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From Stablecoins to Tokenized Assets: An Integrated Analysis of Decentralized Finance Architecture, Risks, and Regulatory Challenges

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Abstract: *Blockchain finance has developed into a complex multi-layer ecosystem where stablecoins, DeFi applications, and tokenized assets work together to offer the functions of payment, intermediation, and asset representation respectively, which have traditionally been the responsibilities of centralized institutions. In this paper, we adopt a computer science perspective to systematically study these three pillars in the context of an integrated crypto-financial stack. First, we perform a structured literature review on design patterns for stablecoins and stabilization approaches as well as cases of depegging events in the context of stablecoins. We then discuss various DeFi primitive technologies including automated market making platforms, lending protocols, and yield aggregator services, focusing on smart contract risks, oracle risks, composability risks, and governance risks in particular. Afterward, we investigate the tokenization technology used to represent physical and financial assets on the blockchain with an emphasis on design decisions and potential off-chain dependencies in the infrastructure. Based on the discussion above, we propose a multi-layer reference architecture for blockchain finance with stablecoins serving as the underlying settlement layer, DeFi as the intermediary layer, and tokenized assets as the top layer, followed by an example of cross-layer risks associated with DeFi protocols.*

Keywords: Blockchain, Stablecoins, Decentralized Finance, Asset Tokenization, Smart Contracts, Systemic Risk.

I. INTRODUCTION

Blockchain technology has enabled the creation of an entirely new generation of financial systems where transactions between participants are handled via smart contracts without any central intermediary. In such systems, decentralized finance (DeFi) protocols have come to play a central role within the crypto market. Over the last several years, the total value locked (TVL) in DeFi protocols has increased to well over one hundred billion U.S. dollars, indicating that many users rely on them and that the amount of money involved is quite significant. On the other hand, some of the recent stress tests, including episodes of depegging of stablecoins and exploits of protocols, have demonstrated that there are new sources of risk inherent to them that have not yet been sufficiently understood. [2,7,9]

Modern research focuses mostly on the individual components of the ecosystem independently, with stablecoins being studied as a means of making payments or as money market funds; DeFi protocols as separate lending or trading systems; and the concept of tokenization is studied from legal and market perspective. In reality, however, the relationship between these components is extremely close, as stablecoins form the basis of the collateral and settlement assets in the DeFi ecosystem; DeFi protocols provide an opportunity to program trade and leverage; and tokenization allows bringing legal and credit risks from offline environment onto blockchain. The shock experienced by one layer in this case, for example, if a major stablecoin loses its peg, or a tokenized collateral asset breaks down, may cascade throughout the protocol dependencies and composability. [11,13,15]

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From a computer science viewpoint, there are some issues concerning the architecture, formalization, and verification of such a crypto-financial stack. Firstly, there is a problem of ensuring that the smart contracts' financial logic will work correctly even when it faces an adversary. Also, oracle systems, governance mechanisms, and cross-protocol composition bring more states and opportunities for attack. The approaches that were developed for the analysis and construction of distributed algorithms and secure software, like formal verification, model checking, fault modeling, and designing incentive-compatible protocols, have already been applied in DeFi, yet not systematized across different systems. [2,7]

The following paper fills the research gap by offering a detailed, CS-based investigation into the three layers of blockchain-based finance architecture: stablecoins, DeFi protocols, and asset tokenization. In particular, the technical aspects of stablecoin design and stability strategies will be considered first. [9] After that, we will analyze some basic primitives of DeFi protocols with an explicit focus on smart contract risk, oracle risk, composability risk, and governance risk. Third, tokenization platforms that tokenize physical world assets and the relationship between their legal nature off-chain and on-chain settlement or collateralization will be examined. Based on the above, we suggest a reference architecture and taxonomy of micro/macro contagion risks in DeFi. It is expected to contribute to research that will eventually lead to modeling of DeFi infrastructure as a distributed system and, consequently, designing resilient, provable, and compliant blockchain-based financial systems. [11,13]

II. BACKGROUND AND RELATED WORK

The advent of blockchain-based smart contract platforms like Ethereum brought forth the concept of a generic environment to execute stateful computations on a shared, immutable database. Leveraging these platforms, DeFi applications are able to express the logic of various financial products like exchange platforms, lending facilities, and derivatives using programs that can communicate and share resources through on-chain states and tokens. However, this design paradigm brings its own set of novel challenges that include, but are not limited to, secure consensus algorithms and oracles.

The stablecoin is one of the key building blocks in DeFi, which is essentially an asset on blockchain technology that aims to keep a stable price level, usually against a traditional fiat currency like the US dollar. Stablecoins have been classified into fiat-based, crypto-based, or algorithmic/hybrid stablecoins in earlier research works. However, recent empirical analysis demonstrates how depegging episodes can swiftly spread across DeFi platforms, leading to a chain reaction within lending protocols and withdrawing liquidity from decentralized exchanges.

There is evidence of research concerning DeFi protocol designs that have shown the fundamental building blocks and their respective threats, such as automated market maker protocols, money market protocols, and governance token decision-making systems. Threats are generally classified into several categories, such as smart contract errors, oracle manipulation, governance takeover, front-running attacks, and systemic risk between protocols. Oracle manipulation vulnerability has been a focus of research with evidence showing that most of the proposed mitigation measures in existing systems against oracle error are inadequate to safeguard against exploits.

