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Decentralized Finance: Development of a taxonomy to support regulatory measures

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DECENTRALIZED FINANCE: DEVELOPMENT OF A TAXONOMY TO SUPPORT REGULATORY MEASURES

Michel Wagner Nicolai Krüger Markus Kleffmann Frank Teuteberg

ABSTRACT:

Amidst rapid developments in digital financial technologies, the need for effective Decentralized Finance (DeFi) regulation is at the center of discussions. This paper aims to develop a comprehensive taxonomy for DeFi that brings to the forefront the diverse structures and characteristics of protocols and applications and can serve as a basis for developing regulatory policies. A detailed analysis of 144 DeFi projects is conducted using a qualitative research approach with inductive methodology. Based on the analysis, a taxonomy has been developed, which can be used to assist in the design of regulatory policies. From this taxonomy, five ideas are derived which could serve as a potential basis for designing future regulatory measures. In doing so, the work highlights the need to develop appropriate regulations for the DeFi market, which has been mainly unregulated to date. The findings highlight the need for increased international cooperation among countries to achieve a uniform regulatory regime that accommodates the DeFi industry's dynamic developments. The taxonomy approach developed in this research may prove to be a critical tool to foster this international cooperation and promote uniform regulation.

KEYWORDS:

Blockchain, DeFi, Regulation, Taxonomy, Decentralized Finance, Dapps.



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Introduction

Interest in blockchain technology has risen sharply in recent years and is characterized by a significant increase in investment and participation. Over the past few years, many companies from various industries such as finance, automotive, healthcare, insurance, real estate, and retail have initiated and implemented highly developed proof-of-concepts. This dynamic development underlines the transformative power and potential of blockchain technology in various business areas (George et al., 2019). This revolutionary technology, which promotes transparency, immutability, and decentralized control, has laid the foundations for the development and spread of Decentralized Finance. It is an innovative technology that has the potential to redefine the traditional financial system (Polyviou et al., 2019, p. 1). DeFi is revolutionizing the financial sector by promoting decentralized services that do away with traditional intermediaries such as banks and insurance companies. The use of blockchain technology and smart contracts enables users to interact with each other directly and without counterparty risk, for example when granting loans or trading and exchanging digital assets. By creating open, interoperable and automated financial solutions, the aim is to enable a wide range of financial services that are more transparent, secure and accessible (Schueffel, 2021, p. 1). This innovative ecosystem can fundamentally change the financial sector by overcoming the hurdles and problems of conventional financial institutions (Meijer, 2022).

Due to the rapid progress in the dynamic DeFi sector, there are many regulatory challenges. The rapid development has created a complex landscape that requires new monitoring and control measures. Regulators need to keep pace with technological developments and develop flexible rules that promote consumer protection and innovation in equal measure (Dünser, 2021). Initial considerations and regulations are already underway around the world to find a balance between innovation and security. In parallel, in the wake of the hype around DeFi products and services, regulators are engaged in ongoing legislative processes on digital currencies that may be linked to the DeFi ecosystem (Krüger & Busche, 2023).

Science plays a central role in the development of meaningful DeFi regulations by providing analysis and insights. This work aims to help gain a better understanding of blockchain technology and the DeFi ecosystem. By examining 144 DeFi projects and creating a taxonomy, it aims to contribute to the discussion on future regulations. The heterogeneous DeFi protocols pose a challenge as they are continuously evolving and require in-depth analysis. Considering incidents such as hacks, appropriate regulatory measures are necessary, although existing approaches are often inadequate. Therefore, this work aims to develop a comprehensive taxonomy to identify regulatory challenges and outline solutions. Thus, we aim to answer the following research question (RQ): What are the foundational dimensions of a DeFi taxonomy that can drive the development of coherent and adaptable regulatory policies?

The remainder of this paper is organized as follows. First, we introduce the concept of DeFi and discuss its significance in the current financial ecosystem. Second, we detail the methodology adopted for developing the DeFi taxonomy, leveraging the conceptual-empirical approach outlined by Nickerson et al. (2013), tailored to encapsulate the diverse functionalities and properties of DeFi protocols and applications. Third, we present our empirical findings, including the classification of 144 DeFi projects, the identification of key dimensions, and the delineation of subdimensions and characteristics that $P_{age 5 of 34}$



emerged from our analysis. Fourth, we discuss these findings within the broader context of DeFi innovation and regulatory challenges, underscoring the taxonomy's potential to inform targeted regulatory policies. Finally, we conclude by summarizing our contributions to the field of financial technology, acknowledging the limitations of our study, and proposing directions for future research in the realm of DeFi regulation and taxonomy refinement.

Theoretical Background

This section provides an understanding of blockchain technology and the DeFi ecosystem based on it. It introduces basic concepts and applications from the DeFi space to provide a solid foundation for the taxonomy developed to classify DeFi projects.

Blockchain technology

Blockchain technology is now a form of distributed ledger technology. The blockchain is a type of distributed register in which digital records, events or transactions are stored transparently for all participants in chronological order (Bundesnetzagentur, 2021, p. 5). Each data record in the blockchain is referred to as a block. When a new block is created, a cryptographic process is used to generate a unique hash value that refers to the previous block. This creates a chain of linked blocks known as a blockchain (Laurence, 2019, p. 2). The first block in the chain is called the genesis block and contains no reference to a previous block (Blocktrainer, 2021). The creation of a block and its inclusion in the blockchain is based on a consensus procedure. This process determines the order in which new blocks are added to the blockchain. There are various blockchain protocols, each of which uses a different consensus mechanism (Laurence, 2019, p. 2-5). Blockchain technology makes it possible to design the blocks to be virtually tamper-proof, like DLT. Successful manipulation of a data record in the blockchain requires the block in question and all subsequent blocks to be recalculated. In addition, the manipulated block would have to be changed on the majority of computers in the blockchain network. For large blockchains such as Bitcoin, such a procedure is extremely unlikely as it is not worthwhile due to the enormous amount of time and computational effort involved (VDI Technologiezentrum, 2018, p. 6-7).

Decentralized Finance

Decentralized Finance, or DeFi for short, is a financial system based on blockchain technology that replaces traditional financial intermediaries such as banks, stock exchanges, or insurance companies with decentralized and automated protocols (Schueffel, 2021, p. 1). DeFi platforms or applications generally use the Ethereum blockchain, although other blockchains offer a similar range of functionalities (Seregin, 2019). In recent years, DeFi has experienced rapid growth. The number of DeFi projects has risen rapidly. While the DeFi market still had a total value locked (TVL) of around 675 million dollars at the beginning of 2020, the market already had a TVL of around 40 billion dollars towards the end of 2021 (Jensen et al., 2021, p. 46). Total Value Locked is a metric that reflects the total amount of digital currencies locked in a specific DeFi protocol or platform via smart contracts (Steidl, 2022). The basic concepts of the DeFi ecosystem are presented below.



Liquidity pools

A liquidity pool is a collection of digital currency units that are deposited in a smart contract to provide liquidity to DeFi applications such as decentralized trading platforms. These are provided by liquidity providers to enable trading and liquidity for cryptocurrencies. In return, they receive trading fees from the transactions in their pool, proportional to their share of the total liquidity (Binance Academy, 2020).

Price oracle

Price oracles are special external data sources in the DeFi ecosystem that provide smart contracts with price information for assets that are relevant for the execution of smart contracts (Liu et al., 2021, p. 2). They are crucial for providing real-time data to determine the current market price of cryptocurrencies or other assets. This information is used to value assets, determine loans, and value collateral (Dzyatkovskii, 2021).

