Decentralized Finance – The Possibilities of a Blockchain "Money Lego" System*

Tamás Katona

With the adoption of blockchain technology, initiatives to provide financial, investment and insurance services to a wide range of users in a decentralized manner have emerged. But can decentralized finance be the alternative to the traditional financial system, or has it only created another "technology playground" for users who are biasedly enthusiastic about crypto-assets? The study examines the key definitions of decentralized finance and then synthesizes them to formulate a new, more complete definition. This is followed by a presentation of the different layers of decentralized finance and their prevalence, as well as an analysis of its benefits and risks. In the conclusions, the author finds that decentralized finance has the potential to provide financial services with an open, transparent and robust infrastructure, and has the possibility of reaching a broad range of users with its basic financial services. However, this requires further development of the sector and effective management of emerging risks.

Journal of Economic Literature (JEL) codes: G10, G15, G20, G23, G24, G28

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1. Introduction

The financial system has undergone fundamental changes in recent years, with the appearance of the FinTech sector.[1] New providers have entered the financial markets, combining digital technologies and financial services in a more efficient and innovative way than any other solution so far. The FinTech ecosystem consists of vastly diverse players, some of which provide new products and services, occasionally outside existing regulations, while others seek to sell products offered

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[1] The FSB defines FinTech as "*technology-enabled innovation in financial services that could result in new business models, applications, processes or products with an associated material effect on the provision of financial services*" (*FSB 2017:7*).

by existing, legacy financial institutions in an innovative form and way. Within the sector, the use of distributed ledger technology and within that the blockchain technology creates the opportunity to reshape the money, capital and insurance markets, by way of disintermediation. As a result of decentralization, new – as yet untested – business models which affect all elements of financial value chains have emerged. Since the network is capable of recording past transactions securely and immutably, blockchains can easily be optimised for a broad range of activities and objectives. For this reason, the blockchain technology could be a "disruptive innovation" (*Dell'Erba 2019*). The application of blockchain technology could "*lead to a reduction of industry rents for the benefit of end investors and of the end users of finance (entrepreneurs and businesses) enhancing market welfare"* (*Avgouleas – Kiayias 2018:1*).

The research group of one of the most important trading platforms, Binance, is of the opinion that the emergence of crypto-assets,[2] including the incorporation of assets existing in the real economy in the form of tokens on the blockchain, i.e. tokenization, has enabled the use of blockchain technology in all sectors, but especially in the service sector (*Binance Research 2019a*). The worldwide, open-source nature of the public, permissionless blockchain[3] allows anyone to join, as opposed to the closed character of centralized financial systems. In decentralization, information is distributed over computer networks without the need for a central actor. In theory, this can result in an unbiased, transparent, immutable and efficient system (*Maker Team 2020*). Another significant benefit of public blockchains is standardisation, as developers can implement individual business models at low cost and in an interoperable[4] manner in a distributed ledger technology system. Linked to this is programmability, which allows *inter alia* for automatic compliance with rules and regulations and other standards.

Approached from the side of transaction costs, *Cong and He* (*2019*) found that blockchain technology, due to decentralization and disintermediation, makes it possible to reduce transaction costs associated with finding and selecting a counterparty, concluding a contract and enforcing a claim. Thus, the parties contact one another directly and execute transactions in innovative ways *(peer to peer).*

[2] e.g. Bitcoin (BTC), Ether (ETH) etc.
[3] With such blockchains, anyone can participate in the blockchain consensus mechanism, and anyone with an Internet connection can perform transactions in the network and get to know the full transaction log (*EC JRC 2019*).
[4] Interoperability is the ability of different IT and network systems to exchange and make use of information.

It is important to emphasize that the provision of financial services today is strongly affected by platformization, due *inter alia* to open banking efforts as a result of PSD2 regulation and the expansion of BigTech companies. *Alstyne et al.* (*2016*) define platforms as business models "*creating value by facilitating interactions between external producers and consumers*". In financial markets, marketplace-type interfaces, where users can access various financial services and non-financial products and services in one place, are becoming increasingly prevalent. Decentralized finance (DeFi) seeks to combine platformization, open banking efforts and blockchain technology to create a global, efficient and decentralized marketplace where users with Internet connection can access an increasingly wide range of financial services (financial, investment and insurance services and payment transactions). The question arises as to whether all of this can be achieved using blockchain technology? Is it possible to operate a decentralized trading platform or to create derivative products? DeFi, which aims to be an alternative to the traditional financial system, seeks to achieve these goals. But is it really capable of accomplishing this ambitious goal, or it is only another "technology playground" created for users who are biasedly enthusiastic about crypto-assets? Furthermore, will the blockchain be able to catalyse the transformation of the entire financial value chains, or will it remain a solution that improves only one sub-process or a single element of the value chain? Among other things, this article seeks to answer this, all the more so, because several Hungarian market participants have been actively involved in the DeFi ecosystem in some form, and domestic users also use DeFi protocols.

2. Problem statements, research questions and the structure of analysis

The fundamental aim of the study is to create a new, comprehensive definition by examining the concept of DeFi, and to present how the ecosystem is structured. It reviews the most important definitions and by synthetizing these, it attempts to describe the concept with its own definition. The question also arises as to what is needed for the wider acceptance of DeFi and in what direction it needs to develop in order to become competitive with the traditional financial system? To this end, the study examines the different layers, prevalence, benefits and opportunities of DeFi, as well as the most significant risks inherent in the system. Finally, based on the findings of the research, the results are presented and conclusions are drawn.

3. Methodology and review of literature

The methodology developed for writing this study is mainly a descriptive, qualitative analysis, which was combined with an evaluation of indicators from public online databases. The use of language in the analysis focuses on comprehensibility in order for the professional and non-professional audience to get to better know and understand this rather new field of science. Since while the topic has become increasingly popular in the international literature,[5] there are quite a few printed publications and monographs in the Hungarian literature that meet the scientific criteria.[6] The Internet is the primary forum used by the DeFi community for publication. Apart from documents containing technical and fundamental analyses, which account for a significant proportion, online contents dealing with the sector, both scientific and non-scientific, can be divided into two well-defined groups. The majority of the sources are documentation describing and analysing the initiatives, such as white papers, frequently asked questions and answers to such. This is the basis for summaries and dissertations that analyse them from a critical point of view, as well as studies that make findings about the DeFi ecosystem or its elements. The vast majority of the sources were written in English, the reason for which is that DeFi builds on the traditionally English-language technology layers and IT infrastructures. Although the sources are of different scientific value, the study took into consideration the relevant publications with both scientific thoroughness and emphasis on more common language. This study attempts to describe DeFi with scientific rigour.

4. Definition and key features of DeFi

As indicated in the introduction, DeFi seeks to create a new ecosystem based on global, decentralized financial services that is easily accessible to everyone and does not require a central authority (*Sandner – Wachter 2019*). According to *Consensys* (*2020*), DeFi is actually a shift from traditional centralized financial systems to peer-to-peer financial solutions enabled by decentralized technologies primarily built on

[5] This is supported by the fact that on the arXiv.org site, operated by Cornell University, the number of studies containing the term DeFi and published between 2016 and 2021 was 417 on 18 January 2021.

[6] DeFi has been studied in a scientific manner, or in an understandable way, primarily in Internet contents. Examples include blog posts on one of the broker-dealer trading platforms, Coincash's blog dealing with DeFi in general (*CoinCash 2020a*), describing the most significant initiatives (*CoinCash 2020b*), or SushiSwap (*CoinCash 2020c*).

the Ethereum[7] blockchain. At the same time, DeFi protocols[8] have emerged and operate on other blockchains (e.g. EOS, TRON, or Cosmos) (*Binance Research 2020*).

Although there is no uniformly accepted definition of DeFi, the literature and market participants more or less mean the same thing by the concept. Related to this, *Birch* (*2020*) notes (somewhat ironically) that "*heads of DeFi companies seem unable to define the sector in a few sentences*". According to *John* (*2020:18*), DeFi *"is a term used to refer to a stack of applications run primarily on blockchains that are emerging as an alternative to the traditional banking ecosystem"*. The above definition implies that DeFi applications use so-called *stablecoins*[9] (e.g. USDT, USDC, Dai, etc.) and additional crypto-assets (e.g. ETH, Wrapped Bitcoin, 0x, etc.) for payment transactions, lending or trading instead of fiat currency. According to the definition of the *Binance Academy* (*2020a*), DeFi is an "*ecosystem comprised of financial applications that are being developed on top of blockchain systems*". It is noteworthy that, on the regulatory side, the Polish Financial Supervision Authority (UKNF), was among the first to define DeFi similarly to Binance's definition as "*an ecosystem of applications aimed at the provision of financial services on DLT*" (*UKNF 2020:6*).