Alongside DeFi, studies on tokenization explore the application of distributed ledger technology to create digital tokens representing claims on tangible or legacy financial assets. These policy reports and regulatory documents consider possible advantages of tokenization, including efficient settlement, fractionalization, and wider investor reach, along with the dangers posed by liquidity risks, leverage, complex connectivity, and operational frailties. Significantly, all these works stress that the tokenized assets will continue being connected with off-chain infrastructure and regulation, posing a set of cross-domain challenges associated with those emerging within the on-chain realm of DeFi systems and stablecoins.

This existing body of literature thus offers abundant yet scattered perspectives, with some focusing on stablecoin depegging and its mitigation, others on DeFi protocol security and governance, and yet others on the financial stability impacts of tokenization. It is precisely what is lacking from the current state of research that a CS-oriented reference architecture and risk taxonomy for this complex system need to be designed, explicitly capturing the inter-layer

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interfaces and risk transmission paths in this ecosystem. This paper draws on the aforementioned literature base and develops such a reference architecture and cross-layer risk taxonomy.

III. METHODOLOGY

This work is conducted using the systematic literature review (SLR) methodology tailored to fit stablecoins, DeFi protocols, and asset tokenization literature research needs. The purpose is to gather, analyze, and synthesize the information currently available regarding stablecoins, DeFi protocols, and asset tokenization, taking into account architecture and risk issues in computer science terms. The SLR methodology consists of four principal stages: problem definition, data sources identification and search, article selection and classification, and synthesis and analysis.

A. Research Questions

When we think about the reasons we are doing this we can figure out what we want to achieve with our literature review by using these research questions:

RQ1: What do people say about stablecoins in terms of patterns things that keep them stable and what could go wrong? How do these things relate to technology and system risks for stablecoins?

RQ2: What are the main parts of DeFi protocol architectures like automated market makers, lending platforms and yield aggregators? How can we find out what kinds of risks are associated with them, such as risks from contracts oracles, governance and how different parts work together for DeFi protocols?

RQ3: How can we turn real world things into tokens using the tokenization infrastructure? How can we understand how these tokenized assets depend on aspects of the environment around tokenized assets?

RQ4: How do stablecoin systems, DeFi protocols and tokenized assets work together? What kind of problems could happen when these systems interact with each other and how can we model and classify these problems, for stablecoin systems, DeFi protocols and tokenized assets?

These research questions can help us solve problems that come up when we do a systematic literature review of stablecoins, DeFi protocols and tokenized assets.

B. Data Sources and Search Strategy

To make sure we cover everything the review looks at both practical sources. We get papers from online libraries like IEEE Xplore, ACM Digital Library, SpringerLink, ScienceDirect and arXiv which are the usual places where computer science and financial technology research is published. We also collect reports from institutions like the Bank for International Settlements the Financial Stability Board and the OECD because they do a lot of analysis on DeFi, stablecoins and tokenisation.

We use search words that combine technology terms with words related to risk and architecture for example: "stablecoin design and depegging risk" "DeFi protocols smart contract and oracle risk" "decentralized finance systemic risk and contagion" "asset tokenisation financial stability implications" and "blockchain tokenisation architecture". We mainly look at papers from 2017 to 2026 because that is when DeFi and tokenisation started to develop fast but we also include older papers about blockchain and smart contracts if they are relevant, to DeFi and tokenisation.

C. Study Selection and Classification

We choose the studies we want to use in three steps. First we look at the title and abstract of each paper to see if it is about blockchain-based finance. We check if the paper talks about blockchain-based finance things like stablecoins, DeFi protocols or tokenisation. If the paper does not talk about blockchain-based finance. If it is an advertisement or a non-technical comment we do not use the paper.

Next we read the paper to make sure it really gets into the details of the blockchain-based finance technology, architecture or risks. We do not want to use papers that just give an overview of blockchain-based finance.

The remaining corpus is then classified along multiple dimensions:

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• Topical focus: stablecoins, DeFi protocols, tokenisation, or cross-cutting.
• Contribution type: conceptual framework, empirical analysis, formal model, system design, or policy / regulatory analysis.
• Risk categories covered: smart contract, oracle, governance, liquidity, leverage, composability, operational, legal/regulatory, and systemic.
This way of looking at the papers helps us to see the picture of blockchain-based finance and understand how all the different parts of blockchain-based finance fit together. It also helps us to find areas where we need to do research on blockchain-based finance, like where certain interactions or risks of blockchain-based finance are not well understood. We can look at blockchain-based finance in a way that has three layers and see what is missing in blockchain-based finance.

D. Case Study and Example Selection

To make the analysis more real we look at some examples from the protocols and assets that people talk about in research papers and policy reports. For stablecoins we look at the ones that are backed by real money and the ones that use algorithms, which have had big problems with their value or have been under a lot of stress as seen in research papers and reports on what went wrong. For DeFi we focus on the known exchanges and lending protocols where people have put a lot of money, which have been studied for their risks or have been hacked in a big way. For tokenisation we look at examples from bond and fund markets that have been turned into tokens and pilot projects that have been highlighted in reports from the FSB and BIS looking at how they were designed and how they affect the system.
These examples are not meant to be a study but rather to show how the proposed system, with many layers and the way we classify risks can be applied to real systems.

E. Synthesis Approach

The people who did these studies looked at the results. Put them together to make a simple model that has three main parts. They took the things that make Stablecoins work and put them in the part that deals with settlements. The basic parts of DeFi protocols were put in the part that deals with intermediaries. The assets that are turned into tokens were put in the part that deals with assets. They also looked at the types of risks and problems that happened and used that information to find the connections between the parts. They kept working on the model until it made sense with all the studies they looked at. This helped them understand how everything fits together which they explain in the parts. They made a list of the risks. How they can affect each other between the different parts of the model, like the settlement layer and the intermediation layer and the asset layer and how Stablecoins and DeFi protocols and tokenised assets work together.