Governance

In a decentralized system, governance refers to a method by which decisions are made and platforms are managed. In DeFi, the goal is usually to distribute decisions to users and stakeholders. They can often submit proposals and vote on protocol changes, developer hiring, governance policies, or other important decisions related to the operation and future direction of the platform by owning governance tokens (Cryptopedia, 2022).

DAOs

A decentralized autonomous organization (DAO) is an organizational structure that is based on smart contracts and works without traditional hierarchies. A DAO creates an autonomous unit that can function without human intervention. Smart contracts ensure security and integrity (Sponagel, 2023). In a DAO, members make collective decisions about the operation and development of a project. Decisions are made in the form of a vote. DAOs enable transparent, unchangeable, and efficient management of resources and activities. They do not require intermediaries and promote a decentralized and democratic co-determination of the community (Altaleb & Zoltan, 2022, p. 122).

Interoperability

The broad acceptance of blockchain and Web3 is limited by their isolated nature, as communication between different blockchains is difficult. Currently, the exchange of cryptocurrencies between blockchains requires a detour via centralized exchanges, which is time-consuming and impractical. Cross-chain interoperability solves this problem by building a bridge between blockchains, allowing users and developers to freely choose how they want to interact with different blockchains without having to rely on centralized intermediaries (Jagdev, 2022). The diversity of functions in the DeFi ecosystem has led to the emergence of various applications and platforms with different purposes. These are explained below and play an important role in the taxonomy later.



Decentralized exchanges

A DEX (decentralized exchange) is a type of marketplace where users can exchange and trade their digital currencies directly with each other without the need for an intermediary, who usually facilitates the transfer and custody of assets. Compared to conventional financial transactions, DEXs offer the advantage of complete transparency. All capital movements and the associated exchange mechanisms can be viewed by anyone (Chainlink Lab, 2022). Conventional and centralized exchanges store their customers' funds in their own wallets. A wallet enables users to store and manage cryptocurrencies securely (Jørgensen & Beck, 2022, p. 1). Smart contracts are used for the exchange. This reduces potential risks of loss and gives users greater control over their funds (Chainlink Lab, 2022).

Lending and borrowing

The concept of lending and borrowing is one of the core aspects of any financial system. It always involves a lender lending money to a borrower who repays the borrowed sum over a certain period. In addition to the money lent, the lender also receives a previously agreed interest rate on his money (Jagati, 2021). Lending in the DeFi ecosystem allows users to receive loans in the form of cryptocurrencies. A loan is made without traditional financial intermediaries such as banks, which makes lending decentralized and globally accessible. Interest rates and conditions for a loan are automatically set and executed by smart contracts (Takyar, 2021).

Stablecoins

In the most basic sense, a stablecoin is a form of cryptocurrency whose value is pegged to external assets, precious metals or a conventional fiat currency such as the US dollar. "Fiat money refers to national currencies that, unlike commodity money such as gold or silver, are 'artificially' created by states or governments" (N26, 2023). Stablecoins are fully backed by reserves one-to-one in the respective currency. In a broader context, a stablecoin can also be seen as a digital financial instrument that uses special mechanisms to ensure that the value of the stablecoin deviates only minimally from a fixed target value (Woltzenlogel Paleo, 2011, p. 1). The main aim of stablecoins is to ensure price stability. In contrast to volatile cryptocurrencies such as Bitcoin or Ether, whose prices can fluctuate greatly, stablecoins are intended to maintain a constant value (Worldcoin, 2023). They are also intended to combine the advantages of cryptocurrencies, such as fast transactions between people and protocols and a high level of security, with the stability of conventional currencies (Rawal, 2020).

Staking, yield farming and liquidity mining

Staking refers to the process of depositing cryptocurrencies in a blockchain to support the network. In return, rewards are paid out in the form of cryptocurrencies. In the DeFi ecosystem, staking can basically be defined as "users locking their crypto assets in smart contracts on layer-1 or DeFi protocols as validators and earning rewards for their participation in maintaining the network" (LeewayHertz, 2022). It can also be further defined as follows: "DeFi staking encompasses various DeFi activities where users temporarily staked crypto assets for different purposes" (LeewayHertz, 2022).



The staking principle can be divided into several categories: classic staking, yield farming and liquidity mining. All three variants pursue the same goal, namely, to generate income from investments.

Yield farming is a strategy in which people stake their cryptocurrencies in various DeFi protocols or platforms to generate yield by providing liquidity. In return, they receive LP tokens that represent their stake in the respective protocol. They can in turn stake these tokens in other DeFi protocols to generate additional yield. The goal of yield farming is to generate the highest possible yield from the available opportunities (Augustin et al., 2022, p. 5-6).

Liquidity mining is a form of yield farming where users provide cryptocurrencies to participate in decentralized exchanges. The exchange awards interest in return and uses AMMs to provide liquidity to the market. Liquidity mining focuses on actively using the assets provided for trading transactions, while yield farming generally uses the deposits more passively (Lehmann et al., 2023, p. 11-13).

DeFi derivates

Derivatives are financial instruments that derive their value from an underlying asset, such as shares, commodities, or currencies. They allow investors to speculate on future price movements or changes in the value of these assets without having to actually own them (Linke, 2022). Derivatives in the DeFi ecosystem also derive their value from underlying assets. The difference from traditional derivatives trading is that DeFi derivatives are based on smart contracts and executed on a blockchain, which offers greater transparency and cost efficiency (Nambiampurath, 2023).

Regulations in the EU

This section presents existing, planned, and expert-recommended regulatory approaches in the EU. The aim is to gain a sound fundamental understanding of what progress and initiatives can be expected in the near future in the area of blockchain, crypto, and, in particular, DeFi regulation, which has already been implemented.

MARKETS IN CRYPTO ASSETS

The MiCA Regulation is an EU regulatory framework for crypto assets that aims to increase investor protection and support the markets. The regulation aims to enable crypto exchanges and digital wallet companies to offer regulated services across Europe. The regulation is expected to come into force from July 2024, with certain provisions taking effect in early 2025. European regulators are working on technical rules to implement the regulation (Beincrypto, 2023; BaFin, 2023b).

In future, providers of stablecoins should meet minimum liquidity requirements and have their legal domicile within the EU. A public register is to promote transparency in the crypto-asset sector by containing a comprehensive collection of white papers on crypto-assets and providing information on issuers and other relevant service providers (BaFin, 2023b).



The EU Parliament has also approved the money transfer regulation to prevent money laundering. In future, crypto service providers will have to identify their customers, making it possible to track transfers of crypto assets at any time. The introduction of the international *Travel Rule* is also intended to help combat money laundering and terrorist financing (BaFin, 2023b; McLaughlin, 2022).

EU DATA ACT - ARTICLE 30

The EU Data Act aims to update existing data protection regulations and meet digital challenges. It aims to clarify misunderstandings regarding the use of data, emphasize citizens' rights, and promote trade in data. Article 30 of the Act specifies legal requirements for smart contracts in the context of data sharing, potentially making the Data Act a regulatory instrument for parts of the crypto market (European Crypto Initiative, 2023; Möllers, 2023).

Article 30 of the EU Data Act states that the following requirements must be met when providing smart contracts for data sharing (European Parliament, 2023, p.100-101):

- 1. Robustness and access control: The smart contract must offer strict access control mechanisms and be highly robust in to prevent functional errors and manipulation by third parties.
- 2. Secure termination and interruption: A mechanism must be in place to terminate the execution of transactions. The smart contract should contain functions that can reset, stop, or interrupt the contract to prevent future unintended executions. The conditions under which the contract can be reset or stopped should be clearly defined. The circumstances under which termination or interruption without consent is permitted should also be checked.
 - a. Equivalence: A smart contract should offer the same protection and legal certainty as contracts drawn up in other ways.
 - b. The smart contract should be designed in such a way that the confidentiality of business secrets is guaranteed.

