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DP17810

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BANKING AND CORPORATE FINANCE

CEPR

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Discussion Paper DP17810
Published 16 January 2023
Submitted 16 January 2023

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www.cepr.org

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Abstract

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JEL Classification: E42, E51, E58, F31, G28, L50, O32

Keywords: Decentralisation, Cryptocurrency regulations, Blockchain, Cryptocurrencies, Financial intermediation

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Decentralised finance (DeFi): a functional approach

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Abstract

“Decentralised finance” (DeFi) refers to a range of applications in the crypto-asset space that seek to disintermediate the provision of financial services through reliance on self-executing computer code (“smart contracts”). DeFi has so far been mainly self-referential in that it has largely facilitated the financing and trading of crypto-assets rather than providing intermediation services to support real economic activity. Yet this may change in the future, should asset tokenisation and/or the use of DeFi applications by existing financial institutions lead to greater interconnections with traditional finance (TradFi). We argue that many of the functions that DeFi tries to mimic are similar to those in TradFi, and so are many of the risks that this intermediation entails. The same economic rationale that has guided financial regulation for decades can hence be applied to the crypto and DeFi world as well. Risks are, however, often exacerbated in DeFi by the severity of market failures (externalities and information asymmetries). Having compared the functions performed in TradFi and DeFi, we show how regulation to protect consumers, maintain market integrity and ensure financial stability applies to DeFi. Finally, we sketch a possible approach to the regulation of DeFi that takes into account its specificities and functions.

Keywords: DeFi, cryptocurrencies, blockchain, distributed ledger technology, regulation.

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Acknowledgements: We are grateful to Peter Andrews, Raphael Auer, Chris Brummer, Stijn Claessens, Agostino Capponi, Marco Dell’Erba, Marc Farag, Sebastian Doerr, Priscilla Koo Wilkens, Gordon Liao, Bénédicte Nolens, Livia Onorati, Antoinette Schoar, Hyun Song Shin and Nikola Tarashev for helpful comments and suggestions. The views expressed in the paper are those of the authors and not those of the BIS. Any errors and omissions are the authors’ own.

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1. Introduction

Decentralised finance (DeFi) is an umbrella term used to describe a number of services in the crypto space that seek to mimic functions of the traditional financial system without financial intermediaries. In DeFi the role of intermediaries is taken over by computer code (so-called “smart contracts”) interacting with blockchains.¹

DeFi can be seen as the continuation of a trend on the digitisation of financial markets that started more than fifty years ago. Back then, Fischer Black (1971) suggested that computers could eventually replace human market makers when intermediating trades on a stock exchange. Today, for almost the totality of spot FX, futures and options, and for a growing share of corporate bonds and government bonds, trading requires little human intervention. The human specialist has been replaced by computer code, developed either by the “new kids on the block”, namely principal trading firms, or by the “e-trading” desk of traditional broker dealers.

This transformation has not been confined to trading, and a similar trend by which computers replace traditional intermediaries is apparent other areas of finance. Access to cash and banking services has been completely transformed, from the then first cash machine installed by Barclay’s bank in north London in 1967 (Batiz-Lazo, Reid and Robert, 2008) to the banking apps available on smartphones in advanced economies (Frost, 2020), the mobile money transfer services available in many African countries (Suri and Jack, 2016) and the recent Pix payment services developed by the Central Bank of Brazil (Duarte, et al 2022). The enabling forces are multi-faceted, but the availability of cheap computer power and the invention of the internet probably stand out as the most relevant. The development of crypto and DeFi in turn required additional technologies, such as improvements in cryptography, the development of distributed ledger technology (DLT) and blockchains as well as advances in computing power and connectivity. With the invention of means to validate transactions without the need for a trusted, centralised third party, crypto-assets were born.

From one perspective, some aspects of the digitisation of financial markets can be seen as the continuation of a trend that embeds innovative technology in the traditional financial sector (TradFi) and improves its efficiency. This perspective is additive to the existing financial system and by its very nature does not require a fundamentally different approach to regulating financial services. But this is not the perspective of most DeFi proponents. They see DeFi as a paradigm shift that completely alters the way in which financial services are provided and see regulation essentially as a potential risk (Harvey et al, 2021). The idea that each individual should be free to decide what to do with their money, and that regulators should not intervene, is deeply embedded in the ethos of large parts of the crypto community. In fact, the underlying philosophy of Bitcoin and of the blockchains that followed it has been that access to its services should not be subject to the control of a central authority and hence that rules and regulations would not be welcome. For instance, this is how Ethereum – the blockchain on which most DeFi applications are built, describes itself on its website:²

“Ethereum is a technology for building apps and organizations, holding assets, transacting and communicating without being controlled by a central authority”

and it goes on:

¹ A blockchain is a form of distributed ledger technology (DLT) in which details of transactions are added to the ledger in the form of blocks of information through a defined validation process. DLT networks are called “public” or “permissionless” if any entrant can serve as a validator or node in the network (ie without permission). See Boissay et al (2022).

² <https://ethereum.org/en/what-is-ethereum> retrieved on 21 December 2022.

“Transactions directly connect sender and recipient without having to deal with any central authority. Nobody else will have access to your funds and nobody can tell you what services you can use” (emphasis in the original).

So far, DeFi has largely facilitated activities within the crypto financial system rather than real economic activity. Due to this self-referential nature, the 2022 turmoil in crypto and DeFi did not have adverse effects outside the system. But given the demonstrated ability of the crypto ecosystem to recover from previous lows, the long-term trend in the increasing use of digital technology in finance, and the appeal of some of its innovative aspects, it is conceivable that DeFi in some form will stage a comeback in the future. Two catalysts for such changes could be a pick-up in the tokenisation of existing assets³ and the use of smart contracts and decentralised applications (DApps) in activities carried out by TradFi institutions. Connections with TradFi and interlinkages with the real economy could therefore increase in the future, giving rise to greater scope for spillovers of financial stability risks. When that happens, it is important that authorities are ready to face the challenges that DeFi may bring with it.

There is an active debate on how to address the risks from crypto and DeFi (Aquilina, Frost and Schrimpf, 2023). Several voices are advocating outright bans of specific activities, arguing that these add little economic value and impose risks on the overall financial system. Another policy approach is to contain the crypto ecosystem, limiting the interlinkages with TradFi in the hope that risks from crypto and DeFi will not spill over. Advocates of this approach may hope to “let crypto burn”, and avoid that any regulation could be seen as conferring legitimacy to the sector (Cecchetti and Schoenholtz, 2022b). A third approach is to regulate crypto and DeFi (Makarov and Schoar, 2022), addressing specific market failures in a manner comparable with financial regulation elsewhere. In addition to these approaches, public authorities can work to build alternatives and address existing frictions in TradFi, for instance by enabling financial innovation built on central bank digital currencies (CBDCs) and tokenised deposits.

If authorities decide to regulate DeFi, a key starting point would be to base it on the economic functions it enables. In this paper we make the case for regulation of DeFi based on first principles. Even taking at face value the assertions made by DeFi proponents – who argue that the replacement of intermediaries with code is a game changer – the rationale for the regulation for services provided in DeFi applies largely in an analogous way as in TradFi. Many of the functions that DeFi attempts to fulfil are akin to those of the TradFi system, and so are the underlying issues that require regulation (even if some manifestations take a different form from that in TradFi). The latter is regulated precisely because, if the system were left untouched, outcomes for consumers, market participants and the overall system would be suboptimal. To correct for market failures, societies therefore impose constraints on entities and activities to enhance consumer protection, the integrity of markets and the stability of the overall system. The same rationale applies even more forcefully to DeFi, where many of the market failures are more serious than in TradFi.

There can be no doubt that regulation will, by its very nature, require that some characteristics of DeFi will have to change or even disappear, and that DeFi will have to row back on its libertarian ethos. A regulated DeFi sector requires accountable actors and supervisors that can intervene and potentially limit which services can be sold and used by entities and individuals. Together with other factors, this means that decentralisation in its purest form is, in our view, ultimately untenable. Economic activity without accountable parties (including those anonymous or pseudonymous at the time of the transaction) would not be compatible either with legal frameworks for regulation nor the economic rationale for these frameworks, and would be likely to face systemic shocks that will derail their long-

³ Tokenisation refers to the creation of a digital representation of an asset (a token), usually on a blockchain. This can include real assets, such as houses, cars or livestock; financial assets such as stocks, bonds and deposits; and other crypto-assets (eg “wrapped” Bitcoin or Ether).

run development. By contrast, a sound regulatory approach that addresses market failures and serves the public interest would help to promote more sustainable innovation.