IV. LITERATURE REVIEW

The existing literature on blockchain based finance can be grouped into three closely related strands: (i) stablecoins and their design, risks, and use cases, (ii) decentralized finance (DeFi) protocol architecture and risk, and (iii) blockchain based tokenization and its governance and technological implications. Together these works provide rich insights into individual components of the crypto financial stack, but they typically analyze each layer in isolation, leaving open questions about how stablecoins, DeFi protocols, and tokenized assets interact as an integrated system.

A. Stablecoins: Design, Risk, User Perceptions, and Inclusion

Five papers look at parts of stablecoin design and how it affects things. Zhang and Zhao came up with a stablecoin-based system called SCoin to make blockchain-based spectrum trading more secure. They think that the tokens we use now are too unpredictable and hurt trust in these markets. Their system uses two types of tokens and a special way of

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agreeing on things called Delegated Proof of Stake. This shows that stablecoins can be made to work for uses but we still do not know much about how to actually use them in the telecom world and what rules would apply.

Yano did a study that grouped ways to keep prices stable into categories like being backed by money, cryptocurrency or commodities. This study also looked at how these systems can be set up and how they work, which helps us understand the economic parts of stablecoins better. Singh and others built on this study. Looked at how to keep stablecoins stable what happens when they lose value and how rules are being made to govern them. They suggested a way to assess the risks of using stablecoins that considers the things about using blockchain technology and the bad things that can happen because of design, rules and market problems. Guan and others looked at how people think about the safety of stablecoins. Found that people care about things like how centralized the system is, how good the collateral is and what rules are in place. They also found that these things affect whether people use stablecoins or not. Kshetri and Voas studied stablecoins in markets and found that they can help people send money save and make payments. They also found that using stablecoins tied to the US dollar can help more people have access to services but it also raises concerns about who controls the money and how rules are made.

All of these studies together show that stablecoins are a new thing that can help with problems like price swings and making payments but they also come with their own set of risks like the risk of the system failing or not being transparent about reserves. They also show that how people behave and big picture policy issues are important. However these studies mostly look at stablecoins on their own or as a way to connect to finance and they do not do much to model what happens when stablecoins fail and how that affects other parts of the financial system or real-world assets that have been turned into tokens. Stablecoins are still an multifaceted thing that we are learning about and we need to understand stablecoins and how they work in different contexts. Stablecoins can be used in ways and we need to know more, about stablecoins and how they affect different markets and people.

B. DeFi Protocols: Architecture, Efficiency, and Risk

The second group of five papers looks at DeFi as a way to do finance using smart contracts. The Federal Reserve Bank of St. Louis review says DeFi is a market that uses blockchain and smart contracts to do exchanges, lending and asset management without middlemen. This makes it transparent, programmable and easy to combine with things but it also has risks like problems with governance and smart contracts. The SoK paper on DeFi makes a list of all the protocols and vulnerabilities and finds ways that people can attack them like manipulating oracles using flash loans and finding bugs in contracts. It also says that even though DeFi is good for innovation it can also make the whole system more risky.

A study that compares CeFi and DeFi finds that DeFi is more transparent and gives users control but it also has more technical and market risks. This means that DeFi and centralized platforms are not replacements for each other but they can work together. The Bank for International Settlements says that a lot of DeFi systems are not really decentralized, because they have a people in charge developers who have too much power and they rely on centralized things like oracles. They warn that if something goes wrong with a protocol or stablecoin it can affect the whole ecosystem. Another article from Springer talks about the technology behind DeFi like automated market makers, lending protocols and smart contract execution. It shows how these things can replace middlemen. They also have problems with scalability oracle reliability and governance design.

All these papers together say that DeFi is a way to do finance that is programmable and easy to combine with other things and it makes things more transparent and automated.. It also has new risks, like technical, governance and systemic risks. However they do not really talk about how DeFi protocols, stablecoin designs and tokenized assets work they just kind of mention them on the side. DeFi is still an infrastructure that improves transparency and automation and DeFi is a new way to do finance. DeFi has risks. Defi is also a new way to do finance that is programmable and composable.

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C. Tokenization: Architecture, Assetization, and Governance

The third part of the literature is about using blockchain to turn world assets and money into tokens. One study called "Tokenization of Everything" looks at how assets can be turned into blockchain tokens, which can make it possible for people to own a part of something and for more people to buy and sell things.. It also says that people are exaggerating when they say that this will make everything fair and open to everyone because these token systems still rely on the financial systems and rules that we already have which limits how free and open they can be. Another paper talks about DeFi and token systems and how platforms like Ethereum make it possible to have services that can be programmed using tokens. This makes things automatic, transparent and cheaper. It also says that the complexity of smart contracts and the lack of rules make it hard for regular people to use.

Research on turning assets into tokens and making them into things says that when we turn physical and digital assets into tokens that can be traded it creates new kinds of assets and makes it easier to buy and sell things.. It also creates problems with the law and governance like who owns what and how to make sure that contracts are fair. Another paper talks about how to govern and regulate systems and how people in charge classify tokens and make rules about who can buy and sell them. It says that because of these rules token markets are starting to look like a mix of centralized systems. Finally a study on the technology and economics of tokenization looks at how smart contracts, ledgers and programmable assets work. Says that they can make things more efficient and faster but also acknowledges that there are still problems with how big they can get how well they can work with other systems and how safe they are.