Indeed, the essence of DeFi may also be captured by the fact that the role of the financial intermediary is taken over by the self-executing computer code, the smart contract. *Sandner and Wachter* (*2019*) describe DeFi with a similar definition*:* "*an ecosystem comprised of applications built on top of public distributed ledgers, for the facilitation of permissionless financial services".* Almost the same definition is formulated by *Schär* (*2020:1*), who argues that DeFi includes "*open financial infrastructures built upon public smart contract platforms, such as the Ethereum blockchain"*. *Zetzsche et al.* (*2020*) emphasize the decentralized nature of financial service provision. According to the authors, infrastructure, markets, technology, methods and applications that enable the decentralized provision of financial services are at the core of DeFi. *Birch* (*2020*) approaches the concept in terms of interoperability: *"DeFi is a financial ecosystem, in which it is possible to build tools,*

[7] Ethereum is an open source, public, blockchain-based distributed computing platform capable of creating, managing, and executing smart contracts. *Schär* (*2020:1–2*) emphasizes that smart contracts are "*small applications stored on a Blockchain and executed by a large network of many computers. (…) Their advantage is a high level of security, in the sense that smart contracts guarantee deterministic execution and allow anyone to verify the resulting state changes"*.

[8] For the purposes of this study, a protocol is a set of rules and procedures that operate a particular decentralized application or applications. A decentralized application (or app) is a software application that runs on a distributed network. The application is not provided by a central server, but by a decentralized network based on the protocol. Basically, the term protocol is used as the collective term for each DeFi provider (e.g. Uniswap).

[9] There is no clearly defined normative definition of the term. According to Global Digital Finance (GDF), an international market self-regulatory organization, "*a stablecoin is a cryptoasset that serves as a medium of exchange and a store of value and is structured to minimise price volatility*" (*GDF 2019a:2*, *2019b:2*). From a monetary point of view, European Central Bank experts have defined stablecoins as "*digital units of value that are not a form of any specific currency (or basket thereof) but rather, by relying on a set of stabilisation tools, try to minimise fluctuations in their price in such currencies"* (*Bullmann et al. 2019:2*).

services and smart contracts and then bond them together on a blockchain, just like lego". Summarizing the various definitions above, from a technical point of view, DeFi can be defined as *the (eco)system of public, permissionless, DLT-based, interoperable protocols and decentralized applications (so-called DApps) built upon them for the provision of financial services.*

In addition, for biased users, DeFi also represents a kind of belief and philosophy. According to *Birch* (*2020*), *"blockchain technology and cryptocurrency are philosophically driven".* In this regard, *Binance Academy* (*2020a*) defines DeFi as "*the movement that promotes the use of decentralized networks and open-source software to create multiple types of financial services and products*".

As already mentioned, in contrast to the traditional financial system, the DeFi ecosystem typically does not rely on centralized intermediaries and institutions but is based on public protocols and decentralized applications. "*... transactions are executed in a secure and deterministic way, and legitimate state changes persist on a public blockchain. Thus, this architecture can create an immutable and highly interoperable financial system with unprecedented transparency, equal access rights ..."* (*Schär 2020:1*). This also means that the use of intermediary institutions (custodians, central clearing houses, etc.) becomes less necessary (*Schär 2020*). An example of putting this principle into practice is that users only need a non-custodial wallet[10] (e.g. MetaMask, Gnosis, Argent) to access DeFi applications and execute transactions. By using such a wallet, the user does not lose control over the crypto-assets and can continuously monitor the status and other details of the transaction initiated. Furthermore, the users have the ability to learn all DeFi transactions (e.g. by using Etherscan).

Unlike traditional financial IT solutions, the source codes of DeFi applications are public, so they can be verified and audited by anyone. Moreover, if the source code is published, for example on the GitHub site, the user can even copy or alter it, thus creating a new protocol.

All of the above definitions state that DeFi is aimed at providing financial services. To acquire an accurate knowledge of the DeFi system, let us look at the financial services offered. Summarizing the findings of *Binance Academy* (*2020a*), *Sandner*

[10] In the case of such wallets, the user remains in possession of the private keys required to dispose over the crypto-assets. Losing the private keys or the phrases needed for the recovery also means losing the right to dispose over the crypto-assets. The security of the system is guaranteed by the fact that the public code cannot be inferred from the public address and the private code cannot be inferred from the public code (*ESMA 2019*).

– *Wachter* (*2019*)*, Schär* (*2020*) and *Maker Blog* (*2020b*), the financial services affected by DeFi can be currently classified into the following groups (also referred to in the literature as DeFi functions):

a) Services similar to monetary banking services (issuance of stablecoins and operation of related payment systems, e.g. MakerDao, EOSDT, Kava);

b) Operation of decentralized trading platforms (DEX), with possible liquidity pooling services associated with them (e.g. Uniswap, Curve Finance, Swerve, BurgerSwap, PancakeSwap);

c) Provision of peer-to-peer and liquidity pool type lending and borrowing platforms (e.g. Aave, Compound);

d) Provision of higher level, complex financial products, which includes the creation of derivatives, tokenization platforms (e.g. Synthetix, Balancer) and prediction markets (e.g. Augur);

e) Insurance products and services (e.g. Nexus Mutual, 3 F Mutual).

Initiatives in the DeFi sector typically aim to implement multiple functions or to provide a kind of "hybrid" service by combining one or more features thereof. This is because in this manner developers try to solve the difficulties and issues arising when using the individual features. On the other hand, they also want to encourage users to use the protocols. All of these help increase the value of the platform and result in new, innovative business models. For example, the Uniswap protocol previously had a basically decentralized trading platform function, but later the liquidity pool function known from Compound was incorporated. This made it possible to better ensure the appropriate level of liquidity required for trading, for instance for swaps, and has thus facilitated the more efficient operation of the protocol. This business model of Uniswap, the automated market maker[11] (*Shevchenko 2020b*), has become a standard in the sector. This is also supported by the fact that using the publicly available source code of Uniswap, the developers created different copies (*fork*) on each blockchain (e.g. SushiSwap, Burgerswap, WhiteSwap) (*Binance Academy 2020b*).

[11] Automated market marker: *"the AMM is a type of decentralized exchange (DEX) protocol that relies on a mathematical formula to price assets. Instead of using an order book like a traditional exchange, assets are priced according to a pricing algorithm."* (*Binance Academy 2020c*).

4.1. Layers of DeFi – the Money Lego concept

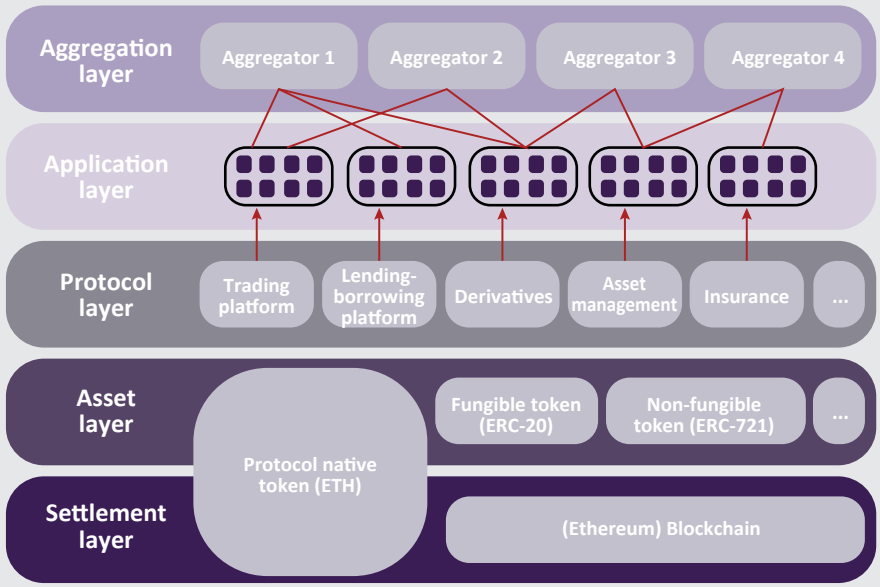
The DeFi ecosystem is often referred to as Money Lego. The concept itself suggests that in a decentralized financial system, the individual protocols and applications are able to interact with one another. Similarly to how Lego building blocks can be assembled, individual protocols and applications of DeFi can be combined to achieve the optimal transaction output (*John 2020; Amler et al. 2021*). This opens up the opportunity to create complex transactions, while also providing an outstanding user experience.