A key starting point to operationalise the regulation of DeFi is to analyse in detail the functions performed by DeFi and map them to specific activities and entities (centralised and decentralised). The next step would be to assess which ones may already be captured by existing rules for TradFi and, in this case, make sure these are followed. If the activities require amended rules, then these should be developed accordingly and appropriately enforced by regulatory agencies who will need to think creatively about the practical challenges, develop the appropriate capabilities and devote resources to this activity. A useful starting point could be the entities (and persons) exerting de facto control on a DeFi protocol.

To account for the specific characteristics of DeFi, we suggest that a potential approach to these new rules is to base them on two main pillars. The first pillar is analogous to the regulation of TradFi and deals with rules that require information that is not easily available on-chain. One example is the imposition of minimum standards on products and services before they can be commercialised, minimum requirements on the skills and expertise of people providing such services (eg developers, the management of foundations), ensuring that customers are protected. Another example is to require the fulfilment of any prudential requirements (eg admissible leverage and liquidity transformation performed by DeFi protocols and similar centralised entities) pre-launch. The second pillar is specific to DeFi and can exploit the fact that a considerable amount of information is available on-chain and that smart contracts can automatically execute an action in response to an input. 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 did take place or that 'best execution' requirements have been met and transactions did take place close to the best available prices. These pillars are relevant not only for existing DeFi innovation based on permissionless blockchains, but also for any future activities based on permissioned DLT, CBDCs and tokenised deposits.

The rest of this paper is structured as follows. Section 2 briefly describes the main characteristics of DeFi. Section 3 outlines a functional approach to financial services and applies it to the DeFi sector. Section 4 describes the economic rationale for regulating DeFi. Section 5 suggests a tentative way forward for regulation and Section 6 concludes.

2. What is DeFi?

DeFi can be generally defined as financial applications run by smart contracts on a blockchain (Aramonte, Huang and Schrimpf, 2021; Carter and Jeng, 2021). It can be thought of as comprising four main layers:⁴

1. *Blockchains*, which provide a ledger on which transactions are recorded and become immutable (settlement layer). To date, DeFi is built on public ('permissionless') blockchains, which are accessible to any potential participant, and provide transparency and confidence over the legitimacy of their records thanks to validators. At the time of writing, the largest DeFi blockchains are Ethereum, Binance Smart Chain and Tron. In principle, DeFi applications could also run on permissioned DLT or other technologies that provide comparable functionality.⁵

⁴ See Schär (2021) for a more in-depth description of the layers.

⁵ See Auer, Haslhofer, Kitzler, Saggese and Victor (2022). The authors propose a DeFi stack reference model that starts from the technical primitives that DeFi protocols rely on. In this model, DeFi could use permissioned distributed ledgers. There may also be means of making permissionless DLT resemble permissioned variants, for instance through whitelisting and blacklisting of entities.

2. *Smart*⁶ *contracts* are computer programs stored on a blockchain that are executed when predetermined conditions are met. They automate the execution of an agreement so that all participants can be immediately certain of the outcome, without any intermediary's involvement or time loss. They lay on top of blockchains and are the building blocks of all decentralised applications (DApps).
3. *DeFi protocols* are the result of the combination of various smart contracts and represent the terms, conditions and standards on which a DeFi product is articulated.
4. *DApps* are graphical interfaces which allow users to interact with the underlying protocols.

DApps are the entry point into DeFi for all but the most technically-savvy participants as they allow users to interact with protocols, smart contracts and the underlying blockchains. They are also the layer enabling financial intermediation in this ecosystem.

Since the so-called DeFi summer in 2020 when investment and developments in DeFi took off, a plethora of DApps has been created. They fall mainly into five main categories, which mimic services provided by TradFi.

Decentralised lending and borrowing applications allow users to borrow and lend crypto-assets against interest. As the assessment of creditworthiness is generally not possible due to the anonymity of participants, loans are almost always over-collateralised. A key difference though with TradFi is that the loans in DeFi are as of yet not used to support financing needs in the real economy, but rather support speculating and arbitraging in crypto-assets. As a result, one can describe the system as being rather self-referential.

Crypto-asset trading platforms allow users to exchange crypto-assets for one another or for fiat currency. Only decentralised exchanges (DEXs) which do not rely on a single entity to manage orders and transactions are true DApps. That said, there are also many centralised exchanges (CEXs) which work similarly to their TradFi counterparts which at present attract the bulk of trading volumes. As such, centralised entities, such as Binance, Coinbase and (until its bankruptcy) FTX act as gateways from the fiat to the crypto world, channeling funds to DeFi. Without the existence of CEXs, the growth of DeFi would have been inconceivable.

Asset management and yield farming apps allow users to pool crypto-assets with other individuals through the use of smart contracts and then allocate these funds to a portfolio of crypto-assets. The smart contract ensures that the fund adheres to its predefined investment strategy. Yield farming is a practice that seeks to maximise returns by lending or borrowing crypto-assets across various DeFi platforms. Smart contracts implement complex strategies that involve the shifting of tokens around different DeFi apps and platforms in the attempt to achieve the highest possible returns.

Derivatives and synthetic assets can be set up in DApps in a manner akin to TradFi derivatives. These derivatives take the form of crypto-assets linked to other crypto-assets (or other assets). Rather than relying on a third party, the governance and maintenance of collateral required for the transactions is controlled by smart contracts.

Margin trading DApps allow users to trade on margin (ie against borrowed funds). The management of such margin is regulated by a smart contract rather than by a broker.

⁶ In a seminal contribution on the nature of (animal) intelligence, Romanes (1882) defined intelligence as "*the faculty which is concerned in the intentional adaptation of means to ends. [...] It therefore implies the conscious knowledge of the relation between means employed and ends attained, and may be exercised in adaptation to circumstances novel alike to the experience of the individual and to that of the species.*" More succinctly Bryson (2019) defines intelligence as "*the capacity to do the right thing at the right time*". Smart contracts are therefore not really *smart* in this sense: they do not react to changes in the external environment but simply execute a set of pre-programmed instructions.

3. A functional approach to financial services

In a seminal contribution to the analysis of innovation within the financial system, Merton (1995) argues that rather than focusing on specific institutions and taking the underlying structure as given, one should rather take the economic functions as given and then analyse the structure that performs them. This approach has the advantage that the functions performed by the financial system can be thought of as ‘primitives’ that are time-invariant, or at least vary very slowly. Using this approach is helpful to assess whether the innovative aspects of DeFi can fall into the different economic functions and understand what the relevant implications for regulation are.⁷

The key **economic functions** performed by the financial system are to provide:

1. ways of clearing and settling payments to facilitate the exchange of goods and services;
2. mechanisms for the pooling of funds to undertake large scale enterprises and/or for the subdivision of shares in enterprises to facilitate diversification;
3. ways to transfer resources through time, across regions and across industries;
4. ways to manage uncertainty and control risk;
5. price information to help coordinate decentralised decision-making;
6. ways to deal with 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 the others.

The brief description of DeFi activities in the previous section already suggests that many of these functions are relevant for DeFi. However, as alluded to above, these functions are performed by DeFi almost exclusively within the DeFi ecosystem itself – in other words, DeFi is at present rather “self-referential”. That is, the intermediation ecosystem allows users to trade and invest in crypto assets, but – at least to date – does not support financial intermediation use cases that benefit the real economy.

This subtle difference notwithstanding, the rest of this section presents examples of which specific activities in both the TradFi and DeFi sectors fall into the above categorisation of economic functions. A summary can be found in Table 1.

Clearing and settling payments. In the TradFi system, this function is carried out by financial institutions through the use of money transfers, cash and securities accounts, credit cards and a large set of back-office operations in a plethora of different types of financial institutions that interact with each other as well as with individuals and corporates. Specific arrangements vary considerably across markets and include the use of collateral, the provision of short-term credit (between clearing and settlement) and the use of central counterparties. The system is ultimately underpinned by central banks that provide access to settlement services to banks (and other e-money providers) and supervise many of the service providers in this space.