This research shows that turning assets into tokens can really change the way markets work by making it possible to digitize assets and make trading more flexible.. Most of the time people look at tokenization as just a way to make asset markets or regulatory systems work better rather than as a part of a bigger system that includes stablecoins and lending or exchange protocols and that shares the same infrastructure and risks. Tokenization is a part of this and it can make a big difference, in how tokenization works. Tokenization can also make it possible for people to use blockchain tokens in interesting ways. Overall tokenization is a part of the blockchain and DeFi and it can help to create new and exciting opportunities for people to buy and sell things.

D. Synthesis and Research Gap

Across all three areas the research says the thing about a few important points: stablecoins are a safe and stable way to move money around in crypto markets DeFi protocols are creating a new way to do finance with computers and tokenization is helping to bring real world things into the blockchain world and deal with rules and laws. Each area finds some big problems. Like stablecoins not being stable and people not knowing what is backing them DeFi protocols having security issues with their computer code and the way they get information and tokenization having issues with how it's run and what laws apply. And they all say that when these areas are connected it can cause big problems.

What is not well understood is a single way to think about stablecoins and DeFi protocols and tokenized assets that sees them as three parts of the same crypto finance system with clear ways for them to work together and ways for problems to spread between them. Most studies only look at one part at a time. Do not show how they are all connected. For example how a problem with a stablecoin can cause big problems in DeFi or how laws, about tokenized assets can affect how the computer code is written and how it works with other systems. Your paper fills this gap by taking the ideas from all 15 studies and making a new framework that shows how stablecoins and DeFi protocols and tokenized assets all work together including how money is moved around how finance works and how assets are used.

V. STABLECOINS – DESIGN, RISK AND ECONOMIC ROLE

Stablecoins are a type of crypto asset that is made to keep its value steady by being tied to a regular currency like the U.S. Dollar. They have become very important for settling transactions and providing collateral in DeFi ecosystems. The way stablecoins are designed affects a lot of things including how steady their price's how decentralized they are,

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how well they use capital how they are treated by regulators and how risk spreads through DeFi protocols and into traditional financial markets. [1,2]

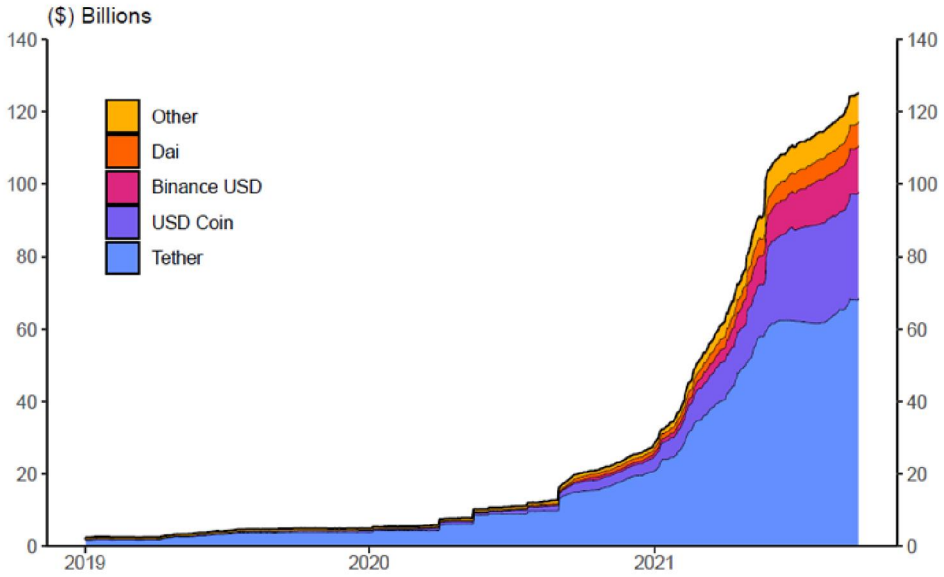

Fig.1. Circulating supply of USD-pegged public stablecoins

This part of the discussion looks at the types of stablecoins and how they are stabilized what role they play in DeFi and payment systems and the main ways they can be risky with a focus, on what happens when they lose their tie to a regular currency and the big picture effects that can have.

A. Design Taxonomy and Stabilization Mechanisms

Most stablecoins are grouped based on how they're backed and kept stable. They can be fiat-backed, crypto-collateralized, algorithmic or a mix of these.

i) Fiat-backed stablecoins are created by companies that keep cash and easy-to-sell assets in reserve. You can exchange them for fiat money at a 1:1 ratio. These companies use help to keep the money safe and follow rules. Examples of these stablecoins are USDT and USDC.

ii) Crypto-collateralized stablecoins work differently. They use digital assets that can change in value and lock them into smart contracts. To make sure the value stays stable they use assets than needed. Like 150-200% of the value. If the value of the assets drops they automatically sell them to keep things stable.

iii) Algorithmic stablecoins try to keep their value steady by changing how many coins are available. They often use tokens and don't have full backup making them very sensitive to people losing confidence in them.

iv) Some stablecoins combine methods. These hybrid models use some backup and some algorithms to try to be decentralized, efficient and stable.. They are still being tested.