REGULATION OF DECENTRALIZED FINANCE - AN APPROACH FOR EUROPE

From a regulatory perspective, the DeFi sector is not yet sufficiently defined. The EU MiCA regulation described above does not yet explicitly take this sector into account. However, the European Commission has formulated initial thoughts on this topic, and experts have published four proposals to reconcile consumer protection with the promotion of innovation in the European DeFi sector (Hoppmann, 2023):

- 1. Calls for the legal recognition of DAOs in European law, as they have not yet been seamlessly integrated into traditional legal structures (Voloder et al., 2023, p. 6).
- 2. The creation of a national API data framework in EU oracle frameworks with MiCA recognition could promote the development of the oracle market (Voloder et al., 2023, p. 6).
- 3. The creation of a government-run monitoring center for DeFi is proposed to publish analysis of DeFi protocols and issue opinions and alerts (Voloder et al., 2023, p. 8).
- 4. Licensed oracles could help increase reliability in the DeFi sector by providing verifiable public information and operating within a legal framework (Voloder et al., 2023, p. 8-9).



Development of a taxonomy

Research methodology

The methodological design of this paper to analyze DeFi protocols and develop an informal taxonomy is based on a qualitative research approach with a clear focus on an inductive approach. This section outlines in detail the research methodology used to investigate the structural and functional characteristics of DeFi protocols and to derive a taxonomy that serves as a basis for potential regulatory measures.

Collection of data

The data collection for this work was carried out using a carefully coordinated procedure to ensure a representative selection of DeFi projects. The basis for the selection of projects is the *DeFiLlama* website. To ensure comprehensive coverage, the selection focuses on the seven most significant blockchains in terms of total value locked (TVL). These blockchains include Ethereum, Binance Smart Chain (BSC), Tron, Arbitrum, Polygon, Optimism and Avalanche, which together have a significant share of 89% (as of August 20, 2023 (DefiLlama, 2023)) of the total TVL on *DeFiLlama*.

Only projects with a TVL of more than USD 15 million were considered for data collection to obtain a targeted amount of data and capture larger projects with potentially greater impact on the DeFi ecosystem. A high TVL may indicate a broader user base, higher liquidity, and the usefulness of DeFi services. However, setting this threshold could lead to overlooking smaller but promising projects that may serve specific use cases and have a low TVL. In total, data was collected from 144 projects (see Appendix 1) that met the defined criteria.

Data analysis

The data collected was analyzed using MaxQDA software, which enables structured and systematic analysis. The qualitative approach involved content-based coding to identify patterns and correlations and gain a deeper understanding. The data was first formatted and structured to ensure efficient analysis. Through an iterative process, relevant concepts, themes, and ideas were identified and coded accordingly. Coding was carried out selectively to ensure that only relevant data for the research question was considered, and relationships were established between the codes. Similarities, differences, and connections between codes were explored to develop overarching themes that corresponded to the research objective. This iterative process led to the formation of categories that were closely linked to the research question and the research objective.

Taxonomy development and validation

The taxonomy was developed using the procedure according to Nickerson et al. (2013), which consists of seven different steps and two possible iterative approaches. The validation of the developed taxonomy is carried out by a combination of different checks. The first type of validation is done by



comparing the dimensions and features with the underlying codes to ensure that they represent the diversity of the data. Further validation steps include checking the taxonomy by applying it to selected projects to test its practical applicability.

The process for developing a taxonomy according to Nickerson is a methodical approach consisting of seven successive steps. These steps are run through iteratively until a defined final condition is reached. There is also the flexibility to choose between an empirical and a conceptual approach within this process. Figure 1 illustrates the process according to Nickerson.



Figure 1: Nickerson taxonomy (Nickerson et al., 2013, p. 345)

The first step of this process involves defining a meta-characteristic. The choice of meta-characteristic is based on the purpose of the taxonomy, which in turn is based on the expected use of the taxonomy. The meta-characteristic should be chosen carefully as it has a decisive influence on the resulting taxonomy (Nickerson et al., 2013, p. 343). For the work considered here, *DeFi functionalities and properties* was chosen as the central characteristic, which makes it possible to classify the various DeFi protocols according to their specific functionalities and properties.

The second step is to define the termination properties that should complete the taxonomy development process. Objective and subjective criteria are used to ensure that the taxonomy has an appropriate structure and meets the requirements. Table 1 shows the objective and table 2 the subjective criteria that were used to design the taxonomy to complete the development process.

Objective ending conditions	Description
All properties or a representative selection of	If not all objects have been examined, the additional
properties were examined.	objects must be examined.
At least one object is classified under each	If at least one object is not found under a
characteristic of each dimension.	characteristic, the taxonomy has a 'null'
	characteristic. Either an object with the

	characteristic must be identified or the characteristic must be removed from the taxonomy.
No new dimensions or characteristics were added in the last iteration.	If new dimensions have been found, further characteristics of the dimensions can be identified. If new characteristics have been found, further dimensions containing these characteristics can be identified.
Each characteristic is unique within its dimension.	If dimensions are not unique, then there are redundancies/duplications between dimensions that need to be eliminated.
Each dimension is unique and is not repeated.	If characteristics within a dimension are not unique, then there is redundancy/duplication in the characteristics that must be eliminated.

Table 1: Objective ending conditions (Nickerson et al., 2013, p. 344)

Subjective ending conditions	Description
Short and concise	The taxonomy should not be confusing or overwhelming. Miller (1956) specifies an optimal number of dimensions of seven plus or minus two.
Robust	The dimensions and characteristics should allow sufficient differentiation.
Comprehensive	All objects should be able to be classified in the taxonomy.
Expandable and explaining	A new dimension or feature should be easy to add.

Table 2: Subjective ending conditions

(Nickerson et al., 2013, p. 344)

The third step of the process deals with the choice of approach, whereby a distinction is made between an empirical and a conceptual approach (Nickerson et al., 2013, p. 343). In this specific work, a conceptual-empirical approach was chosen. This means that the taxonomy is first developed based on existing knowledge, experience, and judgment before being refined using empirical data.

Steps 3 to 7 (see Fig. 1) are carried out iteratively. First, the dimensions of the taxonomy are designed based on subjective ideas about similarities and differences between the objects. These dimensions must correspond to the previously defined meta-characteristics. Various objects are then checked to see whether they have the characteristics of the respective dimensions. Irrelevant characteristics can be removed, and new relevant characteristics added. After each iteration, the system checks whether both the objective and subjective termination conditions have been met. If not, the process is continued iteratively until both conditions are met. This iterative approach allows the taxonomy to be continuously evaluated and refined until it has reached an appropriate structure and meaningfulness (Nickerson et al., 2013, p. 343).



Findings

This section presents the central research results of the paper. The information obtained from MaxQDA is presented in the form of tables and relevant correlations are shown. Furthermore, the developed taxonomy is presented. These results are the outcome of a comprehensive data analysis, which makes it possible to gain insights into the structure and dynamics of the DeFi projects studied. The following sections offer a condensed presentation of the insights gained and provide a holistic picture of the research work.

Data evaluation

Table 3 presents the results of a study on applied blockchains, where 144 DeFi projects were analyzed. The left part of the table shows that the projects are assigned to different blockchains based on the highest TVL. However, some projects may be active on multiple blockchains at the same time. The right part of the table shows the actual occurrence of the projects on the respective blockchains, even if they do not have the highest TVL. 96 of the analyzed DeFi projects (66.67%) operate mainly on the Ethereum blockchain.