The interoperability and financial nature of DeFi is well illustrated by the so-called *Schär* (*2020*) model that shows how each DeFi application and protocols are built on one another as layers. The lowest layer (settlement layer) is the blockchain used, which contains the basic operating rules of the ecosystem. In fact, transactions are executed at this level. The second (asset) layer is built on this, which includes the created crypto-assets (e.g. ETH, Dai). The main functions of DeFi are set out in the third protocol layer.

The next layer is the application layer, which includes user-oriented applications that interconnect the protocols and standards in the individual protocol layers. The interconnection of smart contracts takes place in a web browser-based front-end interface; therefore, the protocols are easy to use and have a high user experience. The aggregation layer is built on (top) the application layer, which is actually an extension of it. Aggregators operate user-centric platforms that connect many different applications and protocols. The platforms involved provide users usually with tools to compare the services and the corresponding costs, and to make otherwise complex transactions easy. Aggregators achieve this by simultaneously interconnecting many different protocols and linking relevant information obtained from each platform. Applications running in this layer allow the user to make informed decision and optimize the benefits obtained by using DeFi applications (*Schär 2020*).

Figure 1 shows the Schär model related to Ethereum. It is clear that the layers involved are hierarchically built on one another in two respects. On one hand, it is important to emphasize that the implementation of each DeFi function is the result of the interactions and transactions of each layer with one another. On the other hand, it must be stressed that, the extent to which a layer is scalable, decentralized, or vulnerable is determined by the features of the underlying blockchain (particularly the applied consensus mechanism) (*Hay 2019; Amler et al. 2021*).

Figure 1
A Decentralized Finance Stack



Source: Plotted based on Schär (2020:3–4)

To illustrate the above, in the DeFi ecosystem, users have the option to take out a loan in Dai stablecoin against their existing ETH equivalent to the value of USD 100, with which they can carry out leveraged trading – let us say – in some other crypto-asset and can then swap the acquired assets on a decentralized trading platform back to Dai and repay the loan. They can arrange the order of transactions with an aggregator application (e.g. Furucombo) for an optimal output and the highest level of user experience. It is also important to note that DeFi applications are available on an ongoing basis, 24 hours a day, 7 days a week.

4.2. Decentralization and yield farming

The concept of decentralization permeates DeFi and represents one of its most important principles. Nevertheless, developers often have to compromise between the level of decentralization and the pragmatism that prioritizes creating a useful product. Therefore, the ideology behind DeFi is a complex blend of decentralization and pragmatism (*Shevchenko 2020a*). While in the case of the blockchains that form the lowest layer of DeFi, due to its distributed ledger technology character, the operation of the network is decentralized and the extent of decentralization may be different for each DeFi protocol. At present, it seems that each initiative

sets the centralization-decentralization ratio on a kind of sliding calliper. Once the initiative is ripe for a higher degree of decentralization, developers will begin to implement it. This was also pointed out by Gustav Arentoft, the European business development representative for the stablecoin initiative at MakerDao, who does not believe that "*[DeFi] is binary in the sense that you are either decentralized or you're like traditional finance. I believe that, on the spectrum, there's space for a lot of different uses"* (*Birch 2020*).

The current highest level of decentralization is perhaps the so-called decentralized autonomous organization, or DAO for short. According to the definition of *Binance Research* (*2019b*) DAO is an *"organizational form"* that exists in the virtual space *"that coordinates the efforts and resources of members via an a priori binding, formalized and transparent set of rules that are agreed upon in a multilateral fashion"*. This is often done in a way that the protocol creates and distributes among users crypto-assets, the so-called secondary or governance tokens embodying the membership rights in the DAO. By holding this, the user can make motions and has voting rights depending on the amount of token held, i.e., can actively influence the operation of the protocol. In addition to buying from the open market, secondary tokens can be obtained from the platform by the users of the protocol concerned, depending on the intensity of use, typically the amount of liquidity made available to the platform (*liquidity mining*). As the number of users changes due to network effects, the value of the platform and as well as the value of the secondary token also changes (*Dale 2020a*). The consequence of the distributed governance model is that users are interested in participating in its governance, as the value of the tokens they hold also depends on the success of the protocol.

At present, almost all decentralized initiatives use the services of other, possibly centralized, entities. The most important of these are oracles. Oracles are "*third-party services that allow smart contracts within blockchains to receive external data from outside of their ecosystem*" (*Tiwari 2020*). Oracles are data sources that can be channelled into smart contracts. This allows smart contracts to access real-time data that is not on blockchains (*Liu et al. 2020:2*). Most often, such data is the real-time price feed of crypto-assets. Oracles alone do not qualify as data sources; they represent a layer that verifies real-world events related to data on the blockchain and submits cumulative data to smart contracts (*Tiwari 2020*).

As a result of decentralization, specifically the secondary token distribution of the Compound liquidity platform, yield farming has emerged. Users using such a strategy lock their available crypto-assets in the liquidity pools promising the highest interest rates, and then they also lock the crypto-assets received as a reward or interest (or the crypto-assets replacing them or acquired against them) on other

platforms to achieve the greatest benefit. Users using a yield farming strategy lock their crypto-assets for a very short period of time (weeks, days, and even a few hours) and, if there is a possibility of arbitrage, they immediately transfer their sources to the new platform. It can be seen that liquidity mining facilitates the implementation of the yield farming strategy. After all, in exchange for providing liquidity, i.e., for locking assets, the user gets a new crypto-asset, a secondary token, the value of which changes with the value of the platform (*Dale 2020a*). At the same time, the user has the option to further lock the secondary tokens received.

5. Examination of key indicators of DeFi

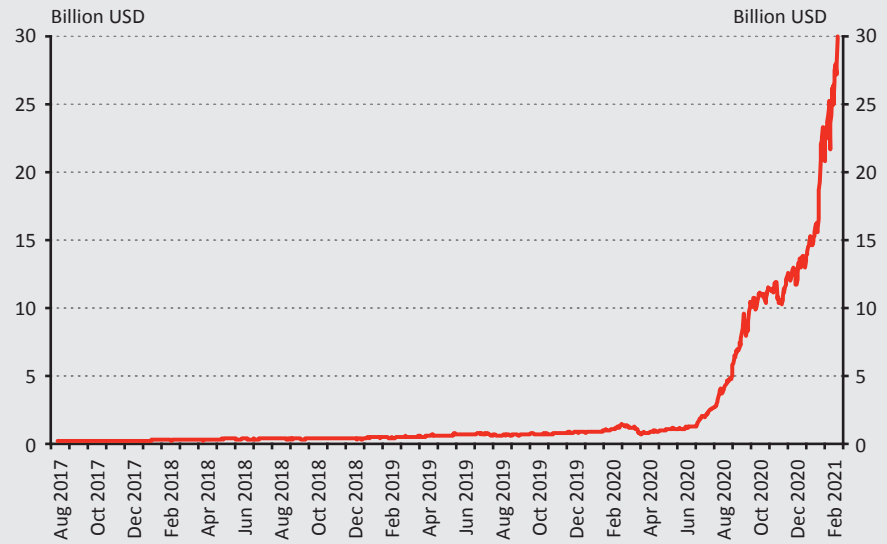
The size of the DeFi sector is illustrated by the aggregate capitalization of the 100 crypto-assets in the ecosystem with the most significant market capitalization. This gives an idea what market participants consider about the combined value of each protocols that belong to DeFi and create crypto-assets. According to the DeFi Market Cap,[12] a portal providing market data, the value of the indicator in question exceeds USD 37.7 billion. CoinGecko,[13] which provides the same service but is likely to use different data and methodologies, sets the amount of combined capitalization similarly at approximately USD 55.8 billion. This ratio is approximately 30 per cent of ETH's market capitalization. Nevertheless, the index surveyed is still a fraction of the S&P 500 index's capitalization of approximately USD 30 trillion.