When looking at these stablecoins we can consider things, like what they're compared to (like a single currency or a group of assets) how decentralized they are and what laws apply to them. All these things affect how risky they are. From a computer science point of view crypto-collateralized and algorithmic stablecoins are interesting because their stability is built into contracts and online management processes. This makes them like machines that can be checked and tested but also attacked. [1,2]

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B. Economic Role in DeFi and Payment Systems

Stablecoins are the thing people use to buy and sell things in the DeFi world. They are also used as collateral when people borrow money. In fact most of the money in DeFi is in stablecoins. This is because stablecoins make it easy to trade and lend money on the blockchain. They also help connect banks to the blockchain. Stablecoins are important for more than DeFi. They can be used to send money across borders quickly. This is a deal because it can help people who need to send money to other countries.. It also raises some concerns. For example if a lot of people in one country start using stablecoins from another country it can cause problems for the countrys money.

People are starting to compare stablecoins to a type of investment called a money market fund. This is because stablecoins have some features. One thing that is worrying is that if a lot of people try to withdraw their money from stablecoins at the time it can cause big problems. This is similar to what happens when people try to withdraw their money from banks all at. So stablecoins are a deal for both the people who make them and the people who regulate them. Stablecoins are really important for DeFi and, for the financial system.

C. Depegging Events and Systemic Risk Channels

We have seen some problems with stablecoins lately. These problems show us how flaws in the design of stablecoins can cause issues. For example, some stablecoins that are tied to algorithms have. Some stablecoins that are backed by real money have lost their value for a short time. People who study these events have found some things that happen. When people lose confidence in a stablecoin they quickly sell it. Take out their collateral. If the collateral is a cryptocurrency and its price falls it can cause a lot of people to sell their assets at the time. In stablecoins there can be a bad cycle where the stablecoin and its related token both lose value quickly. [1, 2]

These problems can spread to parts of the DeFi system. For instance, if many people are using the collateral for different loans and one loan starts to have problems it can cause problems for all the other loans. This can lead to a wave of selling which can cause problems for lending protocols and drain the liquidity from automated market makers.

Some people are using machine learning to predict when these problems might happen. They are looking at things like how transparent the reservesre how volatile the collateral is and how well the protocol is governed. Reports on policy and stability are also pointing out potential problems. For example, if a lot of people are using a stablecoin and it becomes unusable it can disrupt the flow of payments. It can also cause people to lose confidence in tokens and platforms. [3,4,5]

From a computer science point of view stablecoins are like parts of a system. We need to think about how all these parts work. We need to look at things like how much collateral's backing a stablecoin and how people can redeem their stablecoins. We also need to think about how the whole system behaves, including things, like arbitrage, liquidation bots and governance decisions. Stablecoins are a part of this system and we need to understand how they work so we can make them more stable. [3,4,5]

D. Computer Science Research Challenges Around Stablecoins

The things that make stablecoins work and the problems that happen with them make us want to study some problems. We need to look at how to write rules for stablecoins and how to check if they are working correctly. We can use tools to check if stablecoin contracts are safe and if they can handle bad people trying to cheat the system. We also need to watch stablecoins while they are working to see if anything goes wrong. We have to keep an eye on things like how much money's backing the stablecoin and if people are trying to cheat with the prices.

We also need to think about how to make sure stablecoins follow the rules that governments make. As governments make rules for stablecoins that are backed by real money or other cryptocurrencies we need to find ways to make sure stablecoins are following these rules. We have to do this in a way that's fair and open but also does not hurt the good things about stablecoins that make them useful. All these problems make stablecoins a great thing to study if you like computers, safety and money. They help us get ready to talk about things, like DeFi protocols and tokenisation layers.

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Stablecoins are a part of this and we need to understand them to make new and better things. Stablecoins are very important. We have to keep learning about them.

VI. DECENTRALIZED FINANCE (DEFI) PROTOCOLS – ARCHITECHTURE, EFFICIENCY AND RISK

DeFi protocols implement financial services such as trading, lending, and asset management directly in smart contracts deployed on public blockchains, most prominently Ethereum. By removing centralized intermediaries and exposing transparent on chain state, they create a programmable, composable "money legos" architecture in which multiple protocols can be combined to build complex financial products. This section reviews core protocol architectures and efficiency properties, then summarizes key technical and systemic risks highlighted in the literature, with emphasis on how these risks interact with stablecoins and, later, tokenized assets. [6,7,8]

A. Protocol Architechture and Core Primitives

Survey and SoK papers say DeFi is built like layers around some types of protocols. Decentralized exchanges, like automated market makers let users trade directly with a pool of money from users. They use a pricing system of order books. Examples are product and hybrid AMMs. They balance how much a trade affects the price and how well they use capital. Protocols for lending and borrowing let users add assets to a shared contract and borrow against positions that have extra collateral. The protocol automatically controls interest rates and liquidations. Protocols for assets, derivatives and asset management use DEX and lending basics. They offer positions, structured products and automatic portfolio strategies. [6,7,8,9]

These protocols work together using standards like ERC-20 and shared infrastructure like price oracles and governance tokens. This makes composability a key feature.. It also means if one part fails, like an oracle or stablecoin issue it can affect many protocols. These protocols are connected through standards and shared infrastructure. This shared infrastructure includes price oracles and governance tokens. DeFi protocols use these to work, However this also means that if there is a problem, with one protocol it can affect others. For example if an oracle malfunctions or a stablecoin loses its peg it can cause issues across protocols.

B. Efficiency, Transparency, and Innovation

The literature shows that DeFi can make markets work better than finance in several ways. DeFi protocols allow trading all the time have clear rules for settling trades and anyone can join in using public blockchains. This reduces the need for middlemen and manual processes. Studies, both practical and theoretical find that Automated Market Maker (AMM) based Decentralized Exchanges (DEXs) make it easier to provide liquidity. This enables trading of common assets without needing a central authority to list them. Lending protocols also automatically change interest rates based on how they are used. This can improve how capital is allocated under conditions.