Blockchains	Quantity	Share in %	Total quantity	Total share in %
Ethereum	96	66.67%	113	78.47%
Tron	4	2.78%	4	2.78%
BSC (Binance Smart Chain)	19	13.19%	44	30.56%
Arbitrum	11	7.64%	44	30.56%
Polygon	5	3.47%	32	22.22%
Optimism	4	2.78%	20	13.89%
Avalanche	5	3.47%	27	18.75%
(Other Blockchains)	-	-	55	38.19%
Total:	144	100%	-	-

Table 3: Evaluation of the category: Blockchains

Table 4 shows a comprehensive presentation of all identified protocol types. In total, these amount to 17 different variants, three of which can be divided into further subcategories. Decentralized trading exchanges are divided into order books and AMMs. The staking segment can also be broken down into the area of liquid staking, while the lending of crypto assets is divided into NFT-based lending. The values in brackets add up to the number of the superordinate category.

DeFi protocol categories	Quantity	Share in %	Description (DefiLlama, 2023)
Liquidity Manager	1	0.69%	These protocols automate the management of investments in decentralized trading exchanges
Payment	1	0.69%	Protocols that offer the possibility to pay with, send or receive cryptocurrencies



Launchpad	4	2.78%	Protocols for the introduction of new projects and tokens
Indexes	4	2.78%	This type of protocol maps the performance of assets
Cross-Chain	3	2.08%	Protocols that create interoperability between different blockchains
RWA	5	3.47%	Protocols that tokenize real-world assets
NFT Marketplace	3	2.08%	Protocols for the purchase and sale of NFTs
Synthetics	2	1.39%	Tokenized derivatives
Insurance	2	1.39%	Insurance for crypto platforms
Derivate	8	5.56%	Protocols for leveraged trading
Services	3	2.08%	DeFi protocols that offer a service to users (automation of investment strategies)
Yield Farming	23	15.97%	Protocols that pay a reward for liquidity
DEX	27	18.75%	Decentralized trading exchanges
– Orderbook	(1)	(3.7%)	A variant of DEX
– AMM	(26)	(96.3%)	A variant of DEX
Staking	16	11.11%	Protocols via which tokens can be staked
 Liquid Staking 	(16)	(100%)	Parallel to staking, you receive a tradable liquid token with the value of the staked tokens
Lending	22	15.28%	Enables users to borrow and lend
- NFT-Lending	(4)	(18.18%)	Taking and giving loans through a deposit of NFTs
CDP	16	11.11%	Protocols that operate stablecoins
Total:	144	100%	

Table 4: Evaluation of the category: DeFi protocol categories

It is noticeable that despite the large number of categories, five main areas stand out clearly: with a combined percentage share of 72.22%, CDPs, lending, staking, decentralized trading exchanges and yield farming protocols dominate.

Table 5 deals with the interoperability of blockchains. It describes the exchange of data and the ability to communicate between different blockchains. On-chain refers to activities within a single blockchain, while cross-chain describes the exchange of information between different independent blockchains. The use of a cross-chain function requires special technologies to ensure the security and integrity of the exchange.



Interoperability	Quantity	Share in %	Description
On-Chain	112	77.78%	Protocols can only interact within their blockchain
Cross-Chain	32	22.22%	Protocols can interact between different blockchains and within their blockchains
Total:	144	100%	

Table 5: Evaluation of the category: Interoperability

Table 6 is dedicated to the topics of Governance and Decentralized Autonomous Organizations. Various governance models are examined and presented in this table. In a community, a project is usually managed by a community structure consisting of different interest groups. Participation in this community can be open to all interested parties or restricted to selected members. The analysis shows that the token-based model is one of the most frequently chosen models, with an approval rate of almost 76%.

Governance & DAO	Quantity	Share in %	Description
Community	1	0.69%	Governance models define the way in which decisions
Token-based	109	75.69%	are made and the respective protocols are managed
Centralized	34	23.61%	
Total:	144	100%	
Use of a DAO	78	54.17%	Projects can be managed by a decentralized autonomous organization
No use of a DAO	66	45.83%	
Total:	144	100%	

Table 6: Evaluation of the category: Governance & DAO

In addition, a certain proportion of centralized models (~24%) were identified in which decisions are made by a single central authority. Table 6 shows that 54% of the projects are managed by decentralized autonomous organizations.

The following table highlights the different token types that are used within a project. First, a distinction is made between fungible and non-fungible tokens. The survey reveals that around 95% of tokens are fungible.

Token types	Quantity	Share in %	Description
Fungible Token	186	95.38%	Exchangeable digital units for assets
Non-Fungible Token	9	4.62%	Non-interchangeable digital units
Total:	195	100%	
Synthetic tokens	2	1.03%	Artificially created digital representations of real assets



Liquidity token	7	3.59%	Digital units for the provision of liquidity in DeFi protocols
Stablecoins	21	10.77%	Cryptocurrency with stable value
– NFT-backed	(1)	(4.76%)	
– EUR-backed	(1)	(4.76%)	
– USD-backed	(6)	(28.57%)	
– Crypto-backed	(11)	(52.38%)	
– RWA-backed	(2)	(9.52%)	Real-world asset (real estate, commodities, etc.)
Staking-Token	17	8.72%	Tokens that are used for staking
Governance-Token	91	46.67%	Tokens to influence decisions in a DeFi project
Utility-Token	57	29.23%	Token that grants access to services or functions in an ecosystem
Total:	195	100%	

Table 7: Evaluation of the category: Token types

A total of 195 tokens were identified in 144 projects. DeFi projects often use several token types. A total of six variants are listed, with stablecoins being particularly differentiated. The focus here is on the type of assets that are backed to stabilize the price. One challenge was the distinction between governance and utility tokens. The boundaries are not always clear, as utility tokens can also be used in governance processes. The table shows that a significant proportion of tokens were classified as governance tokens, with them playing a dominant role at over 46%.

The following section deals with oracles, which are widely used in DeFi projects. There are different oracle categories, including reward, base-fee, DAO, staking, emergency, and price oracles. These can be divided into three groups: On-chain, Off-chain and Aggregated.

Types of oracles	Quantity	Share in %	Description
On-Chain	93	83.78%	Data within a blockchain
Off-Chain	8	7.21%	Data from outside a blockchain
Aggregated	10	9.01%	Combination of on-chain and off-chain or a combination of different off-chain sources
Total:	111	100%	
Reward oracle	1	0.90%	Provides data on rewards or incentives in blockchain applications
Base fee oracle	1	0.90%	Service for current transaction fees in blockchain networks
DAO oracle	2	1.80%	Service for external data in decentralized autonomous organizations
Staking oracle	2	1.80%	Real-time information on staking yields



Emergency oracle	1	0.90%	Rapid provision of information in critical situations
Price oracle	104	93.70%	Real-time data for assets
– Elastic	(1)	(4.76%)	
– Coinbase	(1)	(4.76%)	
– Optimism	(1)	(0.96%)	
– Pyth	(2)	(1.92%)	
– JustLink	(1)	(0.96%)	
– WinkLink	(1)	(0.96%)	
- UMA´s Optimistic	(1)	(0.96%)	
– UniSwap	(5)	(4.81%)	
– Binance	(3)	(2.88%)	
– OpenSea	(1)	(0.96%)	
– Chainlink	(50)	(48.08%)	
Total:	111	100%	

Table 8: Evaluation of the category: Types of oracle

Around 84% of the oracles identified use the on-chain architecture, in which data is processed directly on the blockchain. A total of 111 oracles were identified. A protocol can use several oracles or dispense with them altogether. Furthermore, 43 projects were identified that work without the integration of oracles. Various providers of price oracles have established themselves within the DeFi ecosystem. A total of 11 such providers were identified. Chainlink occupies the leading position among the most frequently used price oracle services with a striking share of 48%. Over 93% of the oracles used belong to the price oracle category.