In addition to capitalization, the most important indicator of the DeFi sector – mainly published on the defipulse page – has become the total value of crypto-assets locked (TVL) in smart contracts.[14] The TVL indicator is used by market participants to measure the performance of all protocols. The TVL shows the degree of liquidity available to smart contracts, i.e. the extent to which users with crypto-assets that can be locked on platforms (supply side) participate in the DeFi ecosystem. This also means that TVL concurrently expresses supply-side confidence in the sector (*Outumuro 2020*). According to the site, the USD-denominated amount of crypto-assets locked in the DeFi ecosystem rose sharply from an initial value of USD 4 in August 2017 until 15 February 2020, when it peaked at around USD 1.24 billion. Subsequently, with market panic over the coronavirus epidemic, it suddenly fell very sharply to USD 487 million. It seems that it was followed by consolidation

[12] https://defimarketcap.io/ records in total 3,802 crypto-assets attributed to DeFi.
[13] https://www.coingecko.com/en/defi
[14] The methodology of the calculation is simple: it sums up the amount of actual collateral in each smart contract examined and then it multiplies this by the spot market commodity selling price denominated in USD. Concerns have recently been raised about the accuracy of the methodology, as some collateral may be taken into account more than once (*Dale 2020b*).

and then, after 15 June 2020,[15] its value suddenly surged due to market sentiment about the emergence and spread of yield farming. All this means that in 2020, the value of the TVL indicator grew to more than 20 times its value (*Outumuro 2020*). At the close of this study, the total value locked in DeFi was close to USD 30 billion (see *Figure 2*).

Figure 2
Total value locked in DeFi in USD (22 August 2017 – 3 February 2021)



Source: defipulse.com

Still, according to DappRadar, the TVL indicator used by defipulse can be misleading. *Outumuro* (*2020*) found that the indicator does not take into consideration the changes on the demand side, especially in the case of lending and borrowing platforms. On the other hand, the value of TVL is fundamentally affected by price changes of crypto-assets locked as collateral. By eliminating the effects of price changes, a more accurate picture of TVL can be obtained (*Abugov 2020*). For our part, we do not wish to take sides in the professional discussions regarding the calculation of TVL, however, we indicate that, according to the DappRadar methodology available at dappradar.com/defi, the adjusted value of TVL after

[15] On that day, the distribution of the secondary token of the Compound liquidity pool type lending and borrowing platform, the COMP, started. Similarly to COMP, several decentralized protocols created and began distributing their own secondary tokens. Thus, with the rapid spread of liquidity mining and yield farming, the value of sources locked in DeFi suddenly skyrocketed (*Wan 2020; Keoun – Godbole 2020*).

eliminating the price effects stood at USD 15.56 billion on 3 February 2021. For the sake of comparison, it is also worth noting that the value of the above TVL indicators calculated in different ways is approximately 9.36–17.98 per cent of the aggregate assets of Hungarian credit institutions measured on 31 December 2020 (*MNB 2021*). The amount of funds locked in DeFi in USD has undoubtedly shown a significant increase to date, but the current volume of locked funds is considered quite small, compared to the estimated size of global fixed income markets estimated to be worth USD 250 trillion (*Binance Research 2020*).

Amler et al. (*2021*) highlight that the increase of the TVL index stems on the one hand from reinvested profits and exchange rate gains, and on the other hand from a dynamic increase in the number of users. The latter trend is also supported by Chen's time series[16] published on the website of Dune Analytics, which found that the number of individual wallets[17] interacting with DeFi protocols increased by 1,000 per cent in 2020. Currently, the number of individual wallets exceeds 1.2 million.

6. Benefits and opportunities of DeFi

DeFi platforms are easily accessible for all users, fast, simple and easy to use, and each platform is interoperable; therefore, the level of customer experience is high. In the case of complex transactions in particular, users can create the order of transactions themselves, set the amount of the transaction cost to be used, and customize the transactions to be performed. In addition, it is important to emphasize the unprecedented high level of transparency: all transactions and smart contracts can be publicly monitored and verified. In contrast to traditional financial systems, this can provide an opportunity to avoid or mitigate risks before they occur.

An additional benefit of the ecosystem is increased efficiency. DeFi replaces the central counterparties trusted by market participants with smart contracts that are theoretically capable of performing the functions of central counterparties, whether it is about custody, escrow agents or performing clearing and settlement. Such solutions, in any case in theory, pose a much lower counterparty risk, and make transactions more efficient overall (*Schär 2020*). A lower need for trust can at the same time reduce regulatory pressure and the need for third-party audits.

[16] https://duneanalytics.com/rchen8/defi-users-over-time
[17] This number does not clearly match the number of users, as a single user can have multiple wallets.

Transparency is further enhanced by the fact that a permissionless blockchain is immutable and resistant to alteration attempts by third parties. It follows from the permissionless nature that users, or developers of DeFi protocols, are currently free to enter the ecosystem without permission from government or market players (*John 2020*).

DeFi also allows users to apply liquidity mining, yield farming and arbitrage strategies incorporating them; therefore it can also be used for investment purposes. Interest is due to users for locking their crypto-assets. In addition to possible "cash flows", holders of secondary tokens can realize exchange rate gains on their crypto-assets as the value of the platform increases. At present, DeFi is undoubtedly less of an alternative to the traditional financial system for users in developed economies compared to emerging economies such as South America, where due to the difficult economic situation, Dai stablecoin, soft-pegged to the USD, has become a popular savings vehicle (*Maker Blog 2020c*).

Comparing the financial transactions that can be conducted in the traditional financial system and DeFi, we find that both areas aim to offer financial products and services to users. The key difference between the two areas stems, on the one hand, from the fact that in the case of the former, users trust the "bank and its related actors", while in the case of DeFi, their trust is vested in the technology and protocols used on blockchains (*Iredale 2020*). On the other hand, the "scene" of the two areas is separate. While traditional financial system is present in the real economy, DeFi builds on the blockchains and manages value there. *Table 1* compares some features of the traditional financial system and DeFi.

Table 1
A comparison of some features of the traditional financial system and DeFi

Characteristics	Traditional financial system	DeFi
Scope of services provided	Full range of financial services	Currently limited range of financial services
Scope of targeted users	Restricted (typically local)	Unlimited (global)
User group	Users in the retail, corporate and public sectors	Predominantly retail, but also the corporate sector has started to open up to the area
Business models	Combining traditional and platform-based business models	New, hybrid business models (e.g. AMM) also offering platform-based services
Control over assets	Financial institutions act as custodians	Users manage their assets (non-custodial wallet)
Availability	Typically limited in terms of time (except for payment systems e.g.)	Always available
Procedures prior to the actual transaction	Occur almost without exception	Users only interact with the protocol for the duration of the transaction
Actor who decides on the transaction outcomes, executes, and monitors the transactions	Within the legal framework, subject to the strength of industry competition, is determined by the institution (with limited influence of the user)	Smart contracts (the transactions are executed in a deterministic manner)
Mutability	Possible	Basically excluded
Reversibility	Settlement finality is a requirement, but applicable rules and regulations may allow the reversibility of transactions	Irreversible
Transaction speed	Variable (fast turnaround time for everyday transactions, longer turnaround time for more significant transactions)	Variable (increased turnaround times due to the operation of blockchains, but promptness is rather typical)
Level of liquidity	Due to prudential rules, it is typically high	Volatile
Transparency	Details of transactions and the IT infrastructure used are typically not public	Transaction data and protocol source codes are public
KYC	Mandatory, client data is managed by the institution. Only identified clients can perform transactions.	Occasionally, however it is not required at the protocol level because it typically occurs when using the wallet service or exchange. In DeFi transactions, users use pseudonym addresses. Their identity remains unknown until the relevant information is revealed.
Fees and costs	Fees and costs are typically higher (but there is scope for reduction and due to digitalisation, this may be realized even in the shorter term)	Rather lower fees (possibly high gas costs)
Determination of fees and costs	Within the legal framework, subject to the strength of industry competition, is determined by the institution	The influence of individuals on the fees and cost structure is smaller. They are shaped by supply and demand due to decentralization, under technical conditions.
IT security	High due to regulation	Lower, but can be enhanced by using (external) audits
Level of customer experience (UI / UX)	High	High
Customer Complaint Management	Ensured	Rather difficult

Source: Plotted based on Borealis (2020), Bybit Learn (2020), Iredale (2020) and Amler et al. (2021)

With proper development of the technology, DeFi may evolve into one of the most significant blockchain sectors. This could create the opportunity to reach billions of users all over the planet and provide access to basic financial services and new, complex products at low fees and interest rates. It can also lead to a paradigm shift in the field of financial services (*Amler et al. 2021*). The paradigm shift could encourage the centralized financial and DeFi ecosystem to cooperate, thus leading to the emergence of new business models in the future that are more efficient and secure than existing ones (*Maker Blog 2020a*). The first signs of cooperation were already seen in the last quarter of 2020. Institutional investors' interest in crypto-assets has increased (*Sinclair 2020; Godbole 2020*). With regard to stablecoins, it can also be observed that an increasing number of issuers are seeking authorization to conduct financial services (*Kabompo Holdings, Ltd. 2020*) or are about to issue stablecoins in the possession of a banking license (*Allison 2020*). Finally, it is important to note that initiatives have emerged that seek to make DeFi functions available to traditional financial institutions and institutional investors (*Curv DeFi 2020*). All these confirm that cooperation and joint development of the two areas can be reasonably expected. At the same time, in the long run, the development of DeFi may also encourage incumbent actors to increase their level of digitization and to enhance the customer experience they offer.