When comparing Centralized Finance (CeFi) to DeFi research finds that DeFi offers transparency. This is because all positions and rules of DeFi protocols can be publicly checked. Users also have control as they can keep their own assets and interact directly with smart contracts. However experts also warn that these improvements in efficiency and innovation come with some downsides.

These include issues, with scalability, speed and complexity of user experience. Often DeFi still relies on infrastructure outside of the blockchain. Examples include websites, custodians and oracles that bring back some elements of central control. DeFi and its benefits are closely tied to these elements. DeFi protocols and DeFi systems need to be understood in this context.[9,10]

C. Technical and Systemic Risk Taxonomy

The State of Knowledge and BIS analyses create lists of DeFi risks that have parts. They usually group these risks into categories like technical, economic, governance and systemic risks. DeFi has contract risks that come from mistakes in the code incomplete information and ways to upgrade the contracts. These mistakes can cause people to lose money or

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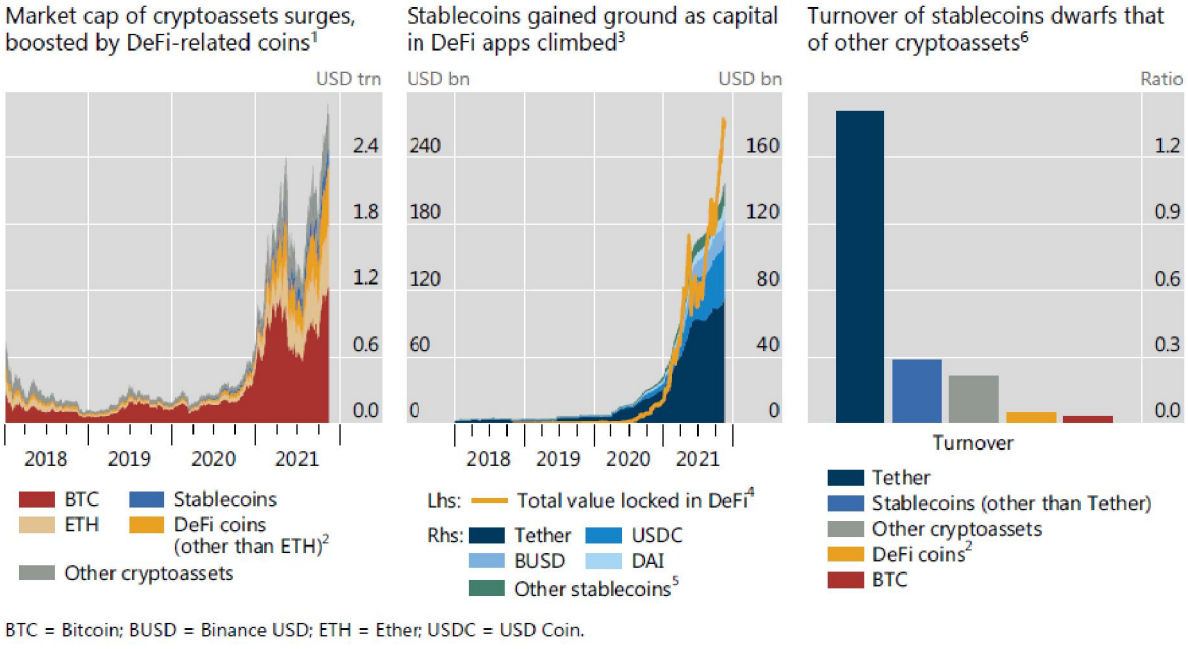
someone to take control of the protocol. We have seen big problems happen even when the contracts were checked by auditors. They can still have mistakes that let people do things.

There is also a risk with oracles. Oracles are like messengers that get information from outside the DeFi system like prices of assets or interest rates. If someone attacks or sets up the oracle incorrectly it can give information. This can cause problems like liquidating assets at the time or letting people borrow money without enough collateral. Governance risk is another issue. This happens when a small group of people have much power to make decisions. They can make changes to the protocol that're not good for everyone. The process of making changes can also be unclear which can cause problems. [6,9,10]

When many DeFi systems are connected and use the money and liquidity it can cause big problems if one of them fails. This is called composability and systemic risk. If a big lending protocol, exchange or stablecoin has problems it can affect the DeFi system. This can happen through a chain of liquidations, loss of liquidity and feedback loops. [9,10]



BTC = Bitcoin; BUSD = Binance USD; ETH = Ether; USDC = USD Coin.

Fig.2. DeFi underpins the rapid growth in crypto activities [9]

Some researchers have looked at the idea that DeFi systemsre not as decentralized as they seem. They found that many systems are actually controlled by a group of people or companies. This can create points in the system and make it hard for regulators to know what to do. Overall the research says that the things that make DeFi strong, like being able to connect systems and automate tasks are also the things that make it fragile. [9]

D. Computer Science Challenges and Open Problems

From a computer science perspective the studies I looked at show that there are problems with DeFi protocols that need to be solved. DeFi protocols need to be checked to make sure they are working correctly and safely. This is important because DeFi protocols have to handle situations like when the market's not stable or when people are trying to cheat the system.