Table 9 illustrates the identified security approaches used by DeFi projects. Six different methods were identified: AML, formal verifications, KYC procedures, insurance, bug bounty programs, and code audits.

Security	Quantity	Share in %	Description
AML	1	0.69%	Anti Money Laundering
Formal verification	8 (2)	4.86%	Process for mathematically checking software for correctness
– Certora	(2)	(25%)	
КҮС	6 (14)	4.17%	Know Your Customer - procedures in which the identity of users is verified
- Cryptergridy	(1)	(7.14%)	
– Seek	(1)	(7.14%)	
– Flooz	(1)	(7.14%)	
– IDOPresales	(1)	(7.14%)	



– Certik	(1)	(7.14%)			
– Cyberscope	(3)	(21.43%)			
– Assure DeFi	(3)	(21.43%)			
- SolidProof.io	(3)	(21.43%)			
Insurance	17 (11)	11.81%	Insurance offers protect decentralized financial proto	tion agains cols	it risks in
– Tidal	(1)	(5.88%)			
– Certik Shield	(1)	(5.88%)			
– Nexus Mutual	(5)	(29.41%)			
– Insurance	(4)	(23.53%)			
Bug-Bounty-Program	84	58.33%	Reward program for reportinand weaknesses	ng software v	vulnerabilities
Code audits	129 (305)	89.58%	Code audits are checks of s defects and quality	software cod	e for security
– Cloakwire	(1)	(0.33%)	– Secbit	(2)	(0.66%)
 Bramah Systems 	(1)	(0.33%)	– Salus	(3)	(0.98%)
– Slowmist	(6)	(1.97%)	– Dedaub	(7)	(2.30%)
– 3rd	(1)	(0.33%)	– Certik	(34)	(11.15%)
– Beosin	(1)	(0.33%)	– Solidified	(5)	(1.64%)
– Watchpug	(1)	(0.33%)	– G0 Group	(1)	(0.33%)
– Sherlock	(2)	(0.66%)	– losiro	(4)	(1.31%)
– Ackee	(2)	(0.66%)	– ChainSecurity	(13)	(4.26%)
– Watchdog	(1)	(0.33%)	– Pessimistic	(2)	(0.66%)
– Althea	(1)	(0.33%)	– Omniscia	(7)	(2.30%)
– CoinFabrik	(1)	(0.33%)	– Spearbit	(4)	(1.31%)
– Zokyo	(4)	(1.31%)	– Zellic	(6)	(1.97%)
– Solidity	(3)	(0.98%)	– Halborn	(10)	(3.38%)
– HashEx	(1)	(0.33%)	– Coinspect	(3)	(0.98%)
– Paladin	(3)	(0.98%)	– Code4rena	(16)	(5.25%)
– Arbitrary	(1)	(0.33%)	– Consensys	(10)	(3.28%)
– Cyberscope	(3)	(0.98%)	– MixBytes	(6)	(1.97%)
– SolidProof	(2)	(0.66%)	– Quantstamp	(8)	(2.62%)
– FairyProof	(2)	(0.66%)	– OpenZeppelin	(15)	(4.92%)
– Hacken	(7)	(2.30%)	– Certora	(7)	(2.30%)
– OtterSec	(1)	(0.33%)	– SigmaPrime	(6)	(1.97%)
– Blocksec	(4)	(1.31%)	– ABDK	(10)	(3.28%)



– ThreeSigma	(1)	(0.33%)	– Runtime Veri	(4)	(1.31%)
– Verilog	(2)	(0.66%)	– PeckShield	(39)	(12.79%)
– Hats	(1)	(0.33%)	 Trail of Bits 	(28)	(9.18%)
– DeFiMoon	(1)	(0.33%)	– Nomoi	(1)	(0.33%)

Table 9: Evaluation of the category: Collateral

Of the 144 projects, one project integrates the AML procedure. Eight projects rely on formal verifications, with 25% of the formal verifications carried out by Certora. Six projects use KYC procedures. It should be noted that a project can use several KYC procedures or dispense with them altogether. This results in a total of 14 procedures, with Cyberscope, Assure DeFi and SolidProof.io being among the most frequently used providers. In addition, 17 projects rely on insurance, with 29% of these insurance policies being covered by the provider Nexus Mutual. In terms of bug bounty programs, 84 of the projects (58%) rely on this measure. In the area of code audits, 129 projects rely on this procedure (corresponds to almost 90% of all projects). Of a total of 305 audits from 52 providers, almost 13% were carried out by PeckShield, 9% by Trail of Bits and 11% by Certik.

The following table deals with the topic of risks. A total of 20 different categories of risks were identified. Technical aspects such as smart contract risks (51 occurrences) and difficulties with the blockchain (8 occurrences) dominate among the most frequently mentioned risks. Price risks and market-related risks are also significant, with price risks occurring 32 times and market-related risks 16 times.

Risks	Quantity	Share in %	Description
Solvency	1	0.60%	Funds cannot be repaid
Token risks	1	0.60%	Price fluctuations, lack of liquidity, regulation or security
Liquidations	3	1.79%	Occur when borrowers lose their deposited collateral
Liquidity	5	2.98%	Problems with buying/selling quickly without losing value
Strategic risks	1	0.60%	Misalignment of returns, protocol changes or losses
Oracle risks	6	3.57%	Incorrect external data can lead to incorrect actions
Slippage risks	1	0.60%	Price changes during a transaction can cause losses
Collateral risks	3	1.79%	Assets may lose value, resulting in the threat of liquidation
Third party risks	6	3.57%	Dependence on external service providers harbors potential risks
Regulatory risks	4	2.38%	Legal changes may affect or prohibit DeFi projects
Governance risks	7	4.17%	Wrong decisions can have negative consequences
Custodial risks	2	1.19%	There are risks if third-party providers have control over assets
Blockchain risks	8	4.76%	For example, technical vulnerabilities could have a negative impact on DeFi projects
Market risks	16	9.52%	Price fluctuations or changes in supply and demand as an example



Counterparty risks	7	4.17%	Counterparty risk is the probability that one of the parties involved in a transaction will be unable to meet its contractual obligations.						
Price risks	32	19.05%	Fluctuations in assets can lead to financial losses						
Black Swan risks	3	1.79%	Unexpected, rare event with serious consequences						
Slashing risks	7	4.17%	Punishment in proof-of-stake networks for rule violations that can cause losses						
Admin keys treasury	4	2.38%	Management of the keys for the <i>safe</i> in a DAO, for example						
Smart Contract risks	51	30.36%	Programming errors, security vulnerabilities and unexpected behavior can cause losses						
Total:	168	100%							

Table 10: Evaluation of the category: Risks

Table 11 presents a holistic summary of the evaluated data in relation to the respective project types. This overview aims to reveal underlying correlations. In terms of governance, 80% of DEX projects with an Automated Market Maker have a token-based governance structure. This constellation enables every token holder to participate in project decisions. Similarly, 90% of yield farming projects have a token-based governance structure in the decision-making process. In contrast, governance structures in real world asset (RWA) projects are 80% centralized.

The following section shows that all lending protocols rely on on-chain-based price oracles. At this point, it should be emphasized that individual projects can also use multiple oracle methods, which requires careful interpretation of the figures. In this context, 83% of projects use on-chain oracles.