In crypto and DeFi, the provision of an alternative way to send payments directly from one party to another without the need for intermediation has been arguably the main vision from the beginning.⁸

⁷ This approach also reduces the risk of an analysis that favours incumbents as they are by definition more heavily represented in the existing system.

⁸ Indeed, the provision of an alternative way to send payments directly from one party to another without the need for intermediation has been the stated aim of bitcoin from the beginning (see Nakamoto (2008)). Bitcoin has failed to provide this function given its highly volatile value when measured in units of fiat currencies as well as other technological

As the sector evolved, however, a number of alternative blockchains have emerged which attempt to improve on the Bitcoin blockchain. At the time of writing, Ethereum is the dominant of these for DeFi applications, followed by Binance and Tron. Yet it is worth noting that, while the clearing and settlement infrastructure is provided by the underlying blockchains, the unit of account for transactions is often represented by stablecoins – cryptocurrencies which aim to maintain a stable value against a major currency (the US dollar in most cases) or other safe assets such as gold (Arner et al, 2020). In practice, DeFi needs a TradFi anchor to function properly. And again, without (for the most part centralised) stablecoins providing a bridging function to the fiat world, it is inconceivable that DeFi would have ever attained any scale.

Table 1: Economic functions and activities in TradFi and DeFi

Function	TradFi example	DeFi example
Clearing and settling payments to facilitate trade	Payment systems, deposit accounts, e-money, cards, central counterparties	Bitcoin network, other blockchains (eg Ethereum, Solana), stablecoins, automated market making (AMM)
Pooling of funds to undertake large-scale enterprises	Stocks, bonds, mutual funds, exchange-traded funds (ETFs)	Asset management DApps, DeFi tokens, governance tokens
Transfer economic resources through time and space	Loans, mortgages, pension funds, mutual funds, etc	Lending DApps, flash loans, asset management DApps, smart contracts
Manage uncertainty and control risk	Loans, insurance contracts, derivatives, hedging strategies	DeFi insurance, derivatives, hedging strategies, smart contracts
Provide price information to coordinate decentralised decision making	Exchanges, trading activities, derivatives	DEXs (and CEXs), AMM, trading activities, crypto derivatives
Deal with incentive problems	Risk management, repeated interactions with the same known counterparties	Smart contracts, overcollateralisation

The clearing of transactions in DeFi does not rely on counterparties but on what is referred to as atomic settlement, ie the simultaneous exchange of two assets conducted through a smart contract. In some cases, this is facilitated by automatic market making (AMM) (Capponi and Jia, 2021; Lehar and Parlour, 2021; Park, 2021). AMM protocols allow traders to exchange one crypto-asset for another automatically on a blockchain. They build on the idea that traders can become liquidity providers by making their crypto-assets available in liquidity pools. Other traders demanding liquidity in turn can use the protocols to buy or sell the crypto-assets in the pool, with relative prices set on the basis of quantities.

Pooling of funds. Pooling resources to invest in large projects is a fundamental feature of TradFi. This provides advantages for investors such as the superior liquidity and higher diversification of pooled

inefficiencies. As such Bitcoin has rather served as a speculative investment or a store of value, whereas stablecoins tied to fiat currencies have strived to be better usable for payment purposes.

investment. It also provides benefits for entrepreneurs who can use the funds to finance their projects and for the economy as a whole which can deploy much higher amounts of capital for productive activities. Mutual funds are a primary example of how the pooling of resources takes place in TradFi, and date back to at least the 18th century in the Netherlands (Rouwenhorst, 2005). Through the use of such tools, investors can provide capital to entrepreneurs and trade in much smaller blocks than it would be possible without them.

Similar tools have been developed in DeFi. Asset management DApps allow institutional and individual investors, investment clubs and companies to allocate their capital to different applications in a seamless way. This replicates the function of mutual funds in the TradFi space. However, at least to date there is little evidence that the funds invested in asset management DApps have contributed to productive investment outside the crypto sector. On the contrary, they have rather been confined to allocating resources from one DApp to the other, thereby fuelling speculation.

Another example of the pooling of funds to carry out large projects in DeFi is the issuance of new tokens at the early stages of a new DApp, as in initial coin offerings (ICOs); this is economically similar to the issuance of stocks and bonds in TradFi. Yet in practice, ICOs – due to a lack of regulation in the “Wild West” phase – have been subject to large-scale fraud, inaccurate disclosure and poor capital allocation. This is because they are ultimately high risk ventures but suffered from inadequate disclosure of information and lack of clarity on initiators and backers (Swartz, 2022; Zetzsche, Buckley, Arner and Fohr, 2019).

Transfer economic resources thorough time and space. Several financial activities serve to transfer economic resources through time and space, thereby bringing savers and investors together, ultimately helping with consumption smoothing and fostering investment. This includes inter alia lending and borrowing activities or mutual funds which give investors the opportunity to allocate their capital to different countries and industries. Indeed, it may be argued that the ability to do so is a core function of TradFi and a key source of societal benefit.

Similarly, in DeFi, the ability to borrow and lend different tokens (in most cases to arbitrage price differences) is a common feature of many DApps- even though such loans are mostly used for gearing rather than the consumption smoothing purposes that Robert Merton had in mind. Such lending has some specific characteristics however, first given the anonymity of users DeFi loans require collateral and second, loans typically do not have fixed maturities and can be repaid at any time. In addition, as discussed above, it is also possible to invest in different projects using asset management protocols.⁹

Manage uncertainty and control risk. Securities and derivatives markets and – especially – insurance markets in TradFi are key examples of activities used to manage uncertainty and transfer risk across the system. Risk management can take the form of hedging, by entering into transactions that reduce or eliminate a future risk (eg the purchase of an option); diversification which allows the reduction of the variance of returns while preserving their mean; or insurance where the risk is transferred to a counterparty in exchange for the payment of a premium.

In the DeFi space, a number of similar services are present that strive to fulfil a similar function. Hedging activities do take place on DeFi exchanges where market participants can enter into transactions to reduce their risks. Protocols also exist that let agents enter into derivatives transactions where payoffs depend on specific states of the world. Similarly, there are some insurance protocols that

⁹ A new type of loan that is only possible in DeFi is a flash loan. This is a particular type of loan that exploits the fact that it takes time to add one block to the blockchain of transactions and that smart contracts can provide atomic settlement. In a flash loan an agent borrows assets and must return them before the next block is added to the chain. If the agent fails to do so, then the initial transaction is not added to the chain and it is as if the loan never happened in the first place. Flash loans are thus fully dependent on blockchains being slow compared to computer time. In many aspects of TradFi where trading takes place in milliseconds or even microseconds flash loans would not be feasible. Currently for example a new block is added to the Ethereum blockchain every 11 seconds and hence it is possible for arbitrageurs to use flash loans.

allow DeFi participants to protect themselves against DeFi-specific risks such as code bugs or hacks that may result in losses.

Provide price information. Many of the prices determined in traditional financial markets, on the basis of the trading activities of market participants, are crucial determinants of the actions of economic agents in the real economy. Interest rates on risk-free bonds such as US Treasuries are crucial for the valuation of other assets, and interest rates are used by households and firms in their daily activities (eg in deciding whether they should borrow money to buy their house). Stock prices are used by asset managers in their capital allocation decisions and futures and options prices are crucial inputs for the risk management of firms across the economy. The process of “price discovery” involves the aggregation of information from different actors and across different trading venues (see eg Hasbrouck, 1995).

Similar activities that facilitate the provision of price information have been replicated in the DeFi space. Prices of DeFi assets are crucial in determining the behaviour of participants within the DeFi space: for instance, the arbitrageur trying to reduce price differences across exchanges, the liquidity provider deciding which tokens to concentrate on, and the asset management DApp deciding to allocate its funds all rely on DeFi asset prices in its decision making. In most cases, this information is publicly available for anyone with the requisite technical capabilities to see. In the future, if DeFi becomes more mainstream or more interconnected with TradFi or the real economy, DeFi prices may become more important for the coordination of decentralised decision making in the real economy as well. The major difference, however is that, for the time being, prices of DeFi (or crypto-assets more generally) only have a very limited impact on the real economy.

