto and DeFi do not spill over to crucial parts of TradFi and the real economy, and hence a "contain" approach is warranted. Financial institutions, and especially banks, given the crucial role they perform in the financial system, should have adequate processes in place to determine the risks they are exposed to if they choose to engage with the crypto ecosystem. Importantly, the focus should not simply be on direct losses caused by changes in the prices of these assets.[19] These processes should also encompass any other potential claims on their balance sheets such as the need to post collateral or raise cash at short notice.

While this chapter is focused on the financial services aspects of crypto, a similar approach is reasonable in cases in which blockchains are used outside the financial services sector. A use case that is often mentioned for blockchain is supply chain management (Gaur and Gaiha (2020)). Should companies come to rely on blockchain for these purposes, a similar containment approach looks reasonable, namely such companies should be able to withstand any outages of the blockchains they are using. More widely, all firms using crypto-related services, should be prepared to face the cyber security risk associated with crypto.

Outside the remit of prudential regulation narrowly defined, the increase in links implies that rules that are similar to those that exist for TradFi are likely warranted to protect market participants that will rely on a crypto ecosystem which is more interconnected with the real economy. The functions played by DeFi integrated with TradFi will be equivalent, and hence equivalent regulation would be warranted. This may include enacting appropriate disclosures, imposing know-your-customer requirements on operators and enforcing minimum standards of professional qualification. This will require adequate resourcing for regulatory authorities and may also require new legal powers. For instance, His Majesty's Treasury (HMT (2023)) suggests that a new regulated activity of "establishing or operating a protocol" could be introduced in law.

In essence, making sure that TradFi and the real economy are well prepared for any shock that is generated by crypto is an essential step to reduce overall risks for the economy.

The risk of cryptoisation

In EMDEs there is a further rationale for regulation: the risk that cryptocurrencies could displace the local currency in real and financial transactions, ie the risk of

[19] The Basel Committee on Banking Supervision has already implemented standards on capital requirements for crypto-related exposures (BCBS (2022)).

cryptoisation. This is similar to the existing phenomena of dollarisation and euroisation, in which households and businesses in EMDEs use the dollar or euro for transactions, hold deposits or take out debt denominated in those foreign currencies. Particularly in regions with a history of high inflation, or where trust in the domestic currency is low, it may be attractive for users to hold assets in a more stable currency or to benefit from lower interest rates on loans denominated in that currency. However, this can result in serious macroeconomic problems, such as weakening the monetary policy transmission (as fewer actors in the economy use the domestic currency or respond to domestic interest rates) and causing growth and inflation to depend on monetary policy set in a foreign jurisdiction for that jurisdiction's needs. Borrowing in foreign currency is also risky: as seen in many past episodes, a sudden depreciation of the local currency can lead to a sharp increase in the value of foreign-denominated debt.

Even more so than dollarisation and euroisation, the widespread adoption of cryptocurrencies as a means of payment or store of value may result in macroeconomic instability and inefficiencies. In extreme cases, such as Venezuela and Zimbabwe, where inflation is extremely high, users view cryptocurrencies as a welcome alternative to the national currency. In other cases, users may be attracted by the speculative nature of cryptoassets, and the potential for higher returns on crypto-denominated investments. However, the volatility of cryptoasset prices means that, if cryptocurrencies are widely adopted for everyday transactions, prices could experience significant volatility. In the extreme, if a majority of transactions in a jurisdiction were conducted in cryptocurrency, this could lead to violent swings in price levels and inflation, with corresponding effects on output, driven by speculative demand in the global market rather than domestic economic fundamentals. For example, the attempt to use bitcoin as legal tender in El Salvador in September 2021 was largely unsuccessful (Alvarez et al (2022)).

In practice, several EMDEs already have higher crypto adoption than advanced economies. Chainalysis (2024) estimated that crypto adoption was highest in India, Nigeria and Indonesia. In these countries, users may want to bypass the existing financial system and domestic currency, for both real transactions and speculative purposes. They may also use FX-denominated stablecoins (eg USD or EUR) for real transactions, representing a new vector for dollarisation and euroisation. If cryptocurrencies or stablecoins become widely used for real transactions, any disruption in these assets could transmit across the economy. As a result, authorities may wish to discourage the use of crypto through regulation, capital controls and tax measures.