	Liquidity Manager	Payment	Launchpad	Indexes	Coss-Chain	RWA	NFT-Marketplace	Synthetics	Insurance	Derivate	Services	Yield Farming	DEX	- Orderbook	- AMM	Staking	- Liquid Staking	Lending	- NFT-Lending	CDP	Total
No. of projects	1	1	4	4	З	5	3	2	2	8	3	23		1	26		16	22	4	16	
Interoperability																					Σ144
On-Chain	1	1	3	4		5	3	2	2	6	2	14		1	17		14	19	4	14	112
Cross-Chain			1		3					2	1	9			9		2	3		2	32
Governance																					Σ144
Community																	1				1
Token-based		1	1	2	3	1	3	2	2	6	1	21		1	21		11	18	3	12	109
Centralized	1		3	2		4				2	2	2			5		4	4	1	4	34
DAO																					Σ78
Usage				2	3	1	2	2	2	5	1	13		1	14		10	10	3	9	78
Oracle																					Σ111

On-Chain	1			4	1	3		1	1	5	1	11	1	15	9	22	4	14	93
Off-Chain										2		1		1	3			1	8
Aggregated										3				1	2		1	3	10
Oracle types																			Σ111
Reward oracle															1				1
Base fee oracle												1							1
DAO oracle												1			1				2
Staking oracle															2				2
Emergency oracle																		1	1
Price oracle	1			4	1	3		1	1	10	1	10	1	17	10	22	5	17	104
Token																			Σ 195
Non-Fungible Token						1				1		3		2	1		1		9
Fungible Token	1	1	4	3	4	5	3	2	2	13	1	27	1	35	25	27	5	27	186
Token type																			Σ 195
Synthetic tokens																	2		2
Liquidity token										2		2		1		1	1		7
Stablecoins						1						2		1		1		16	21
Staking token	1				1							1		1	11	2			17
Governance token			1	2	3		2	2	2	6	1	18		18	9	15	3	9	91
Utility token		1	3	1		5	1			6		7	1	16	6	8		2	57
Security																			Σ432
AML						1													1
Formal verification														2		6			8
КҮС			14			2										1			17
Insurance				1								8		3	2	1	1	1	17
Bug bounty program	1			4	2		1	1	1	3	1	17		17	6	18	3	9	84
Audits	4	2	9	11	3	8	3	2	5	11	7	38		64	31	62	8	37	305
Risks																			Σ168
Solvency														1					1
Token risks										1									1
Liquidations																2		1	3
Liquidity												1		1		3			5
Strategic risks												1							1
Oracle risks				1								1				2		2	6





Collateral risks								1				2			3
Third-party risks						1	1	3						1	6
Regulatory risks			1			1		1			1				4
Governance risks					2			1		1		2		1	7
Custodial risks	1										1				2
Blockchain risks			1			1	1	1			2			2	8
Market risks	1						1	5		3		3	1	2	16
Counterparty risks	1					2						4			7
Price risks			2		1	1	2	2		5	4	7	1	7	32
Black Swan risks												1		2	3
Slashing risks											7				7
Admin Keys Treasury								1		1	1			1	4
Smart Contract risks			2		1	3	2	13		3	6	11	1	9	51

Table 11: Overview & allocation

With regard to tokens, it is evident that CDP, lending and DEX protocols in particular use more than one token. A protocol token and a governance token are often used for project decisions.

In terms of security, DEX and lending protocols in particular rely more heavily on audits being carried out. On average, DEX protocols have 2.4 audits per project, while this figure is 2.8 for lending protocols. The table also shows that launchpad protocols in particular make greater use of KYC procedures (14 out of a total of 17), while only 4.5% of lending protocols use this procedure. With regard to risks, it is clear that yield farming protocols in particular frequently refer to the possibility of problems with smart contracts. In addition, 43% of CDP protocols indicate price risks. This topic also plays a significant role in lending.

DeFi taxonomy

Based on the collected data, a comprehensive taxonomy was developed in the next step. The DeFi taxonomy is presented in Table 12 and is divided into nine different dimensions and corresponding characteristics, thus meeting the subjective condition short and sweet according to the requirements of Miller (1956).

The first dimension categorizes the various blockchain platforms that serve as the basis for different DeFi applications. This dimension comprises eight characteristic properties, including blockchains such as Ethereum, Tron, Binance Smart Chain, Arbitrum, Polygon, Optimism and Avalanche. To enable a complete classification and to fulfill the given subjective requirement of comprehensiveness, this dimension also includes the category Other.

The second dimension focuses on the different DeFi project types, taking into account all types identified in the previous analysis. Despite the low occurrence of certain protocol types such as $P_{age 23 of 34}$



Payment (with an occurrence of 0.69%) and Liquidity Manager (also with a frequency of 0.69%), it is important to integrate them into the taxonomy so that the criterion of comprehensiveness according to Nickerson is fulfilled. This dimension is broken down into a total of 21 characteristics, four of which were further differentiated into subcategories. It includes a variety of types such as Services, Payment, Launchpad, Indexes, Cross-Chain, RWA, NFT-Marketplace, Synthetics, Insurance, Derivatives, Liquidity Manager, Yield Farming and CDP. The DEX protocol type can also be subdivided into AMM and order books. Staking can also be subdivided into Liquid Staking and Lending into NFT Lending. The classification Other is available for all other types.

Another dimension is the issue of interoperability. This refers to the ability of different blockchain systems to communicate with each other. A distinction is made here between cross-chain and on-chain.

The next dimension deals with the various governance models used within the projects analyzed. In the course of the analysis, it emerged that all 144 projects examined can be assigned to one of three core models. The community model consists of various individuals and companies that are responsible for managing governance. In a token-based model, people can acquire shares, which gives them an active role in the governance process. This promotes democratic participation and influence. There is also the centralized model, in which all key decisions are made by a single central party that has overall control over the project.

The fifth dimension focuses on the implementation of DAOs in the respective projects. A clear distinction is made here between implements a DAO and does not implement a DAO. This differentiation is of particular importance, as DAOs could potentially be the focus of future regulatory measures.

The following dimension deals with the topic of oracles. The research identified various types of oracles, including reward, base fee, DAO, staking, emergency, and price oracles. Given the project-specific nature of most of the oracles identified, the taxonomy was developed by focusing on the most frequently used oracle. This results in six different characteristics in this dimension. To begin with, a division is made into on-chain, off-chain, and aggregated oracles to enable an initial clear distinction to be made between the different types. This is followed by a categorization into price oracles and the absence of an oracle. The property Other oracles is again used to fulfill the subjective requirement of comprehensiveness.

A further dimension is required to classify the various token types found in the projects analyzed. First, a basic distinction is made between fungible and non-fungible tokens. The next step is a categorization based on the respective properties of the tokens. The tokens can be classified as synthetic, liquidity, staking, governance, or utility tokens. Special attention is paid to stablecoins, which can be divided into different categories based on the deposited assets: Euro, Real World Items, NFT, USD, cryptocurrencies, and an additional category Other. This category reflects the possibility that there may be alternative methods of hedging stablecoins that have not yet been captured in the current analysis. To ensure the comprehensiveness of the taxonomy, the characteristic Other was also added in this dimension. This ensures that potential options that are not yet known or defined can be taken into account in future analyses and assessments, thus contributing to the sustainable applicability of the taxonomy.

The penultimate dimension is dedicated to the topic of safety. It takes into account a large number of identified measures that contribute to improving and strengthening project security. Key features $P_{age 24 \text{ of } 34}$



include the implementation of an anti-money laundering procedure and a know-your-customer procedure. Furthermore, the integration of insurance for the financial protection of digital assets is emphasized. Formal verification processes, bug bounty programs and code audits are also listed for technical security. They contribute to the identification and elimination of security vulnerabilities.

The final dimension of the taxonomy comprises the potential risks that can occur within DeFi projects. A total of twenty different risks were identified in the study, which were divided into eight main categories for better clarity. Financial risks form the first category, which includes various sub-categories such as collateral risks, liquidity risks, risks associated with liquidations, payment-related risks and risks associated with the management of administrator keys and treasuries. Technical risks were also identified, which can be further subdivided into token risks, oracle risks, smart contract risks and blockchain risks. The category of market risks takes into account general market risks and also integrates liquidation and liquidity risks. In addition, operational risks cover strategic, regulatory, and governance-related risks. Execution risks are also relevant, as they include slippage risks, for example. Security risks are also considered in detail and include specific risk factors such as slashing and custodial risks. The last two characteristics include third-party risks, which include potential dangers from external actors, and event risks, which consider unforeseeable events.