Deal with incentive problems. Incentive problems arise in financial markets because parties to financial transactions usually cannot easily observe each other’s actions and because enforcement mechanisms are not costless to use.¹⁰ TradFi has developed a number of tools to mitigate such problems. These include the development of long-term relationships between different economic agents, so that participants to a transaction can learn about each other (eg the counterparty’s creditworthiness) in repeated interactions. Other means include the development of complex contracts that attempt to align the long-term incentives of the different parties to a transaction. Nonetheless, because it is not possible to determine all states of the world in advance, “contract incompleteness” (Coase, 1937) is a key economic reason for why business activities are performed by centralised entities, ie firms, rather than in a decentralised way. This leads Aramonte et al (2021) to argue that decentralisation in DeFi is a misnomer and that some forms of centralisation are inevitable.

The underlying problems apply *mutatis mutandis* to DeFi but, given the differences in the underlying technology, some of the solutions are not available. In particular, given the anonymity (or pseudonymity) of DeFi wallets it is simply not possible to establish comparable long-term relationships among participants.¹¹ Hence, to mitigate incentive problems all DeFi transactions that require the extension of credit are considerably over-collateralised so that lenders have access to assets if borrowers do not make good on their promises (Aramonte, Doerr, Huang and Schrimpf, 2022). In addition, the actions taken by DeFi agents are hard-coded into smart contracts and cannot be modified by market participants even if they wanted to. This avoids incentive problems but it also implies that there is no flexibility to adapt to changing situations which however are a constant feature of business life. In TradFi the institutional environment has adapted to account for such changes through governance arrangements and legal frameworks. Of crucial importance here has been the development of a judicial system that can adjudicate in case of disputes etc.

¹⁰ The relevance of information issues for incentive problems is discussed in detail in Section 4.

¹¹ Some DeFi protocols have implemented a process of credit delegation, where a depositor can delegate borrowing power (ie provide loans) to other users they trust. The loan can either be agreed off-chain or on-chain via smart contracts. Indeed, this implies that DeFi needs to do away with anonymity to allow these transactions to exist. These transactions are then economically equivalent to peer-to-peer lending ones that take place in TradFi.

Hence while the technology used and the market participants differ, the underlying functions performed by TradFi and DeFi are not dissimilar (see also Allen, 2022 and Cecchetti and Schoenholtz, 2022a). This implies that the basic rationale for the regulation of TradFi and DeFi does not differ substantially. The challenge is to allow genuine innovation, while at the same time ensuring that the new technology does not harm consumers or result in large-scale stresses that could endanger market functioning or have negative repercussions on the economy as a whole.

Merton (1995) uses a simple analogy of how one could regulate a newly designed high-speed passenger train. He assumes that, if the train used existing tracks, it could crash and damage the innovator (who would not be able to reap the rewards of the innovation), the passengers (who would be wounded in the crash) and the system as a whole (as the tracks would be damaged). A simple policy of imposing a low speed limit ensures safety but it does not enable innovation and is not optimal in the long term. A more appropriate policy would be to facilitate the upgrade of the tracks, impose a temporary speed limit until the upgrade has been completed and then let the high-speed train use the tracks.

With DeFi, regulators are facing a similar issue. Some aspects of the technology (eg more efficient clearing and settlement, easily auditable software) could provide real benefits – either in the DeFi sector, or through adoption by TradFi – and they should not be lost. Yet the risks should not be underestimated either. To use a different analogy, and one which is more aligned with the present, one could think of DeFi protocols and apps as *self-driving financial institutions* (Brooks, 2021). Many of the decisions to be taken are hard-coded in smart contracts and will be executed autonomously. This raises some core issues: when things go wrong, who is responsible to make them right, to pay redress when due and to be ultimately accountable to society as a whole? ¹²

While the need to regulate DeFi is shared by some parts of the industry,¹³ several commentators have argued that there is less (or in some cases no) need to regulate DeFi. Harvey et al (2021) only discuss regulation as a potential “risk” to the DeFi environment itself; and the ethos of large parts of the crypto community is that the access and use of blockchains should not be subject to the control of a central authority and hence that rules and regulations would not be welcome as the quote from the Ethereum website in the introduction shows.

Yet regulation in the financial system exists because societies have implemented frameworks designed to prevent important societal harms that have emerged repeatedly over centuries. The next section discusses why, if DeFi wants to mature and play a non-trivial role in the modern financial system, regulation will be required. It shows that the economic rationale for the regulation of TradFi applies to the DApps that have been introduced so far – and will apply to those that will be introduced in the future – as the underlying economic forces at play are not different.

4. The economic rationale for financial regulation in DeFi

The main – but not the only – economic rationale for the regulation of financial intermediation activities is the presence of market failures, ie features that result in suboptimal outcomes which can in principle be improved upon with a policy intervention.¹⁴ Market failures can be characterised into two broad sets,

¹² In a video, SEC Chairman Gary Gensler uses a different analogy to make a similar point, in his view arguing that no regulation is needed in the crypto space because of the different technology would be akin to arguing that drivers of electric cars do not need a seatbelt because they do not use gas. See [What Are Crypto Trading Platforms? | Office Hours with Gary Gensler](#).

¹³ See for instance GBBC Digital Finance (2022).

¹⁴ See Goodhart et al (1998) and Llewelyn (1999) for an in-depth discussion of the rationale for the regulation of financial markets. We use a similar approach in this section.

namely information problems and externalities.¹⁵ Information problems arise either when the available information is not adequate for market participants or when one party to a transaction has access to a different set of information either before or after the transaction has been completed. Externalities are indirect costs or benefits that impact a party other than those involved in a transaction and in financial markets they can result in outcomes where the process of intermediation grinds to a halt.

On top of market failures, there are at least two additional economic rationales for the regulation of financial markets. These are the existence of economies of scale in monitoring financial firms and markets, and the existence of consumer demand for regulation.

Financial regulation is often also categorised on the basis of the objectives it attempts to achieve. Typically, there are three: first to give consumers of financial services an appropriate degree of protection; second to have markets that work effectively and orderly – often referred to as market integrity and, third to ensure that the financial system as a whole is stable.

This section describes in more detail the rationale for financial regulation. It shows why it is not confined to TradFi and which mitigants are present both in TradFi and DeFi (summarised in Table 2), highlighting the inadequacy of those currently present in DeFi. It also discusses which tools are typically used in TradFi – and could therefore potentially be used in DeFi – to achieve the objectives of financial regulation (summarised in Table 3).

Information problems

Economists have long known that market outcomes can be sub-optimal in the presence of information problems¹⁶ and that public intervention can, in principle, lead to better outcomes in these cases.¹⁷ Information problems can take two forms: (i) inadequate information on some of the characteristics of the products or (ii) information asymmetries, where a party to a transaction knows more than the other even before or after the transaction takes place.

Inadequate information

The lack of adequate information can be the result of the lack of incentives of firms to properly highlight the characteristics of their products,¹⁸ or be related to the specific characteristics of financial products. These are often complex, their quality depends on a number of attributes and, in contrast to many goods whose quality will become apparent soon after they are bought, the quality of many financial products will only be revealed a long time after purchase.

In DeFi, the functions are very similar to those in TradFi, so the same issues are present. Can an investor trust the development team behind a new DApp? How will a specific smart contract behave as the underlying economic situation evolves and its inputs change? Is the code embedded in the contract going to do what counterparties expect it to do if an oracle malfunctions?¹⁹ Where would the money flow if one of the external inputs such as those in oracles changes unexpectedly? These are all examples

¹⁵ Behavioural biases – ie departures from the assumption of consumer rationality – are sometimes categorised as an additional form of market failure (Erta et al 2013). They are indeed important and an additional reason why regulation may be necessary, but they are characteristics of market participants and vary little by function. We therefore do not focus on them here.

¹⁶ See Stiglitz (2017) for an excellent review.

¹⁷ Whether public intervention is beneficial in practice depends on the existence of tools that can correct the information problem and crucially on the costs of implementing these tools being lower than the benefits they deliver to society.