We need to come up with models and tools to check DeFi protocols. We also need to analyze how different DeFi protocols work together. In the world people use many DeFi protocols at the same time like money legos. DeFi protocols need to keep track of things like how much money's available and how much is being used. To make sure DeFi protocols are working correctly we need to watch what is happening in time and catch any problems before they

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become issues. This means we need to look at whats happening on the blockchain like how much money's being used and also look at what is happening outside of the blockchain like what people are saying about the stablecoin reserves. The research shows that how people make decisions and how DeFi protocols are set up are closely connected. So when we design DeFi protocols we need to think about how people will use DeFi protocols and how they will respond to problems. This is why we need to bring areas of study together like computer systems, how to design good mechanisms and how people behave. DeFi protocols are what motivated us to come up with a framework, where DeFi protocolsre a middle layer, between the stablecoin layer and the tokenized asset layer helping to make things more efficient and managing risk.

VII. TOKENIZATION OF ASSETS – FRAMEWORKS AND MARKET IMPACT

Tokenization is a way to record ownership of world assets like property or bonds as digital tokens on a blockchain. This means that people can own a part of something that they could not afford before. Tokenization is different from putting records on a computer because it allows people to trade and own parts of assets in a new way. Tokenized assets can be traded directly between people without the need for intermediaries. Can be included in smart contracts. This is made possible by the use of blockchain technology. An issuer or custodian will lock an asset like a bond or a piece of property. Then issue digital tokens that represent that asset. Smart contracts will handle the transfer of these tokens. Make sure that everything runs smoothly. Studies have shown that tokenization can make it easier for people to invest in things and can increase the number of people who can buy and sell assets. This is because tokenization allows people to buy and sell parts of assets rather than having to buy the whole thing. Tokenized assets can also be settled faster than assets, which means that people can get their money or assets more quickly. However some people think that tokenization is not as revolutionary as it seems. They say that it is a new way of doing things that we already do rather than a completely new system. They also say that tokenization still relies on the financial system and the rules that come with it. This means that it is not as accessible to everyone as it could be. [11,13,15]

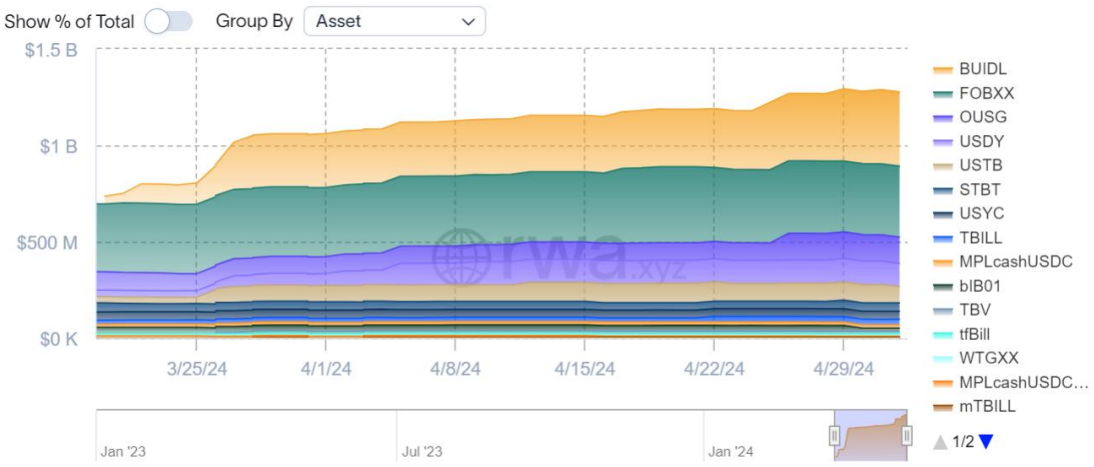

Fig.3. Tokenized RWA statistics

According to the data from the tokenized RWA statistics platform RWA. in Figure 3, the value in the tokenized treasury sector has soared to nearly $1.3 billion in April 2024 from $100 million at the start of 2023. This significant increase indicates an urgent need for a more advanced method to manage RWAs, including asset ownership, trading monitoring, and asset origin tracing. [14,15]

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Governance and regulation are also important when it comes to tokenization. Regulators are still figuring out how to deal with assets and are often treating them like traditional assets. This means that there are rules and regulations that need to be followed even when tokens are being traded on a blockchain. To comply with these rules many platforms are using a combination of blockchain technology and traditional financial systems. There are also challenges to tokenization, such as making sure that the system is secure and can handle a large number of transactions. There are also issues with interoperability, which means making sure that different platforms and systems can work together. From a perspective there is a need for more research on how to make tokenization work safely and efficiently. This includes figuring out how to verify that smart contracts are working correctly and how to make sure that tokens are secure. There is also a need for risk models that can take into account the complexities of tokenization and the way it interacts with other parts of the financial system. [11,12]

Tokenization is a topic and there are many different perspectives, on it. Tokenization is a way to use blockchain technology to make it easier for people to invest in and own assets. Tokenization can make assets more accessible. Can increase the number of people who can buy and sell them. However tokenization also relies on the financial system and the rules that come with it which means that it is not as revolutionary as it could be. Tokenization is a topic that will continue to be discussed and developed in the coming years. [11,12]

VIII. INTEGRATED LAYERED ARCHITECHTURE AND CROSS LAYER TAXONAMY

The reviewed literature on stablecoins, DeFi protocols and asset tokenization shows that blockchain finance is a - layered system. Each layer has a function but is closely connected to the others.

a. At the base permissionless blockchains and smart contracts provide a shared execution environment.

b. On top of this stablecoins act as a settlement and liquidity layer.

c. DeFi protocols implement intermediation and leverage.

d. Tokenized assets represent claims on world or traditional financial instruments.