Dimension	Characterist	ic										
Blockchain	Ethereum		Tror	Tron					Ar	Arbitrum		
	Polygon Op		Opti	Optimism			Avalanche			her		
Protocol type	Services	Payn	nent	ent Launch			pad Indexes			Cross-Chain		
	RWA	NFT- Mark	etpla	ce	Synthe	etics	Insu	rance		Derivate		
	Liquidity Ma	nager			Yield F	arming	CDP			Other		
	DEX			Staking				Lending				
	АММ	Orderb	ook	Liquid-Staking				NFT-Lend				
Interoperability	Cross-Chain			•	On-Chain							
Governance	Community			Toke	en based			Centralized				
DAO	Use of a DAC)		•		No u	se of a	DAO				
Oracle	On-Chain			Off-0	Chain			Aggregate	d			
	Price oracle			Othe	er oracle	S		No oracle				
Token type	Fungible Token			<u>.</u>		Non-Fu	ngible	gible Token				
	Synthetic to	Liquidity token				Staking token						



	Governance token			Utility token		Other	Other			
	Stablecoins									
	EUR	Real- World-Item		NFT	USD	Crypto		Andere		
Security	AML KY		KYC		Insurance		Other			
	Formal verif	ication		Bug-Bount	y-Program	Code au	Code audits			
Risks	Financial ris	ks		Technical r	isks	Market	Market risks			
	Operational risks			Execution	Execution risks			ovider risks		
	Security risks			Event risks		Other	Other			

Table 12: DeFi taxonomy

To successfully complete or end the development process of a taxonomy according to Nickerson et al. (2013), certain objective and subjective conditions must be fulfilled. When describing the dimensions, the subjective completion condition comprehensiveness has already been mentioned several times, which states that all objects in the taxonomy can be classified. In addition to this condition, there are three further conditions. In addition to comprehensiveness, the condition of conciseness (short and sweet) is also fulfilled, as the taxonomy has a total of nine dimensions. Furthermore, the balanced structure of a total of 73 characteristics within the nine dimensions confirms the fulfillment of the robustness condition, as there is appropriate differentiation. It is also possible to add further dimensions and characteristics to the existing taxonomy, thus fulfilling the condition of extensibility. One possible extension could be the inclusion of a dimension that systematically captures the value proposition of DeFi projects (Puschmann & Huang-Sui, 2023, p. 13).

Apart from the subjective criteria, objective conditions must also be considered. On the one hand, it is required that all or a representative selection of the properties are included in the study. In this case, the taxonomy based on 144 projects fulfills this requirement. An additional requirement is that at least one object must be classified under each characteristic. There is a problem at this point: the taxonomy was subsequently supplemented with the characteristic Other. This serves to ensure that the taxonomy is also applicable beyond the representative selection of projects. This subsequent change could theoretically contradict the second objective condition. Regardless of whether the condition was fulfilled at the time of development, it could be argued that the taxonomy no longer meets the provisions of Nickerson et al. (2013) due to the subsequent modification.

Nevertheless, the remaining objective conditions are fulfilled, as no new dimensions or characteristics were added in the last iteration and each characteristic is unique within its dimension, without any dimension being repeated.



Validation of the DeFi taxonomy

Validation of the taxonomy is important as it ensures that the taxonomy correctly and reliably records the projects to be classified. Furthermore, validation serves to confirm whether a taxonomy is applicable and useful in the respective context. Gaps or errors can also be identified retrospectively during the validation process.

To validate the taxonomy developed in this paper, two random DeFi projects were selected that are not included in the list of representative projects for the analysis. The two projects are Yeti Finance (Yeti Finance, 2023) and Swappi (Swappi, 2024). The validation in Table 16 was created based on the information from the documentation of the two projects.

Dimension	Yeti Finance	Swappi						
Blockchain	Avalanche	Other (Conflux)						
Protocol type	CDP	DEX -> AMM						
Interoperability	On-Chain	Cross-Chain						
Governance	Centralized	Token based						
DAO	No DAO used	No DAO used						
Oracle	Price oracle; other oracle	No oracle						
Token type	Fungible Token -> Stablecoin -> USD; Fungible Token -> Utility- Token;	Fungible Token -> Governance-Token						
Security	Bug-Bounty-Program; Code- Audits	Bug-Bounty-Program; Code-Audits						
Risks	Technical risks; Financial risks; Market risks	Technical risks						

Table 13: Validation of the DeFi taxonomy

For a clear presentation, the results are presented in a condensed table. This table includes all nine dimensions of the developed taxonomy, whereby unused characteristics are hidden for a clearer visualization. The results obtained show that both projects analyzed could be successfully categorized within the taxonomy, with a corresponding characteristic identified for each dimension.

Discussion

Theoretical implications

In recent years, the emerging decentralized financial world has shaped the financial sector (Schueffel, 2021, p. 1). With a multitude of projects emerging in a rapidly growing ecosystem, it becomes imperative to create structures and categories to adequately understand and regulate them. This paper examines a total of 144 DeFi projects spread across seven different blockchains, with the majority residing on the Page 27 of 34



Ethereum blockchain. The analysis led to the identification of 16 different types of projects, paying particular attention to their interoperability, governance structure, use of oracles, used types of tokens, applied security measures, and considered risks. We contribute to the body of knowledge through our inductive, real-life data-set taken from existing DeFi projects.

With such a taxonomy as a foundation, DeFi-oriented researchers can create own research pipelines and benefit from the categories and definitions presented in this paper. We believe that this is an important asset for academia, as the DeFi world lacks – due it its' nature – of anchor points in literature.

In addressing the complex landscape of decentralized finance, researchers are confronted with a situation reminiscent of the Hydra from mythology, where each branch of inquiry—be it legal, technical, or economic—presents its own set of challenges and perspectives. Our work aims to offer an interdisciplinary scaffolding via the proposed taxonomy, thereby facilitating a holistic approach to navigating the multifaceted issues inherent in DeFi research. This endeavor seeks to harmonize these diverse aspects, providing a unified framework for future exploration and understanding.

Practical regulatory implications

Through the detailed analysis of 144 DeFi projects and the subsequent development of a comprehensive taxonomy, five key regulatory approaches were identified.

CERTIFICATION AND EVALUATION OF BLOCKCHAINS

Our taxonomy identified seven blockchains (cf. section *Collection of data*), each built on its own blockchain protocol and community; yet, this dataset is only a subset of the existing DeFi ecosystem. In contrast to the classical banking system, where regulators and policymakers have a legal counterpart during the consideration phase, DeFi will always lack this counterpart. The DeFi world faces the challenge of ensuring the security and reliability of the underlying technologies, with blockchains forming the basis. Introducing a certification system for blockchains could help increase trust by clearly presenting risks and benefits and evaluating blockchains based on various criteria. An essential criterion for the evaluation is the blockchain program code, the consensus mechanism, and the number of active participants. These factors contribute to security and performance. Potential barriers to regulatory proposals include resistance to government interference, concerns about bias, technological advancement, auditor independence issues, and international consensus building. Despite these challenges, such measures could boost confidence in DeFi and make the sector safer.

