Mapping the Blockchain's Decentralized Finance Characteristics

Gede Natha Wijaya Kusuma[1], Andry Alamsyah[2], and Dian Puteri Ramadhani[3]

[1,2,3] Telkom University, Jl. Telekomunikasi, 40257, Indonesia
[1]nathawijaya@student.telkomuniversity.ac.id

Abstract. The integration of blockchain technology, particularly through Decentralized Finance (DeFi), has transformed the financial industry. As of January 2023, the DeFi crypto market had reached a market capitalization of $46.21 billion, serving a user base of 6,686,500. DeFi surpasses Traditional Finance (TradFi) in several aspects, including lower fees, inclusivity, faster processing, accessibility, transparency, programmability, security, and the absence of intermediaries. For end users, the advantages of DeFi lie in self-custody of their assets, peer-to-peer transactions, and the ability to harness programmability for complete control and creativity. However, despite the rapid growth of DeFi, there is a notable lack of comprehensive research on DeFi mapping, particularly in terms of its benefits, risks, financial services, and technology. This study aims to delineate the characteristics of DeFi mapping and address the research gap in DeFi knowledge.

Keywords: Digital Economics, Decentralized Finance, Financial Institution, Traditional Finance, Mapping Characteristics, Blockchain.

1 Introduction

Blockchain technology offers significant potential for digital transformation [1], providing benefits such as credibility, transparency, accessibility, and cost-efficiency [2]. It has been widely adopted in various sectors like education, healthcare, and finance [3], and plays a crucial role in combating corruption [4]. In finance, DeFi is a key component of the crypto financial system, with major platforms including Ethereum, Finance Smart Chain, and Tron. It's important to note that DeFi can be implemented on authorized Distributed Ledger Technology (DLT) platforms or similar technologies [5].

DeFi operates on decentralized blockchains, relying on DLT for security [6]. It offers diverse financial services like lending, exchanges, asset management, and more [7]. Early DeFi apps were on permissionless blockchains, allowing direct transactions and validation without central control [8]. DeFi also utilizes Real-World Assets (RWA), tokenizing off-chain assets for returns, aiming to enhance opportunities and market efficiency compared to TradFi [9]. Asset tokenization and decentralized applications (DApps) further boost financial market efficiency [5].

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Tokenization merges digitization, securitization, and blockchain to convert traditional assets into digital ones. It enables direct custody and settlement, offering portfolio flexibility, transparency, security, speed, traceability, and cost savings. This fosters a robust infrastructure for a transparent digital asset ecosystem, making the capital market inclusive for participants of all sizes [9].

DeFi has the potential to transform TradFi by bridging cryptocurrency assets with traditional markets, offering transparency, disintermediation, accessibility, low fees, high-interest rates, and programmability not found in TradFi [10], [11]. It enables global lending and borrowing at reduced costs [12]. DeFi protocols act as alternatives to banking and investment services rather than payment solutions like Bitcoin or Ethereum [13]. In case of issues, DeFi provides insurance using on-chain and off-chain data for policy pricing and claims [14].

Our research indicates a lack of comprehensive publications examining DeFi mapping characteristics. This is supported by Coin Gecko's 2020 study, which found that among 694 participants, 40% were unfamiliar with DeFi, and only 3% used DeFi platforms [15]. Azmi's survey of 694 respondents also revealed that the lack of awareness or knowledge about DeFi's functionality is a major barrier to adoption, despite its potential to create an alternative financial system independent of traditional banks or trusted third parties [16].

The research aims to develop DeFi knowledge by mapping its characteristics and ecosystem. This mapping aims to provide valuable insights to the academic and professional community, stimulate further research, and address existing challenges. To achieve this, we employ a qualitative research approach; we organized this paper into the following topics. In Section 1, we conduct an in-depth investigation to gather background knowledge on DeFi through literature reviews and phenomenological research. Section 2 processes and analyzes blockchain in the financial industry and defines the main aspects of the DeFi ecosystem. Section 3 outlines the process of mapping the characteristics of DeFi. Section 4 presents the results and discussions of the DeFi mapping. Finally, in Section 5, we present the conclusions drawn from the paper. This research has the potential to promote awareness and knowledge about DeFi, ultimately contributing to its wider adoption.

2 Literature Review & Definition

2.1 Blockchain in Financial Industry

In 2022, blockchain technology emerged as a catalyst for the advancement of financial markets [17]. By ensuring transaction integrity and eliminating the need for intermediaries, blockchain enables decentralized systems to replicate the functionality of centralized ones [18], [19]. The introduction of Bitcoin and blockchain revolutionized trustless transactions, offering transparency and secure data storage for diverse applications [20]. Blockchain technology promotes network-wide consistency through its unalterable and resilient ledger [21]. The initial application of blockchain involved decentralized peer-to-peer digital currency transactions, spearheaded by Bitcoin as the pioneering cryptocurrency [22].