7. Fundamental risk factors of DeFi

DeFi is also not a risk-free sector: in fact, *Acheson* (*2020*) considers it clearly terrifying "*a financial system without oversight or an off switch* (as it) *is even more vulnerable to manipulation and error than one that is legally accountable to the user and can be fixed when things go wrong"*. Acheson points out that the source of risk in the context of DeFi is primarily the technology independent and trustless character, which is further exacerbated by regulatory uncertainties. These risks became a reality in 2020 during attacks against decentralized trading platforms. During the (at least) three attacks against bZx (Fulcrum), attackers acquired a total of approximately USD 9 million worth of crypto-assets, of which USD 8 million was returned (*Khatri 2020a; 2020b; 2020c; 2020e*). Moreover, on 19 April 2020, crypto-assets equivalent to USD 25 million – 99 per cent of the platform's assets – were appropriated by a hacker from the dForce (Lendf.me) lending and borrowing platform (*Foxley – De 2020*).

Among the main risks, we can generally distinguish blockchain-related and market risks, as well as DeFi-specific risks. The latter group can be further subdivided into operational risks, including consumer protection risks, as well as regulatory and compliance risks.

7.1. Examination of the key risks associated with blockchains in relation to DeFi

Among the risks associated with blockchain, first the findings of *Hay* (*2019*) and *Amler et al.* (*2021*) on decentralization are worth mentioning, according to which each application is only as secure and scalable as the underlying blockchain is. Scalability constraints (e.g. limited block size), especially for Ethereum as the most important blockchain for DeFi, can cause interruptions in the execution of transactions. Scalability constraints result from time to time in increased transaction costs. On Ethereum, TRON or TomoChain blockchains, senders must also pay transaction fees, so called gas or energy for the execution of transactions, for example for the transfer of tokens. Gas prices are a function of real-time market demand and supply (*Binance Research 2019a*).

Ethereum is particularly notorious for its significant gas costs.[18] The fees to be paid in the ETH are used by Ethereum, *inter alia*, to reward nodes that validate transactions. Due to the limitations of Ethereum's scalability, increased network traffic (network congestions)[19] can significantly drive up gas costs, and consequently, a higher fee will be required to validate a transaction. Increased traffic can also cause congestion in the network. Since transactions are ranked based on gas prices, transactions with higher unit costs take precedence over those with lower ones. The consequence of this is that, if a given transaction is not at the top of the ranking, it is either executed late or not executed at all.[20] In order to execute the transaction, the user has the opportunity to optimize it, in particular to adjust the gas price so that the transaction is executed for sure. For example, MetaMask wallet or EthGasStation transaction fee calculator can help with this. This clearly results in higher gas costs on the user side.

Based on data from Dune Analytics, *Amler et al.* (*2021*) pointed out that the emergence and popularity of DeFi has fundamentally influenced the rise in gas prices in the Ethereum network. Estimating the average unit value of gas required for DeFi transactions to be between 40 and 540 gwei, the authors found that the value of gas burnt daily in the second half of 2020 exceeded USD 1.5 million. As a consequence of this, the dramatic increase in gas prices due to the spike in demand for DeFi applications made it impossible for many non-DeFi applications to operate.

Binance Research (*2019a*) found that there is no doubt that some transaction fee needs to be set, but overly high fees deter users from using blockchain. This is further exacerbated by the fact that on some blockchains, transaction fees can

[18] For each transaction, the maximum amount of gas willing to be spent must be set out (gas limit). The price of a single gas unit is denominated in gwei (1 gwei = 10^{-8} ETH) (gas price). The product of the two shows how much gwei is required for the transaction.
[19] The reason for this may be, for example, market turbulence due to the fall in the ETH.
[20] Depending on the protocol, non-validated transactions will either be deleted after a specified period of time or "stuck" and will be pending until the user re-initiates the transaction with the appropriate gas price.

only be paid in a single asset. There is a trend towards the continuous emergence of second layer solutions that seek to increase blockchain scalability in order to ensure network traffic, while also seeking to reduce on-chain fees (e.g. Polygon). Other blockchains allow users to pay transaction fees in any valuable asset. It is also important to note that the developers of Ethereum have developed a blockchain reform, Ethereum 2.0, which is currently being gradually implemented. Ethereum 2.0 aims to eliminate, or at least mitigate, the gas problem observed with blockchains by using new scalability solutions (*Edgington 2020*).

7.2. Market risks

In the context of market risks, it is obvious to refer to the volatility of crypto-assets.[21] This affects the DeFi ecosystem in two ways. On the one hand, the price of crypto-assets (notably secondary tokens) issued by DeFi protocols and applications can fluctuate extremely, similarly to well-known crypto-assets. On the on the other hand, the price changes of crypto-assets locked as collateral fundamentally affect the position of the user, which can even lead to the loss of the entire collateral in the event of market turmoil.

As shown in *Section 4.2.*, the DeFi sector takes advantage of network effects for growth. The continuously emerging, new but often immature DApps use social media for their marketing activities and are offered by influencers in various forums to a targeted, primarily retail user groups. With the emergence of yield farming and liquidity mining, this type of influence has resulted in a bubble-like situation in the sector, especially in the secondary token markets. Unrealistically high daily returns were observed, which may not have reflected the future potential of the DApps behind the assets. Due to certain developers with reserved holdings in secondary tokens selling out their long positions, a protocol failure or a hacker attack, prices plummeted and token holders suffered very high losses (*Foxley 2020b*; *Palmer – De 2020*). Such behaviours show a high degree of similarity to unwanted pump & dump-type market manipulations or other frauds and scams in capital markets (*Amler et al. 2021*; *UKNF 2021*). As it is currently quite difficult to deal with this type of behaviour, when using DeFi for investment purposes, investors have to mitigate the market risks by applying different risk management solutions (e.g. diversification, hedging).

7.3. Specific risks of DeFi

It is clear that interdependence is one of the most attractive features of DeFi, but it is precisely this that also poses a key risk. Due to interdependence, shocks in one layer can spread through the entire structure and render the chain of overlapping tokens worthless (*Schär 2020; Amler et al. 2021*). The fact that individual protocols

[21] For the purposes of this study, volatility shall mean the price fluctuation.

and applications are reliant on the external data supplied by oracles can also pose a risk of interdependence. Improper data supply, for example if the oracles report incorrect price feed data to the protocols due to the occurrence of some operational risk (e.g. manipulation or failure to obtain data), can result in substantial damage.

As a result of *targeted manipulation*, perpetrators can obtain crypto-assets from the individual platforms in an unfair manner. This risk became apparent on 14 and 18 February 2020 as a result of hacker attacks against bZx DEX. Both attacks applied the same principle. After borrowing the crypto-assets, the perpetrators used various leveraged trades to influence the price feed of the oracle used by the lending and borrowing platform (*Foxley 2020a*), then exchanged their assets to the original asset of the loan and made a significant profit (approximately USD 1 million) after repaying the loan. Since the source of profit was the liquidity pooled by other users, the perpetrators may have harmed ultimately other users with the attacks. The attacks disabled the so-called sanity check function of bZx protocol, which would have been responsible for verifying that after the swap the position will not be defaulted. In both cases, the perpetrators exploited the bugs of the smart contract during the attack (*PeckShield 2020*). In addition, the above attacks may also affect the price of the crypto-assets involved, resulting in heavy losses to their holders.

In order to mitigate the above risks, it is essential that DeFi platforms use more well-functioning, transparent and reliable oracles (*Amler et al. 2021; Liu et al. 2020*). It is a tendency for participants to use the oracles offered by centralized trading platforms (e.g. Coinbase Oracle)[22] (*Anisimov – Youngblood 2020*), in addition to decentralized oracles (e.g. Chainlink, Uniswap, etc.).