¹⁸ Gabaix and Laibson (2006) show that firms have no incentive to disclose their prices in the presence of myopic consumers.

¹⁹ An oracle is a service that enables smart contracts to access off-chain data (eg on certain market price movements) that are needed to determine the action that a smart contract must take.

of how information is not fully adequate and of questions that will be asked by consumers before they can confidently choose which products to use and where to invest their money.

Table 2: Economic functions, rationales for regulation and mitigants in TradFi and DeFi

Function	Rationale for regulation in TradFi and examples	Mitigant in TradFi	Rationale for regulation in DeFi and examples	Mitigants in DeFi
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 (content of smart contract is difficult to assess for consumers)	Clearing is instantaneous in many instances. Yet, no mitigants for stablecoins or other systemic players
Pooling of funds to undertake large-scale enterprises	Information problems; inadequate information and information asymmetries (e.g. 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
Transfer economic resources though 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).
Manage uncertainty and control risk; Provide price information to coordinate decentralised decision making; Deal with incentive problems.	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

Information asymmetry

The core issue with information asymmetries is that the different knowledge of the characteristics of a product or service may lead to markets being smaller than they should be, to the quality of products to be less than optimal or – in extreme cases – to the complete collapse of markets.²⁰

Information is central to the functioning of financial intermediation in general (Allen, 1990). Hence, it will be central to the functioning of DeFi, too, if it wants to leave its niche of catering to a limited set of participants and become an earnest competitor or complement to TradFi.

Given its novelty, it is complex for consumers to differentiate across products depending on their quality in the DeFi space. Low-quality products can therefore remain on the market for very long periods of time. Indeed, recent experience shows that outright scams can persist for long periods. Furthermore, 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 takes their biases into account and very little chance to compare different providers in the market. Furthermore, the structure of decentralised autonomous organisations (DAOs)²¹ 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.

Potential solutions and shortcomings in TradFi and DeFi

In TradFi, many of the problems related to both inadequate and asymmetric information, are solved or mitigated through mandatory disclosure and supervisory reporting, the imposition of minimum standards or the use of trusted intermediaries (eg financial advisers, brokers). Mandatory disclosure is helpful if the source of inadequacy is the lack of incentive from firms to reveal the appropriate information. But it is not sufficient if consumers fail to act on the information even if it is available.²²

Reasons why this may be the case are because the information is too complex for customers to absorb, or consumers may simply assume that if a product is “allowed” to be on the market then it meets some basic standards. In these cases, the imposition of minimum standards is beneficial as it indicates to consumers that products must fulfil a minimum set of characteristics.

DeFi proponents argue that a considerable amount of information is already disclosed given the way in which the sector works. The code underpinning smart contracts can be accessed and audited by everyone willing to spend the resources necessary to do so and transactions are perpetually available and unmodifiable. But this does not imply that disclosure in DeFi is not required. The mere 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 focus on the more important aspects of products and services,²³ and even in those cases it is not a panacea that will solve all problems.

²⁰ Many of the original models of information asymmetries were developed with financial markets in mind. Rothschild and Stiglitz (1976) show that in the presence of asymmetric information an insurance market may not provide willing buyers with the amount of insurance they desire. Grossman and Stiglitz (1980) show that investors do not gather an optimal amount of information as they will not reap the full reward of doing so. Famously, Akerlof (1970) shows that the market can completely collapse due to adverse selection in markets with asymmetric information and while its most widely known example deals with second-hand cars, the paper describes insurance and markets where honesty matters in depth.

²¹ 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.

²² This is one area where behavioural biases are particularly important. Smart (2016) shows that the way in which information is disclosed - and not simply what information is disclosed - is crucial to change the behaviour of consumers.

²³ See Brummer (2022) for a discussion of how disclosure could be embedded in DeFi regulation.

Another analogy may be helpful in this context. Medicine books are all *transparent* to anyone that has access to a university library. But this does not imply that anyone with access to a university library can be trusted to make decisions on the best treatment for his or her own illness, and even less so for the illnesses of others. Understanding the implications of the information contained in medicine books requires skills that need to be learned through significant human capital investment. Similarly, in DeFi the fact that smart contracts are based on open-source software does not imply that everyone with access to an internet connection will be able to understand and assess their features. And, unfortunately, there is ample evidence that even providing consumers with some financial education may have limited effects on household financial welfare (Willis, 2008). Real expertise simply requires time and effort to be acquired; since this process is costly, it may not be reasonable to expect this of all consumers.

Table 3: Economic functions, regulations in TradFi and its objectives

Function	Consumer protection	Market integrity	Financial stability
Clearing and settling payments to facilitate trade	Minimum standards (eg. constraints on which firms can provide the service).		Prudential requirements (micro and macro); Margin requirements; Deposit insurance.
Pooling of funds to undertake large-scale enterprises	Minimum standards (eg. appropriateness tests); Disclosure requirements (eg. on investment strategy); Reliance on intermediaries and/or advisers	Conduct of business rules (eg. limits on self-trading); Disclosure requirements (eg. if directors transact).	Risk management requirements (eg. constraints on asset quality, liquidity management tools).
Transfer economic resources though time and space	Minimum standards (eg. appropriateness tests); Disclosure requirements (eg. on sensitivity of loans to interest rate changes); Reliance on intermediaries and/or advisers.		Prudential requirements for lenders (micro and macro); Risk management requirements (eg. collateralisation).
Manage uncertainty and control risk	Minimum standards (eg. minimum insurance coverage); Disclosure requirements (eg. on claims ratios); Reliance on intermediaries and/or advisers.	Conduct of business rules (eg. constraints on orders that can be sent to exchanges);	Prudential requirements (micro and macro); Risk management requirements (eg. constraints on asset quality).
Provide price information to coordinate decentralised decision making	Minimum standards (eg. listing rules); Disclosure requirements (eg. prospectuses).	Conduct of business rules (eg. constraints on orders that can be sent to exchanges); Minimum standards (eg. listing rules).	Prudential and risk management requirements for exchanges. Margin requirements.
Deal with incentive problems	Disclosure requirements (eg. on inducements); Reliance on intermediaries and/or advisers.	Minimum standards (eg. minimum qualifications for market participants); Conduct of business rules.	Margin requirements; Collateralisation.

Furthermore, there are important areas of the DeFi ecosystem where appropriate information that could make a difference is not transparent at all. The identity of the developers of DApps 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 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 agree on when purchasing one.²⁴

In some cases, however, full disclosure is just impossible because sellers have inherently more information than buyers on the specific characteristics of their products. In this case, no amount of disclosure at the point of sale will alleviate information asymmetries that are relevant once the transaction has been completed. Rug pulls are a typical example in the DeFi space.²⁵ Once the developers of a new DeFi project have obtained funds from investors through the issuance of tokens, it is very difficult, if not impossible, to monitor their behaviour. There is a chance that they do not put in enough effort in building the DApp, or even worse, they may simply disappear with the money raised. The anonymous nature of DeFi increases the incentive to do so given the lack of reputational damage. In the example of Terra/Luna, the developers were associated with a very similar product (Basis Cash) just a few months earlier. Furthermore, while in TradFi consumers can at least try to pursue managers through the courts, as they know who they are, in DeFi this is much more difficult as in many cases all consumers know is the identification number of a wallet. The problem of “rolling bad apples” (FSB, 2018) in DeFi is substantially worse, as such “bad apples” can reappear more quickly, potentially under pseudonyms. And even if it may be possible to pursue the various foundations underpinning the projects, it can be simply unclear where the liability may lie.²⁶

At present, the imposition of minimum standards and reliance on trusted third parties have little or no place in DeFi. The permissionless nature of blockchains implies that anyone can set up a new DApp without having to meet any standard. While nothing stops users relying on the advice of a trusted third party when making choices in the DeFi space, this clearly runs contrary to the underlying philosophy of decentralisation and of the replacement of financial intermediaries with smart contracts. In Section 5 we discuss how some of these obstacles could be overcome.