2.2 Decentralized Finance (DeFi)

DeFi utilizes blockchain technology for executing transactions, including loans and exchanges, within its systems [3]. DeFi protocols establish an open and decentralized financial infrastructure, enabling global access to self-sovereign and censorship-resistant financial services. DeFi facilitates peer-to-peer connections, making basic financing more accessible and affordable [12]. It represents a paradigm shift in the creation, distribution, and utilization of financial services, leveraging decentralized software across peer-to-peer networks [23].

2.3 Peer to Peer(P2P)

P2P is a transparent transaction mechanism that ensures data privacy without the involvement of third parties [24]. In blockchain transactions or within the DeFi context, P2P typically involves a two-step process. Parties negotiate and agree on exchange rates for specific pairs of crypto assets, followed by the execution of these transactions on-chain using smart contracts [25]. P2P systems enable DeFi by allowing users to trade crypto assets directly with each other, reducing costs and improving liquidity.

2.4 Smart Contract

Smart contracts are programs residing on a blockchain network, executed by a distributed group of validators [25]. Smart contracts integrate code into the blockchain, making it immutable once applied to the network. These contracts execute automatically when specific conditions are met, offering transparency and robust security due to their blockchain-based storage. In the DeFi ecosystem, users manipulate variables based on predefined rules using programming languages like Solidity or Python [26]. They maintain control over their assets through smart contracts, while financial entities facilitate asset trading without direct ownership [14]. Smart contracts embody predefined rules, governing their actions and evolution, with multiple investors contributing to decision-making and fund allocation.

2.5 Decentralized Autonomous Organization (DAO)

A DAO is a decentralized system that operates on a public blockchain, enabling entities or organizations to facilitate self-governance and coordination among individuals through a predefined set of rules [27]. DAO enables organizations to function continuously and synchronize their operations through computer code or smart contracts. In DAO, investors typically remain anonymous and may lack trust in one another [20].

2.6 Decentralized Applications (DApps)

In contrast to traditional applications, DApps operate on a decentralized P2P network instead of relying on centralized servers [1]. DApps distribute authority and control among users, with three primary types: centralized, distributed, and decentralized. Centralized apps have a single authority, distributed apps spread information across nodes, and DApps lack a single control point. DApps have four main features:

transparency, economic activities, blockchain validation, and resilience to server shutdowns.

2.7 Traditional Finance (TradFi)

TradFi relies on central intermediaries like banks and stock exchanges for transactions [28]. These institutions manage assets, prevent fraud, and maintain trust through legal frameworks [29]. KYC(Know Your Customer) and AML (Anti-Money Laundering) compliance is mandatory by law to mitigate criminal financial activities. KYC verifies customer identities, while AML combats money laundering and financial crimes within a broader framework. TradFi's extensive infrastructure allows it to provide financial services on a larger scale than crypto finance [30]. Despite fund control limitations, TradFi offers advantages like payment flexibility, increased returns, and customer support.

2.8 Decentralized Exchanges (DEXs)

DEXs are digital marketplaces where traders can directly exchange cryptocurrencies without intermediaries. These exchanges leverage smart contracts on the Ethereum blockchain and P2P to ensure secure and automated transactions [8],[37]. P2P exchanges within DEXs facilitate direct user trading with a more lenient verification process. DEXs empower users to choose their preferred payment method, access the best available rates, and enjoy lower transaction fees.

2.9 DeFi Service and Market Mechanism

DeFi applications, including exchange, lending, and asset management protocols, are integral to the DeFi ecosystem [3]. The DeFi ecosystem encompasses various services, including lending, payments, asset management, security, stablecoins, insurance, borrowing, staking, yield farming, and DEXs. DEXs are supported by automated market maker (AMM) protocols, utilizing algorithms to establish the prices of digital assets within liquidity pools [30]. AMMs utilize algorithms to determine asset prices, enhancing transparency and providing valuable information for buyers and sellers [29]. DeFi's market mechanism empowers users to control and modify multiple assets through its services [3].

2.10 Tokenization

Tokenization converts tangible and intangible assets into digital tokens representing ownership shares of the underlying assets. Tokenization, enabled by blockchain technology, revolutionizes trading traditionally illiquid assets, such as shares in new ventures, commodities, art, and real estate, through initial coin offerings [32]. Tokenization is experiencing a resurgence in its widespread use for collateralizing RWA and facilitating risk management.