This stacked structure enables composability and automation.. It also creates channels through which local shocks can spread into system-wide instability. [5,6,7,9]

Stablecoins play a role as a medium of exchange and collateral in DeFi. They also act as a bridge between on-chain activity and traditional financial markets. Event studies and risk analyses show that depegging events and redemption dynamics can trigger liquidity spirals and price dislocations. This is especially true when leverage and automated liquidation mechanisms are prevalent. DeFi protocols form the intermediation layer. They use contracts and oracles to implement exchanges, credit markets and asset management strategies. These rely heavily on stablecoins and tokenized assets. Systemic risk frameworks emphasize that composability creates a network of exposures. Failures of a stablecoin or lending market can cascade through shared collateral pools. [11,13,14]

At the asset layer tokenization introduces on-chain representations of off-chain assets. This embeds custodial dependencies into the same environment that powers DeFi and stablecoins. Policy studies show that tokenized instruments are often used as collateral or investment products within DeFi. Legal disputes or regulatory actions affecting the underlying assets can stress on-chain protocols.

A cross-layer risk taxonomy can be organized along two dimensions:

• The layer at which the risk originates. Such as reserve, market and protocol structure or governance and infrastructure.

• The type of amplification and transmission channel. Such as leverage or automated liquidations.

For example a custodial shock at the reserve layer of a fiat-backed stablecoin can propagate through DeFi protocols. It can then spill back into markets through forced reserve asset sales. Conversely a legal intervention affecting a tokenized asset can trigger on-chain deleveraging in protocols.

From a computer science perspective this layered view highlights research directions:

• Formally specifying and verifying invariants across protocol compositions.

• Designing monitoring systems that observe indicators at each layer.

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• Developing patterns that limit contagion.

By framing stablecoins, DeFi protocols and tokenized assets as components of a programmable financial stack the proposed architecture provides a foundation, for systematic analysis of systemic risk. It also aids in the design of resilient crypto-financial systems. [3,6,7,9]

IX. DISCUSSION AND IMPLICATIONS

The integrated view of stablecoins, DeFi protocols and asset tokenization shows that blockchain finance is a financial stack. Its behavior comes from interactions across economic and legal layers not just one component. For computer science, traditional security and performance analyses are not enough. Researchers need to look at stablecoins, lending markets, DEXs, bridges and tokenized assets as modules. These modules are linked through shared state oracles and governance processes. This new way of thinking matches work on systemic risk. It uses network and agent-based techniques to model DeFi. It shows that local protocol rules can fail under stress even if individual smart contracts seem correct. From a design standpoint robustness should be built at interfaces. For example between stablecoins and DeFi or between DeFi protocols. Liquidation mechanisms in lending protocols could include models of risk. Collateral frameworks could treat assets differently. [3,5,6,7]

This kind of design is like tools in traditional finance.. It must be implemented as transparent smart-contract logic. The analysis also affects verification, monitoring and tooling. Formal methods are being applied to DeFi contracts. We need compositional verification techniques that look at interacting contracts and assets. Runtime monitoring systems should combine on-chain and off-chain information. This can provide warning signs for systemic stress. For practitioners this means building observability layers and dashboards. These should treat the -financial stack as one system, not isolated projects. [9,11]

Finally the framework clarifies policy and regulatory questions. Reports, from BIS, FSB and central banks say that stablecoins, DeFi and tokenization are often regulated separately. They are tightly coupled in practice. The layered architecture supports coordinated approaches. Oversight should focus on roles and common risk channels not just individual technologies. [9,11]

X. LIMITATIONS AND FUTURE RESEARCH

This paper talks about stablecoins, DeFi protocols and blockchain-based tokenization. It tries to combine these things into one system.. It has some limitations. The analysis is mostly based on a few papers and recent reports. It does not include a study or detailed analysis of all the data. So some special designs and local rules are not included. The paper also just thinks about the design and risks in a way. It does not test how things would work in life or with real data. The paper also does not consider technologies like faster processing, secret codes and special permissioned DeFi systems. These are changing how the system works. These limitations mean there is research to be done. One thing to do is to combine the design with data analysis. This could help us understand how problems spread through DeFi networks. Another thing to do is to create tools that can check if everything is working correctly. These tools could help managers and regulators see risks in time. A third thing to do is to design protocols and rules together. This is especially important, for stablecoins that earn interest, special DeFi systems and big asset tokenization.

Finally future work could look at combining AI and DeFi. For example AI could help predict and manage risks. These are a few ideas. There is still a lot to learn about stablecoins, DeFi protocols and blockchain-based tokenization.

XI. CONCLUSION

This paper says that we should look at stablecoins, DeFi protocols and blockchain-based tokenization as parts of a bigger system that work together. We have a settlement layer that is made up of stablecoins an intermediation layer that is made up of DeFi protocols and an asset layer that is made up of real-world and traditional financial instruments. We looked at fifteen research papers and policy reports to see how each part of this system works. We found out that each part has its set of problems and risks. For example stablecoins have issues with being transparent about their reserves

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and keeping their value stable. DeFi protocols have risks related to contracts oracles and how they are governed. Tokenized assets have custodial and interoperability challenges. These problems can affect each other. Cause bigger issues with the whole system. We used this information to propose a framework that can help guide research on blockchain-based systems. This framework is made up of layers and it looks at the risks that can happen between these layers. It says that we need to make sure the connections between the layers are strong and that we need tools that can look at how different protocols work. At the time we think that there are opportunities for technical and regulatory experts to work together as stablecoins, DeFi and tokenization become more important parts of the global financial system. The main point, for researchers and practitioners is that they need to think about the system and how all the different parts work together including the code, markets and laws that govern stablecoins, DeFi protocols and blockchain-based tokenization.

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