Externalities

In financial markets, the behaviour of one part to a financial transaction can have substantial effects on other entities and in some cases on the stability of the system as a whole. The typical example is a so-called cascade of defaults, where the default of a party to a financial transaction triggers the default of other entities.²⁷ For instance, a failing bank can impose losses on other banks thereby causing the banking system to reduce the provision of credit with impacts on growth. But a cascade of bank defaults is not the only source of externalities. As has become clear in past stress episodes, non-bank financial intermediaries (eg insurance companies, mutual funds, clearing houses) can be a source of financial instability, too, through the pecuniary externalities created by deleveraging pressures (Aramonte, Schrimpf and Shin, 2021). Indeed, the so-called “shadow banking” system played a key role in the great financial crisis of 2008, as leverage and liquidity mismatches arose in bank-like activities in financial markets (Gennaioli, Shleifer and Vishy, 2013; Adrian and Ashcraft, 2016).

Although it can be argued that systemic externalities are present across all the functions carried out by the financial system, these are more pervasive in two functions. The first is clearing and settlement of trades, which underpins many markets, and where a failure to clear and settle may have important ripple effects to multiple actors and markets. The second is the transfer of resources through space and

²⁴ 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, FAQs) and the legal terms and conditions.

²⁵ 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.

²⁶ For instance, in the OlympusDAO project, the project creators were only known by the pseudonyms “Zeus” and “Apollo”;

²⁷ For a discussion of the prevalence of systemic externalities in financial markets see Brunnermeier et al (2009).

time, as the provision of credit inherent in this function gives rise to the network of exposures that can collapse following a default.

In TradFi, systemic externalities are mitigated in four ways: (i) prudential regulation and supervision of financial institutions, (ii) imposition of strict risk-management requirements, (iii) deposit insurance for deposit-taking institutions, and (iv) in extreme cases, with central banks acting as lenders (or dealers) of last resort.

A look at centuries of financial history reveals that regulations were introduced in TradFi precisely because the system to prove financial functions is ultimately unstable if private incentives are left unchecked. And there is no reason why the dynamics present in TradFi during shocks would not be present in the DeFi space. In some instances, mitigants are present within DeFi itself – for instance, atomic settlement implies that there is no need to clear transactions and that counterparty risk would be substantially reduced. But in other cases, these mitigants are not present. For instance, stablecoins which are used for settling payments in DeFi have proven to be highly unstable and their failure may well have systemic effects within DeFi. In addition, the lack of regulation – and indeed the events of May and November 2022 – suggest that DeFi will be more likely to be subject to episodes that will threaten its internal stability.

While in 2022 crypto and DeFi were not large enough and not interconnected enough with TradFi to generate negative spillover effects to the real economy, financial stability risks could increase over time as the size and interlinkages grow.²⁸ And there are already signs that the interconnections between crypto and TradFi are growing. In mid-2022, for instance, a number of asset managers announced that they were setting up processes to allow institutional customers to access crypto-assets.²⁹

Indeed, there are several reasons to believe that certain kinds of risk are even more pervasive in DeFi than in TradFi. The anonymous nature of transactions means that reputational risk is likely much lower and thus the incentive to take on larger risks higher. Furthermore, the feature that all loans rely on (usually highly volatile) collateral given that there is no other mechanism to monitor the behaviour of borrowers or enforce a payment makes the system less stable. This is an inescapable consequence of the fact that wallets are anonymous and cannot be linked to physical or legal persons. The need to over-collateralise loans implies that any price decline results in the liquidation of collateral which further depresses the price of tokens used as collateral in other lending applications. In the jargon of economics, a pecuniary externality is present which leads to systemic risk being propagated in the system (Chiu, Yuan and Zhang, 2022; Aramonte, Doerr, Huang and Schrimpf, 2022). Finally, DeFi composability³⁰ gives rise to multiple layers of interdependent networks (Kitzler, Friedhelm, Saggese, and Haslhofer, 2021) which are more fragile than isolated networks. In interdependent networks, the failure of a node in one network can result in the failure of dependent nodes in another network to fail. Hence, the failure of a

²⁸ Levine (2022) puts it well: “Over many centuries a financial system grew up, as an adjunct to the real world. That financial system enabled people to do more stuff in the real world. They could build railroads or semiconductor factories or electric cars, because they could raise money from strangers to fund their activities. They could buy bigger houses, because they could borrow money from banks. [...] Crypto, meanwhile, has built a financial system from first principles, pure and pleasing on its own, unsullied by contact with the real world. [...] And it’s attracted a lot of finance people [...]. And their task is to build back down, step by step, to connect the elegant financial system of crypto to the real world. You’ve built a derivatives exchange, cool, cool. But can a real company use it to hedge a real risk facing its real factory? You’ve built a decentralized lending platform, awesome. But can a young family use it to buy a house? And the answer is, you know, maybe, give it time. The crypto system has attracted a lot of smart people who want to solve these problems, in part because they’re intellectually interesting problems and in part because solving them will make these people rich.”

²⁹ See Financial Times, [Asset managers bet big on crypto despite market rout](#) (12 August 2022)

³⁰ Composability is the interoperability of components within a design system. In DeFi it refers to the feature that Apps and protocols can interact and be stacked on top of each other (sometimes referred to as the “Lego” property).

small fraction of nodes in a single network, may lead to catastrophic effects in multiple networks (Buldyrev, Parshani, Paul, Stanley and Havlin, 2010).

Structural vulnerabilities at play during the turmoil of May and November 2022

Systemic issues within DeFi were forcefully at play during the events of May and November 2022. In May, the algorithmic stablecoin TerraUSD collapsed in just a matter of two days once it became clear that the 20% yield promised on the Anchor protocol for staking TerraUSD coins was unsustainable.

In practice, the arrangement around TerraUSD and its sister coin Luna resembled a Ponzi scheme. The effects of this collapse reverberated through the DeFi – and more generally the crypto – ecosystems resulting in the default of other entities and forcing some of the largest firms in the crypto space to inject their own liquidity into the system.³¹ Indeed, it might have been coincidental but it was revealed after the fact that the people that founded Terraform Labs, the company responsible for the creation of TerraUSD, were responsible for a similar project (Basis Cash) that failed a few months earlier.³² It is unlikely that, in the presence of regulation the same people would have been allowed to set up a very similar project only a few months later and that without anonymity they would have managed to raise the necessary funds to do so.

In November 2022, a similar dynamic resulted from the rapid failure of FTX, then one of the largest centralised CEXs. A number of crypto entities ran into trouble and in some cases had to stop withdrawals. Some commentators argued that the FTX-related events show that DeFi is the solution rather than the problem as the underlying protocols (“true DeFi”) continued functioning and the FTX collapse was most likely due to fraud.³³ The reader will not be surprised that we disagree with this interpretation. First, the functioning of the underlying blockchain is a very low bar to achieve: it would be equivalent to claiming that there were no issues with TradFi in 2008 because phone lines did not stop working. But our view is that such commentators are victims of the *no true Scotsman* fallacy as they are relying on a very limited description of what DeFi represents in practice.³⁴ DeFi is closely intertwined with centralised entities and activities in the crypto ecosystem (Aramonte, Huang and Schrimpf, 2021) and relies on flows of fiat money that these entities intermediate to grow. Without these interactions DeFi would undoubtedly not have gained the scale and prominence it achieved. It would simply be akin to an esoteric hobby, eg enthusiasts exchanging baseball cards. But more importantly, in this paper we have described how the market failures present in TradFi are also present in DeFi and hence that regulation to correct market failures is warranted in both.

At the time of Terra/Luna turmoil, the overall size of DeFi was small (approximately USD 130 billion in total value locked in early May 2022) and it was even smaller in November (at approximately USD 41 billion) when FTX filed for bankruptcy. These effects did not percolate to the real economy. But the crypto ecosystem demonstrated an ability to recover from lows in other occasions and some parts of the technology may well find their way through TradFi and develop additional links with the real economy in the future. In such a scenario, the systemic implications would be much larger.

³¹ See [DeFi’s Existential Problem: It Only Lends Money to Itself - WSJ](#)

³² See <https://www.coindesk.com/video/recent-videos/usts-do-kwon-on-earlier-failed-stablecoin-basis-cash/>

³³ See for instance Cassatt (2022), “[FTX Showed the Problems of Centralized Finance, and Proved the Need for DeFi](#)”, Coindesk, 11 November 2022.