Transactions concluded on blockchains are irreversible and are executed by smart contracts in a predetermined way. In this context, smart contract vulnerabilities pose significant operational and security risks. The study previously stated that the source codes of DeFi protocols and previous transactions are public, and thus anyone can access them. This also opens up opportunities to exploit the weaknesses and bugs in smart contracts (*Amler et al. 2021*). Hackers could siphon off the assets managed by the smart contract from the system, cause chaos, and even cause the system to collapse completely. As a result of a hacker attack, losses can be very high for both the platforms and the users. But there is no need for a hacker attack, the *code* may simply be *faulty*. For example, in the case of the YAM stablecoin initiative, the market capitalization of the secondary token issued by the platform (YAM) lost ninety per cent of its value in thirty minutes because developers disclosed that a bug was found in the system (*Khatri 2020d*). Average users are not expected to understand the exact operation of smart contracts, to "read the code", and thus they may not be familiar with the operation of the platform and its possible limitations,

[22] Compound, for example, uses also Coinbase Oracle.

and this carries the risk of suffering losses. The existence of so-called administrator or *admin keys* can also pose operational risks. Those who have this can shut off the given DeFi initiative. *Obtaining and use of the keys by unauthorized parties* can have unpredictable consequences for a project. Requiring a multiple signature (multi-sig) upon use, as well as a timelocks may mitigate certain operational risks. A high concentration of secondary tokens may also pose operational risks as it would enable a person or persons to have decisive influence over the operation of the protocol.

The constant threats are forcing platforms to stay continuously up to date in terms of security. *Amler et al.* (*2021:5*) consider the "*using well-known design patterns and best practices*" as a good starting point for mitigating such IT risks. In addition, professional organizations conducting audits (e.g. Open Zeppelin or Trail of Bits) and other developers have appeared, who publish the results of their investigations in various forums. In our view, this type of risk management is important for mitigating IT and operational risks, but due to its limited nature, it cannot completely eliminate uncertainty.

7.4. Regulatory and compliance risks

According to the DeFi principle, "*the code is the law*". It is precisely the aim of the movement that there should be no need for a central participant to settle disputes, etc. This role is fulfilled by a transparent smart contract, and optimally each participant receives the expected outcome. Potential regulation may conflict with the DeFi's decentralization efforts. Because of the "bridge-building" efforts between DeFi and traditional finance, it is not unprecedented for a regulated institution to enter the market of DeFi services and to create new products there.[23] In view of this, the regulatory and compliance risks of DeFi cannot be circumvented.

Two simple questions used in relation to centralized entities can help reveal the risks involved with DeFi. Who or what, where and based on what can be held liable, i.e. is there a person behind the protocol who can be held accountable and from whom damages can be claimed? Protocols do not have an organization legally recognized by a jurisdiction but governed by smart contracts. Protocols are developed and supervised primarily by one or more developers. Protocols that have become DAOs consist of rules converted into pre-defined and transparent computer codes, which are governed by a community of secondary token holders or by algorithms, for a specific purpose. This also means that if the organization is not a legal entity, claims cannot, or only to a limited extent, brought against it. Certainly organizations of various legal types may be related to the platforms, but the enforcement of

[23] It is arguable that the deposit acceptance and lending provided by the centralized entity denominated in and or secured by crypto-assets can be considered part of DeFi. For our part, we do not want to take a position on this, but it can be stated that new, "hybrid" business models have also emerged as a result of DeFi.

claims against them or the developers could only be achieved indirectly at best, and the outcome is rather uncertain. Legislative provisions by analogy with piercing the corporate veil, pursuant to which programmers and developers who create and supervise the DeFi protocol are ultimately responsible for its operation might bring some legal certainly, but also could have quite far-reaching consequences and even set the sector back in development. *The lack of a directly accountable entity is considered to be DeFi's most significant regulatory risk.*

To answer the "where" question, it is important to highlight that DeFi, cannot always be attached to states, as opposed to the institutions that make up the traditional financial intermediation system. Due to the novelty of the area and the lack of a legally established organizations, the international division of tasks (jurisdiction) between the relevant national competent authorities has not developed and it is questionable whether it can be established at all. For example, it can occur that a multi-country activity is subject to prior licencing, in which case it is questionable which supervisory authority should authorize and supervise the activity (*Zetzsche et al. 2020*). Similarly, it remain unclear where the damaged user can turn to complain or seek redress.

In the financial markets, especially in the European Union, the *principle of the same activity, same risks, same regulation* is accepted, in order to minimize the possibility of regulatory arbitrage and create a level playing field for market participants.[24] It is a question of whether the activity of the DeFi protocols can be classified as a regulated activity (e.g. deposit acceptance, lending or insurance). At present, they cannot or will not be seamlessly qualified. For activities not subject to financial regulation, only general standards, such as general consumer protection rules, can be applied. Contractual provisions on exclusive jurisdiction and applicable law may render the enforcement of users' claims more difficult.

Whether a particular business model is subject to existing regulation must either be enshrined in law or determined by the regulatory authorities. A good example of this is the case of the tokenised fund type of stablecoins.[25] Some of the tokenised funds may qualify as electronic money. It also implies that platforms engaged in certain business activities involving tokenised funds may be subject to prior regulatory authorisation (e.g. deposit acceptance, lending). As the activity is carried out by computer code, it is yet unclear which participant should be obliged to obtain it or, in the lack of that, to cease the activity.

[24] Some question the application of the principle, stressing that the risks involved may vary depending on the entity performing the activity (*Restoy 2020*).

[25] Tokenised funds are *"units of monetary value that are stored electronically in a distributed ledger to represent a claim on the issuer and are issued, on receipt of funds, for the purpose of making payment transactions to persons other than the issuer"* (*Bullmann – Klemm – Pinna 2019:12*).

Moreover, DeFi protocols provide services related to crypto-assets, so the regulatory classification of the individual services should include the legal classification of crypto-assets affected. Namely, as stated in *Section 4.1,* DeFi's asset layer consists of the crypto-assets created by each protocol. Certain crypto-assets are likely fall into the regulated sphere (financial instruments, electronic money), although not "gap-free". Indeed, the crypto-assets that do not fall within the scope of existing financial regulation are left unaddressed.

Owing to legal uncertainty, users typically attempt to enforce damages due to the occurrence of risks (e.g. hacker attacks) in some manner by using *social media*. Users go public with their statements and claims attempting to persuade platform developers or affected users to follow the behaviour they believe is correct. This type of pressure from a large number of users ("*comment fights*") may be suitable to achieve the desired goal (*Palmer – De 2020*).

Pricing of regulatory and compliance risks may also result in higher transaction fees for certain platforms. The tax assessment of DeFi platforms, especially which state they are subject to taxation also represent a grey area.

Regulatory efforts[26] have been made to reduce regulatory uncertainty, especially concerning stablecoins, but it is remain to be seen whether they will achieve the desired result. Along with these, it is a step forward that regulators have recognized the importance of the area and are examining the possibility of regulation.

8. Results and findings

The study has sought to underline that DeFi could represent a new paradigm in the field of financial services and has the potential to create a truly open, transparent and robust infrastructure for financial services. Due to the interoperability of the protocols, anyone can check all of the transactions and analyse transaction data and draw conclusions from them for the future. One of the findings of the study is that *DeFi puts the data of all financial transactions in the hands of users and it is solely up to them how deeply they process them*. It does all of this in a digital environment where the user experience (UX) is considered to be especially good.

DeFi has launched a new wave of innovation, creating "trustless" versions of traditional financial systems on the one hand, and on the other hand offering *new solutions (e.g. liquidity pools, stablecoins, etc.) that are unthinkable without a public blockchain*.

[26] The Stablecoin Tethering and Bank Licensing Enforcement Act in the USA and the draft regulation of Markets in Crypto-assets in the EU.

The previously mentioned risks, often due to the immaturity of the sector, may decline over time by virtue of development. *With the emergence of more and more products, the range and quality of financial services available to users is also expanding.* At the same time, market participants need to be aware of the risks that have not yet been identified due to extreme innovation and relatively low utilization so far. We should also realise that the concept of decentralization can sometimes be misleading, as there may be actors who are able to access the system in some way (e.g. with admin keys), whether to update a smart contract or initiate an emergency shutdown. It needs to be seen that there is still a need for trust in the system and, as previously emphasized, the ratio of centralization to decentralization may vary from protocol to protocol.