Safeguarding market participants in the DeFi ecosystem

In the discussion above, we focused on how to manage the risks that DeFi and crypto pose for TradFi and the real economy. Here, we focus on how to tackle issues in the crypto and DeFi ecosystem, itself, in particular around safeguarding investors and other market participants.

Had DeFi remained a very niche activity in which only a limited number of agents were active, regulators could have remained tolerant of the complete lack of regulation of the system. They could potentially have just tried to discourage participation by issuing consumer warnings and highlighting the very high-risk nature of the system. However, as the number of investors and the amount of money they invest reached a critical mass, investor protection elements have become a significant concern for regulators (Auer et al (2023); Cornelli et al (2023)).

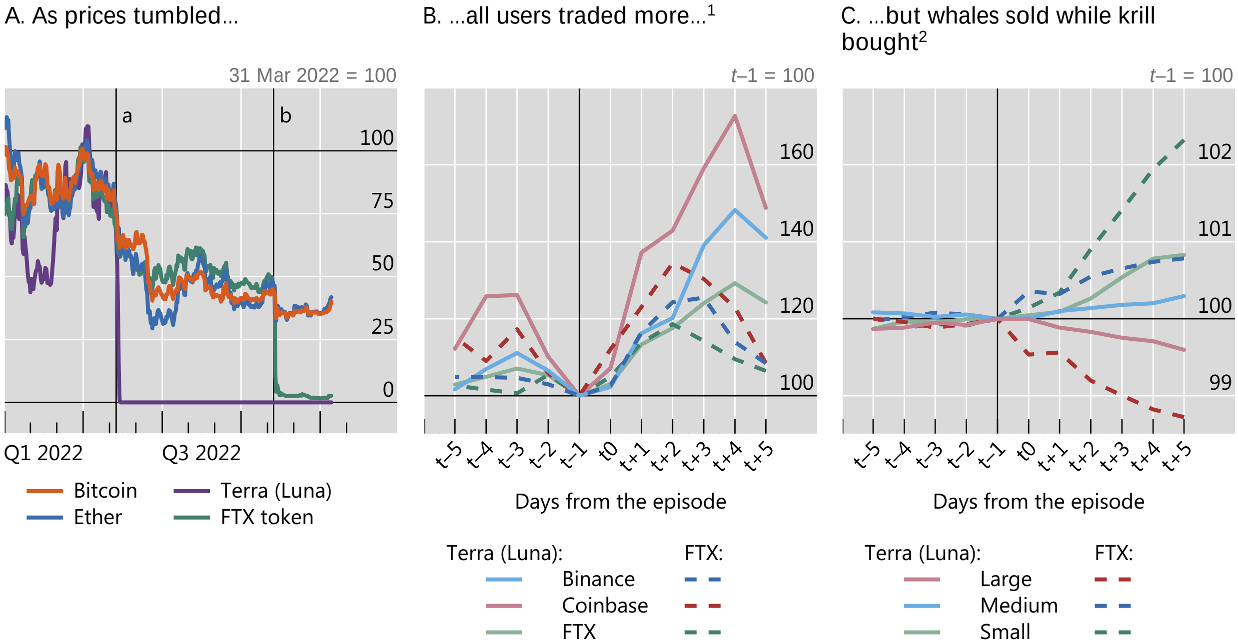
A key starting point is to base the regulation of DeFi on the economic functions that each protocol enables. Mapping these functions to specific activities and entities, authorities should determine where new rules are needed and then develop those by taking into account the challenges associated with the decentralised nature of DeFi. It would be useful to analyse the entities (and persons) exerting de facto control of a DeFi protocol and, for the majority of retail consumers, the Dapps that represent the entry point to the ecosystem.