³⁴ The fallacy involves protecting a bold claim (eg “no Scotsman eats sugar in his porridge”) against counter-examples (“my uncle Angus eats sugar in his porridge, and he is Scottish”) by removing these cases from consideration (“he is not a *true* Scotsman”).

Economies of scale in monitoring

The previous sub-sections highlighted that in the presence of externalities and information asymmetries there is an important role for regulation to mitigate these market failures. But even in a world where market failures are not present (or not sufficiently large to cause problems in practice), and where information asymmetries can be solved by the market itself (eg because information can be understood and gathered by all parties to transactions, but it is costly to do so) there are efficiency considerations that suggest that having a limited set of authorities monitoring the system would be beneficial. Dewatripont and Tirole (1994) make this argument specifically for bank depositors who are not particularly well placed to assess the likelihood of a bank to fail.

Especially in retail markets, where the duplication of efforts would be extremely large, and consumers are less well placed to understand the necessary information, having a designated regulatory authority guarantee that a minimum set of standards are met on an ongoing basis is rational. Consumers may also under-appreciate the benefits associated with an ongoing monitoring of market participants, especially if they only purchase their products infrequently. In addition, consumers may just assume that, given the very large potential number of buyers, the monitoring would be done by others.

Having a central party monitor the market not only avoids the potential duplication of efforts from all market participants but also ensures that the monitoring is done by people who are more knowledgeable of the underlying products than the average consumer. Another advantage of concentrating the monitoring of activities in a limited number of regulators is that they can be given the legal power to compel market participants to change their behaviour or the characteristics of their products and services, which is a much more direct mechanism for change than the pressure exercised by consumer choice.

Therefore, while DeFi proponents highlight transparency in that all consumers can check the code underpinning all DeFi applications, they fail to recognise that having all consumers parse through the entire codebase of a DeFi application before deciding whether or not to invest in it is socially wasteful. This is true even under the assumption that these potential investors have the necessary skills to understand what the code does in practice and how it would behave in different states of the world.

These issues are compounded by the fact that DeFi is new, and it is therefore more difficult to predict how it would interact with other parts of the financial system in various circumstances. In a nutshell, end-investors – even more so if they are retail investors – are particularly badly placed to monitor the quality of the products produced in DeFi and indeed even sophisticated investors experienced large losses in May and November 2022.³⁵

Consumer demand for regulation

If DeFi remains a self-contained ecosystem in which a small section of the population is active and only some *true believers* or crypto maximalists invest, then it is possible that the demand for regulation will not grow. However, this also implies that, in practice, DeFi would remain an insignificant part of the global financial system, potentially developing into a sandbox for the testing of technology, but with limited practical use.

If, on the other hand, DeFi aspires to grow and provide meaningful services to a significant part of the population, then consumer demand for regulation will undoubtedly grow. Such growth will be driven in part by consumers' need to be reassured that the market failures mentioned above have been resolved or at least reduced. If consumers see DeFi as a self-contained, risky but otherwise harmless

³⁵ For instance two Canadian pension funds (the Caisse de dépôt et placement du Québec and the Ontario Teachers' Pension Plan) lost more than \$200 million in these episodes.

ecosystem they will not particularly care whether it is properly regulated. But if their pension savings, insurance and deposit accounts will be provided by DeFi, they will want to know that their money will be protected if things go wrong, and that the entities operating in the DeFi space are worthy of their trust.

Consumer demand for regulation will grow even if current market participants argue that they are fully informed of the risks they face now. Indeed, even if the current participants in DeFi will not ask for regulation, as the sector expands new ones will undoubtedly do so. There are many examples in TradFi where even in the presence of disclosures that alert consumers that products are risky, consumers do try to get compensated when things do not turn out right for them after the fact.³⁶ There is no reason to believe that they will stop doing so simply because the nature of the intermediation changes. And indeed there is evidence that even current DeFi investors are not different in this respect: following the collapse of the Terra/Luna ecosystem, more than 4'000 investors formed the *UST Restitution Group* in an attempt to track down the founder of Terraform Labs and be compensated for their losses.³⁷ Allowing multiple similar episodes to take place could also impact the credibility of regulatory agencies going forward. In November 2022, following the failure of FTX, in a turn of events that is surprising only for people who did not pay attention to previous episodes, a number of DeFi insiders and legislators did blame regulators for the failure to protect consumers.³⁸

Given that consumers will demand such regulation they will also be willing to pay for such regulation to be set up. Regulation in this case could play a role akin to an insurance product where consumers pay a 'premium' in exchange for a reduction in risk.

5. Regulating DeFi: a potential way forward

While the DeFi sector is currently stagnating in the aftermath of the high profile failures of 2022, it is entirely conceivable that it – or a related set of services marketed under a new moniker – will grow again in the future. There is at present an active debate on how to address the risks from crypto and DeFi with a number of potential approaches being put forward (Aquilina, Frost and Schrimpf, 2023). Such approaches include (i) a potential ban of crypto activities, (ii) insulating TradFi from crypto, and (iii) bringing (parts of) crypto into the regulatory perimeter. Some jurisdictions may well discuss the ban of some specific activities. For instance, a debate on prohibiting blockchains relying on proof of work on environmental grounds was very active in the EU in 2022. And making sure that TradFi institutions are appropriately insulated from the risks emanating from unbacked crypto-assets with no intrinsic value is surely good practice, a good example of which are the standards recently finalised by the Basel Committee on Banking Supervision (2022).

The key point of this paper, however, is that for those activities that attempt to fulfil similar functions the economic rationale for regulating TradFi applies with equal (or even greater) force to DeFi. If authorities were to pursue this route (including confined to only parts of the crypto ecosystem), we

³⁶ To name just a few examples from different time periods and geographic locations, the Cirio and Parmalat scandals in the early 2000s led to substantive legislative changes in Italy (Calcagno 2011), the Lehman minibond scandal in Hong Kong resulted in the call for substantial changes to financial regulation (Amer et al 2010) and, more recently investors in the UK have been demanding stricter regulation following the failure of London Capital & Finance (See [Consumers deserve stronger, faster protection](#), *Financial Times* (21 January 2021)).

³⁷ See [Retail investors become vigilantes in hunt for crypto's most wanted man](#), *Financial Times* (19 October 2022)

³⁸ See for instance [The Role Regulators Played in the FTX Fiasco](#), *Coindesk* (10 November 2022) or [US watchdogs play blame game over FTX demise](#), *Financial Times* (18 November 2022).

sketch a few ideas in this section on how the regulation of the sector could be pursued accounting for its special features.

Some DeFi proponents would argue that the decentralised nature of DeFi makes regulation considerably more difficult and maybe even unnecessary. But, various entities either within the DeFi ecosystem or in the wider crypto ecosystem de facto do exist and can be subjected to regulatory requirements. Entities include quasi-centralised platforms, the foundations that support blockchains and individuals that, de facto, exercise control on DApps, either because they own a large share of tokens in a DAO or because they are the “face” of a particular DApp.³⁹ These entities form a natural entry point for regulators into the DeFi ecosystem (Aramonte, Huang and Schrimpf, 2021).⁴⁰

In determining the way forward, we suggest that regulators should take a number of steps to determine the appropriate rules for DeFi. The starting point should be to analyse in detail the functions performed by DeFi (along the lines we suggest in Section 3). These functions should then be mapped to specific activities and entities in the DeFi ecosystem. Next will be to assess which ones may already be captured by existing rules and, in this case, make sure these are followed. If the activities require amended rules, then these should be developed accordingly and then appropriately enforced. This will require adequate resourcing for regulatory authorities, and in some cases new legal powers and enforcement practices given diffused accountability in the DeFi space.

To achieve the objectives of consumer protection, market integrity and financial stability, we suggest a two-pillar strategy that takes into account the specific characteristics of DeFi. The first pillar is analogous to the regulation of TradFi and deals with rules that require information that is not easily available on-chain. The second pillar is specific to DeFi and can exploit the fact that a considerable amount of information is available on-chain and that smart contracts can automatically execute an action in response to an input.