The emergence of DeFi may also be a wake-up call for incumbent institutions. In our view, DeFi and the traditional financial system are not "*fire and water*". DeFi solutions may be reflected in centralized FinTech structures, and even organizations such as the Chicago DeFi Alliance see DeFi solutions as the way out of the recession caused by the coronavirus and consider the area concerned to be a possible path for future financial developments. The realization of this can be facilitated if incumbent participants become more open to the DeFi sector and, as far as possible, show more flexibility in their cooperation.

With proper development of the technology, in particular if scalability issues can be resolved, DeFi can grow into one of the most significant blockchain sectors. This could create an opportunity for DeFi to reach even a wide range of users and ensure access to basic financial services, while also leading to a paradigm shift in the area concerned. And this could also encourage players in the centralized financial system to create more efficient and secure business models than the existing ones, or just to seek partnerships with DeFi players.

References

Abugov, I (2020): *Adjusted TVL as a better way to track growth in DeFi*. https://dappradar.com/blog/adjusted-tvl-as-a-better-way-to-track-growth-in-defi. Downloaded: 27 August 2020.

Acheson, N. (2020): *Crypto Long & Short: DeFi and Traditional Finance Are Forming an Unlikely Friendship*. https://www.coindesk.com/defi-traditional-finance-friendship. Downloaded: 25 April 2020.

Allison, I. (2020): *One of the World's Oldest Banks Is Issuing a Euro Stablecoin on Stellar*. https://www.coindesk.com/one-of-the-worlds-oldest-banks-is-issuing-a-euro-stablecoin-on-stellar. Downloaded: 9 December 2020.

Alstyne, M.W. – Parker, G. – Choudary, S. (2016): *Pipelines, platforms, and the new rules of strategy*. Harvard Business Review, 94(April): 54–60, 62. https://hbr.org/2016/04/pipelines-platforms-and-the-new-rules-of-strategy. Downloaded: 26 April 2020.

Amler, H. – Eckley, L. – Faust, S. – Kaiser, M. – Sandner, P. – Schlosser, B. (2021): *DeFi-ning DeFi: Challenges & Pathway*. https://arxiv.org/abs/2101.05589. Downloaded: 19 January 2021.

Anisimov, A. – Youngblood, L. (2020): *Introducing the Coinbase price oracle*. https://blog.coinbase.com/introducing-the-coinbase-price-oracle-6d1ee22c7068. Downloaded: 26 April 2020.

Avgouleas, E. – Kiayias, A. (2018): *The Promise of Blockchain Technology for Global Securities and Derivatives Markets: The New Financial Ecosystem and the 'Holy Grail' of Systemic Risk Containment*. Edinburgh School of Law Research Paper No. 2018/43, pp 27. http://dx.doi.org/10.2139/ssrn.3297052

Binance Academy (2020a): *The Complete Beginner's Guide to Decentralized Finance (DeFi)*. https://academy.binance.com/blockchain/the-complete-beginners-guide-to-decentralized-finance-defi. Downloaded: 12 July 2020.

Binance Academy (2020b): *What Is Uniswap and How Does It Work?* https://academy.binance.com/tutorials/what-is-uniswap-and-how-does-it-work. Downloaded: 12 August 2020.

Binance Academy (2020c): *What Is an Automated Market Maker (AMM)?* https://academy.binance.com/en/articles/what-is-an-automated-market-maker-amm. Downloaded: 12 December 2020.

Binance Research (2019a): *The World of Tokenization.* https://research.binance.com/analysis/tokenization. Downloaded: 26 August 2019.

Binance Research (2019b): *Theory and praxis of DAOs*. https://research.binance.com/en/analysis/dao-theory. Downloaded: 6 December 2019.

Binance Research (2020): *DeFi #3 – 2020: The Borderless State of DeFi*. https://research.binance.com/analysis/2020-borderless-state-of-defi. Downloaded: 17 December 2020.

Birch, J. (2020): *MakerDAO's Gustav Arentoft: Decentralization Is Not a Binary Choice*. https://cointelegraph.com/news/makerdaos-gustav-arentoft-decentralization-is-not-a-binary-choice. Downloaded: 24 March 2020.

Borealis, N. (2020): *Decentralized Finance (DeFi) vs. Traditional Banking*. https://nathanborealis.medium.com/decentralized-finance-defi-vs-traditional-banking-50c208b77412. Downloaded: 17 December 2020.

Bullmann, D.– Klemm, J. – Pinna, A. (2019): *In Search for Stability in Crypto-Assets: Are Stablecoins the Solution?* ECB Occasional Paper No. 230. https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op230~d57946be3b.en.pdf. Downloaded: 25 March 2020.

Bybit Learn (2020): *DeFi vs CeFi Cryptocurrency: What Are The Differences?* https://blog.bybit.com/learn/defi/defi-vs-cefi-differences. Downloaded: 15 December 2020.

CoinCash (2020a): *Mi az a Decentralized Finance (DeFi)?* (*What is Decentralized Finance (DeFi)?*) https://hu.coincash.eu/blog/mi-az-a-decentralized-finance-defi. Downloaded: 25 March 2020.

CoinCash (2020b): *10+1 DeFi projekt, amire érdemes odafigyelni.* (*10+1 DeFi projects to watch out for*) https://hu.coincash.eu/blog/101-defi-projekt-amire-erdemes-odafigyelni. Downloaded: 25 March 2020.

CoinCash (2020c): *SushiSwap: a legjobb kaja a DeFi tálcán?* (*SushiSwap: the best food on the DeFi tray?*) https://hu.coincash.eu/blog/sushiswap-a-legjobb-kaja-a-defi-talcan. Downloaded: 8 September 2020.

Cong, L.W. – He, Z. (2019): *Blockchain disruption and smart contracts*. The Review of Financial Studies 32(5): 1754–1797. https://doi.org/10.1093/rfs/hhz007

Consensys (2020): *Blockchain for Decentralized Finance (DeFi)*. https://consensys.net/blockchain-use-cases/decentralized-finance/. Downloaded: 8 September 2020.

Curv DeFi (2020): *The first ever institutional-grade enterprise DeFi solution*. https://info.curv.co/hubfs/Curv%20DeFi%20Fact_Nov%202020.pdf. Downloaded: 16 December 2020

Dale, B. (2020a): *What Is Yield Farming? The Rocket Fuel of DeFi, Explained*. https://www.coindesk.com/defi-yield-farming-comp-token-explained. Downloaded: 6 August 2020.

Dale, B. (2020b): *Why DeFi Pulse's Key Metric Is So Simple It's Confusing*. https://www.coindesk.com/defi-pulse-decentralized-finance-data-site-tvl. Downloaded: 26 August 2020.

DappReview (2020): *2020 Q2 Dapp Market Report by DappReview*. https://dapp.review/article/274/2020-Q2-Dapp-Market-Report-by-DappReview. Downloaded: 6 August 2020.

Dell'Erba, M. (2019): *Demystifying Technology. Do Smart Contracts Require a New Legal Framework? Regulatory Fragmentation, Self-Regulation, Public Regulation*. University of Pennsylvania Journal of Law & Public Affairs, In press. https://ssrn.com/abstract=3228445

Edgington, B. (2020): *What's New in Eth2 – 25 July 2020*. https://hackmd.io/@benjaminion/eth2_news/https%3A%2F%2Fhackmd.io%2F%40benjaminion%2Fwnie2_200725. Downloaded: 25 July 2020.

EC JRC (2019): *Blockchain now and tomorrow*. European Commission Joint Research Centre. http://doi.org/10.2760/901029

ESMA (2019): *Advice on Initial Coin Offerings and Crypto Assets*. https://www.esma.europa.eu/sites/default/files/library/esma50-157-1391_crypto_advice.pdf. Downloaded: 6 August 2019.

FSB (2017): *Financial Stability Implications from FinTech*. https://www.fsb.org/2017/06/financial-stability-implications-from-fintech/. Downloaded: 17 December 2020.

Foxley, W. (2020a): *Everything You Ever Wanted to Know About the DeFi 'Flash Loan' Attack*. https://www.coindesk.com/everything-you-ever-wanted-to-know-about-the-defi-flash-loan-attack. Downloaded: 24 February 2020.

Foxley, W. (2020b): *Fishy Business: What Happened to $1.2B DeFi Protocol SushiSwap Over the Weekend*. https://www.coindesk.com/sushiswap-liquidation-weekend. Downloaded: 7 September 2020.