REGULATION OF DAOS

The increasing popularity of DAOs in the DeFi sector underlines the need to clarify their legal position within the European regulatory framework. The taxonomy presented distinguishes whether an application uses a DAO or not, with 78 out of 144 projects using a DAO (cf. section *Data evaluation*). A first step towards effective regulation would be the clear legal recognition of DAOs in European law. It could be counterproductive to insert DAOs into existing legal structures. They require specifically tailored legal recognition. The legal framework for DAOs should be based on clearly defined criteria that consider the specificities of these organizations. This requires definitions that include factors such as



decentralization of decision-making and automation through smart contracts. This framework should also clarify the rights and obligations of DAOs, such as transparency standards or ethical obligations. It is also important to clarify liability regulations to determine the extent to which members are affected in the event of legal disputes or financial losses.

Potential obstacles to such regulation could be resistance within the DAO community, the international nature of many DAOs and the constant evolution of these structures. It is crucial to find a balance between regulation and freedom of innovation. To ensure this, the legal framework should be developed in cooperation with the DeFi and DAO community so that it considers current challenges and needs.

LICENSING OF ORACLES

The analysis of the 144 DeFi projects shows that the majority of oracles used in the DeFi world are price oracles. It is particularly noteworthy that out of 111 oracles analyzed, 104 functioned as price oracles and 50 of these oracles use the services of Chainlink (cf. section *Data evaluation*). Oracles, and price oracles in particular, play a central role in the DeFi ecosystem, underlining the need for robust regulation. Price oracles, for example, provide prices for various cryptocurrencies in a DeFi project. An error or manipulation of an oracle can have significant financial consequences. It would, therefore, make sense to create a specialized supervisory authority that deals exclusively with the licensing and monitoring of Oracle services. A systematic approach to checking data quality, transmission security and resistance to manipulation could help to strengthen trust in these services. The introduction of transparency standards, such as the obligation to disclose data sources, would also help to gain the trust of users. Furthermore, the various countries worldwide could provide their own oracles with data.

However, there are also some potential obstacles that should be considered when implementing this regulatory initiative. The constant evolution of technology could cause regulation to lag behind the latest developments. In the event of errors or inconsistencies in the data, the question of who is held responsible for financial losses or other negative effects could arise. There is also the issue that cross-border DeFi projects may find it difficult to ensure a consistent oracle service if different countries have different regulatory approaches to oracles. These potential obstacles need to be carefully considered if the EU or other state actors plan to regulate in this area.

STABLECOINS

Based on the projects analyzed, stablecoins represent a relevant part of the DeFi landscape, with a share of over 11% (cf. *Table T*). Their ability to mitigate the volatility of traditional cryptocurrencies while offering users the benefits of blockchain and DeFi makes them essential. The taxonomy of this paper categorizes stablecoins based on different coverage types. Therefore, it is crucial to ensure that these tokens are actually backed by real value. To ensure this, it would make sense to introduce regular auditing and certification of stablecoin providers. This could be carried out by an independent, regulated auditing body. Stablecoin providers could be required to make their reports publicly available on a quarterly basis via a central platform, similar to the annual reports of companies in the Federal Gazette. To ensure the integrity of the deposited reserves, it could even be considered that these reserves must be deposited with a regulated and recognized institution.



The cost of regular verification and certification, especially for smaller providers, could be quite high and thus pose a major challenge. Another significant obstacle is again the global nature of the DeFi sector. It could also be difficult to enforce regulations if providers operate outside the regulated space. Technical challenges arise, particularly with stablecoins backed by NFTs or other cryptocurrencies. It could be complex to determine a precise and stable value of the deposited assets.

MORE SECURITY

Security in the DeFi world is not only crucial for user trust but also for the stability and growth of the entire sector. An interesting finding from the analysis of the projects shows that out of 144 DeFi projects, 129 are already conducting code audits (cf. <u>Table 9</u>). A total of 305 audits were carried out by 52 different companies. However, the large number of audit companies involved raises questions about the consistency and quality of these audits and underlines the urgency of setting quality standards for these companies. It would, therefore, be advisable to regulate audit companies in the DeFi industry. For example, a central certification authority could take over the licensing of audit companies. This is already the case with auditing companies, for example. This authority would not only be responsible for issuing licenses but would also ensure that all licensed companies meet the latest and highest security standards. Decentralized trading exchanges are also becoming increasingly popular. However, their decentralized nature and the associated anonymity also pose regulatory and security issues. The introduction of KYC procedures in decentralized trading exchanges could help minimize the misuse of such platforms for illegal activities and increase security for all users. With the introduction of MiCA, centralized exchanges within the EU are already obliged to implement a KYC procedure. However, this hardly applies to decentralized exchanges in the DeFi sector, as they generally do not support transactions with fiat currencies. They are primarily designed for the exchange of cryptocurrencies. The exchange of cryptocurrencies into fiat currencies typically requires a central exchange, which will be regulated in the European Union in the future.

However, there are, once again, potential obstacles that should not be ignored. The introduction of KYC procedures could be seen by the community as a restriction of anonymity and, thus, as an encroachment on the basic principles of the crypto world. In addition, the worldwide enforceability of regional or national regulations in the global DeFi world is again problematic. There is also the question of reconciling different audit standards when DeFi projects are so diverse. Finally, the cost of regular audits by licensed companies could be an additional hurdle, especially for smaller DeFi projects.

REGULATORY OUTLOOK AND LIMITATIONS

In an industry characterized by rapid innovation and a high degree of anonymity, unregulated activities can lead to significant financial losses for those involved (BaFin, 2023a). However, thoughtful regulation can not only protect consumers, but also increase trust in DeFi services and make them more accessible to the general public, including institutional investors. A structured regulatory framework can provide the much-needed framework for sustainable growth and innovation without compromising the security and integrity of the system.

The future of DeFi regulation faces various complex challenges that go far beyond the conventional boundaries of financial regulation. The decentralized nature of DeFi projects, which operate across



borders and often without a central administrative entity, presents regulators with a unique task. The existing country-specific regulatory framework seems insufficient to assess the dynamic and global nature of DeFi adequately. In light of the findings from this research, it appears that a new approach is needed that promotes broader international cooperation and coordination. One possible direction could be intensified cooperation between countries at a multilateral level to achieve some uniformity in regulatory standards. Furthermore, the integration of licensing procedures for oracles and audit firms could play a central role in the future, as they help to create a more robust control infrastructure that minimizes fraud and manipulation in the DeFi landscape. The EU has already taken the first steps in this direction and, with the MiCA regulation and the EU Data Act, has created a regulatory framework that is intended to protect the interests and ensure the safety of consumers. However, the future goal should also be global coordination of regulatory standards to avoid the fragmentation caused by different regulatory frameworks in different countries.

Finally, it could be crucial to find a balance that both supports the rapid development of DeFi and minimizes the risks associated with this new technology. Careful and coordinated global regulation could be the key to ensuring a stable and secure development of the DeFi landscape, which has the potential to change the traditional financial world fundamentally.

Conclusion

Blockchain forms the foundation for DeFi, a financial system without central institutions that is enabled by smart contracts. While the EU is introducing regulations for crypto assets with the MiCA regulation, DeFi and DAOs remain unregulated. To address this area, a taxonomy has been developed to support regulatory measures. The taxonomy provides a structured and comprehensive classification of the DeFi sector by considering various aspects such as blockchain types, protocol types, governance structures, token types, security measures and risks. Based on the analysis of 144 DeFi projects, five regulatory approaches were proposed to promote stability and security. It emphasizes that multilateral cooperation and uniform standards are crucial to ensure balanced regulation. The developed taxonomy thus provides a solid starting point for effective regulatory strategies by systematically categorizing and classifying the diversity and structure of the DeFi sector. This structured approach allows regulators to target the specific characteristics and risks of different DeFi protocols and develop appropriate regulations. By applying this taxonomy, regulatory measures can be more precise and targeted to ensure the long-term integrity and stability of the DeFi ecosystem.

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