The first pillar relates to rules that – given their nature – require access to information that is not available on the blockchain or that cannot be accessed by smart contracts. One example would be the imposition of minimum standards on products and services before they can be commercialised, minimum requirements on the skills and expertise of people providing such services (eg developers, the management of foundations) to ensure that customers are protected. Another example is the fulfilment of any prudential requirement (eg restrictions on liquidity mismatches or leverage) pre-launch. But this pillar would also apply in circumstances where more than a simple condition that can be checked by a smart contract is required. For instance, this would include checks that ongoing disclosures are clear and not misleading, or compliance with any requirements that governance decisions are taken in a specific way. Concretely, the following actions, in some of the most relevant segments of DeFi may be envisaged:

- Stablecoin issuers should be regulated such that they must segregate client funds, invest them in pre-defined safe assets and regularly disclose such asset backing, and comply with rules that prevent money laundering and terrorism financing. Work in these areas is already progressing at an international level (see CPMI, 2022 and FSB,p 2022)
- Irrespective of the subtleties of different legal systems, tokens that have characteristics that make them economically equivalent (or substantially similar) to securities should be regulated

³⁹ There are complex legal issues here on which we claim no expertise. For instance, there is a large debate on whether many tokens are securities and on whether a DAO has characteristics that makes it general partnership or a limited liability company. We are not qualified to enter such debates but want to highlight that from a regulatory perspective it is definitely possible to find ways to impose regulatory constraints on actors in the DeFi space.

⁴⁰ Borio, Claessens and Tarashev (2022), argue that authorities cannot regulate functions directly as these are too abstract and need to regulate specific activities or entities. They argue that activity-based regulation is more appropriate when an activity can fail even if the entities performing it are still operational and it is feasible to constrain the activity in isolation. By contrast, entity-based regulation can reduce externalities due to entities failing in the performance of a combination of activities

as such, with appropriate requirements around disclosure, investor rights, appropriateness of the investment etc.

- DeFi protocols akin to shadow banking given their deployment of leverage and presence of liquidity mismatches have the potential to generate system-wide stress and hence should be subject to additional prudential oversight. For instance, protocols for staking or yield farming that offer investors fixed returns should be subjected to requirements (both prudential and conduct) that mitigate outsized use of leverage and liquidity mismatches. Moreover, such activities may need to be carried out in clearly defined entities and not be entangled with other activities.

Some of these proposals are already in discussion in legislative initiatives for crypto-assets in major jurisdictions, such as the Markets in Crypto-Assets (MiCA) Regulation in the European Union, and various legislative proposals in US Congress. It is quite likely though that the turmoil of May/November 2022 will give further impetus and amendments to these efforts.

The second pillar would entail, whenever possible, the embedded supervision and embedded regulation approaches envisaged respectively by Auer (2019) and Zetzsche, Arner and Buckley (2020). For DApps that are already at a relatively advanced level of development and have fulfilled pre-launch compliance with rules that depend exclusively on on-chain information or on information that can be easily accessed and assessed by smart contracts could be automated by reading the status of the blockchain. Examples of where such an approach could work in practice include ensuring that smart contracts were executed correctly in line with the status of the ledger, that the disclosure of information did take place or that 'best execution' requirements have been met and transactions did take place close to the best available prices. Further examples include:

- DeFi protocols designed to support payments could build in processes for suspicious activity reports and other safeguards to prevent money laundering and terrorism financing, eg by embedding code that could flag anomalous transactions or check that wallets involved in such transactions are not blacklisted.
- Lending protocols could build in compliance with anti-usury regulations (eg capping the interest rate in line with legal norms of the local jurisdiction).
- Protocols that resemble mutual funds should be designed to comply with requirements around reporting value (eg variable net asset value or low-volatility net asset value requirements), and to include tools such as swing pricing where needed.
- Any tokenised representation of an asset may eventually fulfil the same conditions as its real-world counterpart. For instance any lending protocol focused on mortgages (should those come into existence in DeFi) should be programmed to comply with loan-to-value (LTV) and loan-to-income (LTI) requirements in line with local legislation.

The landscape of regulation (and supervision) will also need to adopt. The production, monitoring and enforcement of appropriate rules would require either adapting the remit of existing financial regulators, or the creation of new entities to deal with DeFi. Given the expertise present in existing regulators, the potential for DeFi to become more intertwined with TradFi and the possible synergies and economies of scale in monitoring the two ecosystems together, it makes sense to expand the remit of existing regulators and underpinning it with the necessary resources to ensure enforcement of (amended) rules. Finally, given the borderless nature of many aspects of DeFi we would argue that international cooperation would be of paramount importance to avoid regulatory fragmentation and arbitrage.

6. Conclusions

The evolution of DeFi in the last few years can be seen as either the continuation of a long-term trend in which financial intermediaries are being replaced by computers or as a paradigm shift in the provision of financial services. The main message of this paper is that, in either case, the rationale for regulation applies to DeFi in a manner analogous to how it applied to TradFi.

While so far DeFi has largely facilitated activities within the crypto system it is possible that it will increase its connections with TradFi and develop deeper links with the real economy in the future. This could happen through the tokenisation of existing assets or the embedding of DApps in TradFi activities. If that happens it is important that authorities are ready to face the challenges that DeFi may bring with it. Similarly, regulation would be needed for innovative new activities that are built on permissioned DLT, CBDCs or tokenised deposits.

This paper has shown that DeFi attempts to fulfil many functions that match those of TradFi. In doing so, it uses a different technology but the objectives it seeks to achieve are very much the same. This means that the economic rationale for the regulation of TradFi applies – with some adaptation – to DeFi as well. Externalities, information problems, economies of scale in monitoring and consumers' demand for regulation will be, and in most cases already are, more relevant in DeFi than in TradFi.

The paper suggests a potential way forward on the regulation of DeFi using two pillars. One of these is akin to the one used in TradFi and the other exploits the potential of programming requirements into DeFi applications. These pillars could bring benefits to society and to private developers, setting the stage for more sustainable long-run innovation.

Of course, there are broader questions regarding the policy strategy toward crypto that need to be addressed (Aquilina, Frost and Schimpf, 2023). Some authorities may prefer outright bans of specific activities, or containment of crypto and DeFi so that risks do not spill over to TradFi or the real economy. They may worry that any regulation will confer legitimacy on the sector. Yet recent events underscore the risks of leaving DeFi in a legal grey area, without checks on outright fraud and excessive system-wide risk-taking. For public authorities with a mandate for the whole financial system, leaving corners of lawlessness within the system may be a risky strategy, and may be difficult to communicate in cases in which shocks lead to larger losses for investors, TradFi and the real economy in the future.

The regulatory approach advocated in this paper naturally requires substantial efforts from legislators, existing regulators and private sector developers to precisely define new rules and frameworks. This is likely to be a long process, and to require continual adaptation as activities continue to evolve. Some DeFi applications that do not comply with the letter or spirit of laws (including clear Ponzi schemes and rug pulls) should be prevented from developing further through robust enforcement action. With regulatory reforms targeting DeFi, authorities face the chance of improving their ability to fulfil their societal mandate to protect the stability of the financial system, protect consumers and prevent abuse. Consumers can rest easier knowing that their delegated representatives have influenced the shape of DeFi applications being developed and that the laws of the land will continue to apply. Responsible private sector developers can face a clearer framework in which to experiment and develop socially useful financial applications for end-users, with greater awareness of potential risks.

Regulating DeFi will likely clash with the libertarian ethos of the crypto community. In our view, the industry is at a crossroads: either staying true to this spirit but accepting being peripheral and on a decline, or embracing regulation while departing from the full decentralisation vision. With multiple crypto crashes and other evidence of inherent risks in the sector, it is likely that the views of market participants (and that of public sector entities) will evolve. In a regulated DeFi sector, where a number of services are used by many individuals and firms, public authorities should be able to intervene and limit which services can be sold and used. Public authorities accountable to society will also likely increase their supervisory efforts on these accountable entities. In many cases enforcement actions will

be needed, toward intermediaries and clients suspected of criminal wrongdoing also for deterrence purposes.

In the end, the largest constraint on the growth of financial innovations is not regulation, but the possibility that inherent market failures will result in market turmoil that derails the long-run growth and development of the market, including the potentially beneficial innovation it may bring. By embracing a regulatory approach focused on underlying economic functions, the private sector will be better placed to build applications that can grow sustainably in the future.

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