A potential approach is to base new rules on two main pillars (Aquilina, Frost and Schrimpf (2024a)). The first pillar deals with rules that require information that is not easily available on-chain and would have to be essentially equivalent to the approach used in TradFi. For instance, minimum standards could be imposed on products and services before they can be commercialised. Alternatively, and perhaps additionally, minimum requirements for the skills and expertise of people providing such services (eg developers and the management of foundations) could be appropriate. The second pillar exploits the fact that a considerable amount of information is available on-chain and that smart contracts can automatically execute a pre-determined action. Regulation could then be embedded in smart contracts to make sure that rules were met. Examples of where such an approach could work in practice include ensuring that smart contracts were executed in line with the status of the ledger, that the disclosure of information took place or that "best execution" requirements have been met and transactions took place close to the best available prices.

A further aspect to be considered is the stability of the crypto ecosystem. Should authorities be worried about the stability of crypto over and above the role it may have for TradFi and the real economy? Our view is that the answer is yes, as crypto has reached a critical mass. In particular, authorities should be concerned with the role of stablecoins. As described above, these instruments have become the means through which participants transfer value within crypto. It will therefore be crucial that stablecoins can keep their promise of maintaining dollar parity in all circumstances. This will require specific regulation of the type of assets that stablecoin issuers can invest in, as well as operational issues to make sure that the exchange of stablecoins for dollars can take place even in stressed market conditions.

A final aspect to be considered is consumer protection. As noted above, retail investors have often chased recent returns, resulting in large increases in crypto trading app downloads in periods of high or rising bitcoin prices and drops when the market cooled. But beyond this, there is evidence that retail investors have systemically lost out relative to wealthier investors. As prices tumbled in 2022, users actually traded more (Graphs 4.A and 4.B). Most disturbingly, large bitcoin holders ("whales") were selling as ordinary retail investors ("krill") were buying (Graph 4.C). This implies that the crypto market, which is often presented as an opportunity for inclusive growth and financial stability, can be a means for redistributing wealth from the poorer to the wealthier.

In stormy seas, "the whales eat the krill" Graph 4



[a] TerraUSD and Luna collapse, 8 May 2022. [b] FTX collapse, 7 November 2022.

[1] Based on daily active users of crypto exchange apps. [2] Based on the number of bitcoin held. Addresses with a balance of less than 1 bitcoin (small), between 1 and 1,000 bitcoin (medium) and more than 1,000 bitcoin (large).

Sources: CoinGecko; IntoTheBlock; Sensor Tower; authors' calculations.

Conclusions

This chapter has analysed the economic functions of cryptocurrencies and DeFi, comparing them with TradFi. It showed that the underlying economic drivers are not different in DeFi than in TradFi, but that the distinctive features of DeFi – such as smart contracts and composability – introduce new challenges and the need for proactive regulatory interventions to safeguard financial stability, while fostering innovation.

As the DeFi ecosystem continues to evolve, several areas warrant deeper exploration. First, the interaction between DeFi and TradFi needs more attention, especially as tokenisation of real-world assets, the use of smart contracts in TradFi and new forms of digital intermediation emerge. Research could focus on understanding the potential systemic risks if DeFi becomes more integrated with TradFi, particularly in critical sectors like banking and insurance. Second, the role of stablecoins in supporting DeFi's growth and the risks posed by their instability require further analysis, spanning both the stability of the DeFi ecosystem itself and its potential spillovers with TradFi. Developing robust frameworks for assessing the resilience of stablecoins and other crypto assets in different market environments is crucial. Third, the regulatory implications of fully decentralised protocols and DAOs is an open area of research. There is a need to explore how governance structures of DAOs may influence financial stability and how regulators might engage with truly decentralised systems. Finally, the potential macroeconomic implications of cryptoisation in EMDEs must be fully understood. Investigating how new forms of central bank money, capital controls and taxation policies can counter the risks of widespread crypto adoption while still fostering technological innovation will be essential. These areas of research are key to shaping a safe and inclusive financial landscape.

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