Foxley, W. – De, N. (2020): *Weekend Attack Drains Decentralized Protocol dForce of $25M in Crypto*. https://www.coindesk.com/attacker-drains-decentralized-protocol-dforce-of-25m-in-weekend-attack. Downloaded: 24 April 2020.

GDF (2019a): *Stablecoin. Taxonomy and Key Considerations.* Global Digital Finance. https://www.gdf.io/wp-content/uploads/2019/10/GDF-Stablecoin-Key-Considerations.pdf. Downloaded: 3 November 2020.

GDF (2019b): *Code of Conduct Part VI. Principles for Stablecoin Issuers*. Global Digital Finance. https://www.gdf.io/wp-content/uploads/2019/10/0010_GDF_VI-Principles-for-Stablecoin-Issuers_Digital_161019.pdf. Downloaded: 3 November 2020.

Godbole, O. (2020): *MassMutual's Bitcoin Buy May Presage $600B Institutional Flood: JPMorgan*. https://www.coindesk.com/massmutuals-bitcoin-investment-marks-adoption-milestone-jpmorgan. Downloaded: 14 December 2020.

Hay, A. (2019): *How Decentralized is "Decentralized Finance"?* https://medium.com/coinmonks/how-decentralized-is-decentralized-finance-89aea3070e8f. Downloaded: 3 September 2019.

Iredale, G. (2020): *DeFi vs CeFi – Understanding the Differences*. https://101blockchains.com/defi-vs-cefi/. Downloaded: 17 October 2020.

John, J. (2020): *Decentralised Finance: Usecases & Risks for Mass Adoption*. https://uploads-ssl.webflow.com/60201c98c0783465694de095/602d76364a228a2f7c9d33a8_Decentralised%20Finance.pdf. Downloaded: 8 September 2020.

Kabompo Holdings, Ltd. (2020): *Application to the Office of the Comptroller of the Currency to Organize Paxos National Trust*. https://www.coindesk.com/wp-content/uploads/2020/12/Paxos-National-Trust-New-York-NY.pdf. Downloaded: 8 December 2020.

Keoun, B. – Godbole, O. (2020): *First Mover: Compound's COMP Token More Than Doubles in Price Amid DeFi Mania*. https://www.coindesk.com/compounds-comp-token-price-doubles-amid-defi-mania. Downloaded: 23 March 2020.

Khatri, Y. (2020a): *DeFi lending protocol bZx exploited, 'a portion of ETH lost'*. https://www.theblockcrypto.com/linked/56134/defi-lending-protocol-bzx-exploited-a-portion-of-eth-lost. Downloaded: 23 February 2020.

Khatri, Y. (2020b): *bZx exploit: Former Google engineer explains how an attacker made $350K in single transaction*. https://www.theblockcrypto.com/post/56171/bzx-exploit-former-google-engineer-explains-how-an-attacker-made-350k-in-single-transaction. Downloaded: 24 March 2020.

Khatri, Y. (2020c): *bZx attacked again, $645K in ETH estimated to be lost*. https://www.theblockcrypto.com/post/56207/bzx-attacked-again-645k-in-eth-estimated-to-be-lost. Downloaded: 23 May 2020.

Khatri, Y. (2020d): *YAM token's market cap collapses by more than 90% within minutes as a flaw gets uncovered*. https://www.theblockcrypto.com/post/74810/yam-token-market-cap-collapses-by-more-than-90-flaw. Downloaded: 2 December 2020.

Khatri, Y. (2020e): *DeFi protocol bZx attacked once again, lost $8 million due to a faulty code*. https://www.theblockcrypto.com/post/77656/defi-protocol-bzx-attacked-lost-8-million-faulty-code. Downloaded: 2 December 2020.

Liu, B. – Szalachowski, P. – Zhou, J. (2020): *A First Look into DeFi Oracles*. https://arxiv.org/abs/2005.04377. Downloaded: 19 January 2021.

Maker Blog (2020a): *How Dai Helps Meet the Needs of the Unbanked in America and Beyond*. https://blog.makerdao.com/how-dai-helps-meet-the-needs-of-the-unbanked-in-america-and-beyond/. Downloaded: 7 May 2020.

Maker Blog (2020b): *Decentralized Finance (DeFi) Trends*. https://blog.makerdao.com/decentralized-finance-defi-trends/. Downloaded: 11 June 2020.

Maker Blog (2020c): *How Dai Became A Favorite Crypto in Latin America*. https://blog.makerdao.com/how-dai-became-a-favorite-crypto-in-latin-america/. Downloaded: 12 December 2020.

Maker Team (2020): *The Maker Protocol: MakerDAO's Multi-Collateral Dai (MCD) System*. https://makerdao.com/en/whitepaper/. Downloaded: 8 September 2020.

MNB (2021): *Aggregated balance sheet of credit institutions: December 2020.* https://www.mnb.hu/en/statistics/statistical-data-and-information/statistical-releases-and-notes/aggregated-balance-sheet-of-credit-institutions/2020/aggregated-balance-sheet-of-credit-institutions-december-2020. Downloaded: 3 February 2021.

Outumuro, L. (2020): *A comprehensive overview of DeFi in 2020*. https://app.intotheblock.com/static-reports/bitstamp/defi/2020-overview/report/a-comprehensive-overview-of-defi-in-2020.pdf. Downloaded: 6 December 2020.

Palmer, D. – De, N. (2020): *SushiSwap Creator Chef Nomi Returns $14M Dev Fund*. https://www.coindesk.com/sushiswap-creator-chef-nomi-returns-dev-fund. Downloaded: 2 December 2020.

PeckShield (2020): *bZx Hack II Full Disclosure (With Detailed Profit Analysis)*. https://peckshield.medium.com/bzx-hack-ii-full-disclosure-with-detailed-profit-analysis-8126eecc1360. Downloaded: 3 August 2020.

Restoy, F. (2019): *Regulating fintech: what is going on, and where are the challenges?* Speech at the XVI Banking public-private sector regional policy dialogue conference: "Challenges and opportunities in the new financial ecosystem", Washington, DC, 16 October https://www.bis.org/speeches/sp191017a.htm. Downloaded: 17 December 2020.

Sandner, P. – Wachter, V. (2019): *Decentralized Finance (DeFi): What Do You Need To Know?* https://medium.com/@philippsandner/decentralized-finance-defi-what-do-you-need-to-know-9cd5e8c2a48. Downloaded: 2 February 2020.

Schär, F. (2020): *Decentralized Finance: On Blockchain- and Smart Contract-based Financial Markets*. http://dx.doi.org/10.2139/ssrn.3571335

Shevchenko, A. (2020a): *What makes DeFi decentralized Rune Christensen on centralized collateral and decentralizing make*. https://cointelegraph.com/news/what-makes-defi-decentralized-rune-christensen-on-centralized-collateral-and-decentralizing-make. Downloaded: 2 February 2020.

Shevchenko, A. (2020b): *Uniswap and automated market makers, explained*. https://cointelegraph.com/explained/uniswap-and-automated-market-makers-explained. Downloaded: 9 September 2020.

Sinclair, S. (2020): *$76M Ether Fund Makes 'World First' IPO on Canadian Stock Exchange*. https://www.coindesk.com/ether-fund-ipo-3iq-tsx. Downloaded: 17 December 2020.

UKNF (2020): *Stanowisko Urzędu Komisji Nadzoru Finansowego w sprawie wydawania i obrotu kryptoaktywami*. https://www.knf.gov.pl/aktualnosci?articleId=71795&p_id=18. Downloaded: 15 December 2020.

UKNF (2021): *Ostrzeżenie Urzędu KNF o ryzykach związanych z nabywaniem oraz z obrotem kryptoaktywami (w tym walutami wirtualnymi oraz kryptowalutami)*. https://www.knf.gov.pl/komunikacja/komunikaty?articleId=72242&p_id=18. Downloaded: 12 January 2021.

Tiwari, A. (2020): *DeFi oracles, explained*. https://cointelegraph.com/explained/defi-oracles-explained. Downloaded: 15 December 2020.

Wan, C. (2020): *The price of DeFi protocol Balancer's governance token surges over 200% on first trading day*. https://www.theblockcrypto.com/linked/69331/the-price-of-defi-protocol-balancers-governance-token-surges-over-200-on-first-trading-day. Downloaded: 24 June 2020.

Zetzsche, D.A. – Arner, D.W. – Buckley, R.P. (2020): *Decentralized Finance (DeFi)*. European Banking Institute Working Paper Series 2020(59). http://doi.org/10.2139/ssrn.3539194