2.11 Liquid Pool

A liquidity pool is a smart contract holding significant cryptocurrency or tokens for decentralized trading networks. It acts as a source of funds, with liquidity providers

contributing tokens. Traders can use these tokens for lending, borrowing, derivatives, insurance, and swapping. Each transaction within the pool incurs a service fee, which the liquidity provider receives as compensation for supplying liquidity [14]

3 Research Methodology

Using a descriptive qualitative methodology, our research advances through multiple stages, encompassing literature reviews and phenomenological research. We found 52 references from May 6, 2022, to May 6, 2023, through a thorough exploration of journals, white papers, articles, and websites. Among them, references [3],[33],[34],[28] specifically discuss DeFi mapping characteristics. The study's objective is to construct influential DeFi mapping characteristics. The research flow is depicted in Fig 1.

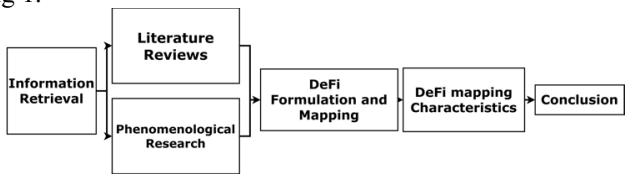

Fig. 1. Research Workflow

Our research begins by retrieving information through phenomenological research and literature review. Various sources include news articles, journals, whitepapers, books, and observations from social media platforms like Medium, Coingekko, and CoinMarketCap. The information retrieval stage is the starting point of the research, employing two key techniques: phenomenological research and literature reviews.

We create DeFi mapping characteristics based on gathered information. In the DeFi Formulation and Mapping stage, we analyze, describe, and map essential components that must exist. DeFi mapping Characteristics involve breaking down the analysis results into four categories in DeFi, providing comprehensive explanations for each category to enhance reader understanding. Graphical subdivisions are utilized to emphasize the essential and specific aspects related to the main problem. The mapping characteristics of DeFi, derived from phenomenological research and literature review, describe the relationship between these four categories in the DeFi ecosystem. Maps are presented as images to enhance comprehension of these relationships.

4 Results

4.1 Mapping Characteristics

Our research identified four dimensions in the DeFi mapping: Advantages, Risk, Product/Service, and Technology. We thoroughly examine each dimension, exploring technology, potential threats, and their interactions. We provide the comprehensive DeFi Mapping in Fig 2 and provide a description of the items and their DeFi context in the tables.

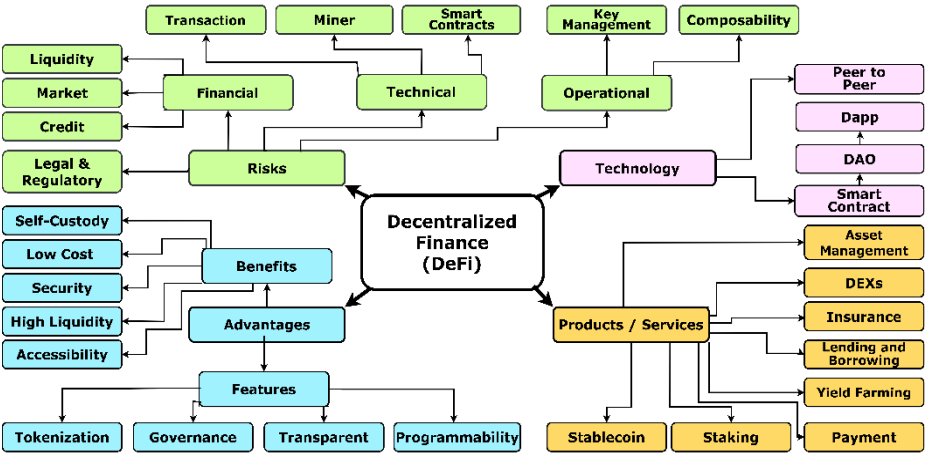

Fig. 2. Mapping of DeFi Characteristics

Technology

Financial has become intricately intertwined with technology and data, with a growing interdependence between the two fields [29]. DeFi is an example of this convergence, enabling user participation in cryptocurrency transactions through blockchain and smart contracts. Our analysis delves deeper into the technologies used in DeFi; shown in Table 1.

Table 1. Technology

No	Item & Description
1	**Peer to Peer:** The P2P DeFi protocol offers an alternative to traditional exchange models and liquidity pools, ensuring transparent clearing mechanisms and data privacy without intermediaries [24]. P2P lending platforms exemplify P2P protocol in DeFi by directly connecting borrowers and lenders, granting easier credit access to borrowers with limited or no options for traditional bank loans, and surpassing the limited online lending services of certain banks and financial institutions [35].
2	**Smart Contract:** Smart contracts ensure the security, reliability, and agreements of transactions in DeFi [26]. Smart contracts serve as the basis for technologies and services such as DAOs and DApps [14]. Smart contracts govern DAO functions and facilitate decision-making and fund allocation for DApp development. Smart contracts ensure open-source accessibility to the source code within DApps.
3	**DAO:** DAO excels in managing digital assets in DeFi through self-governance and coordination via autonomous code. DAO leverages decentralized blockchains to achieve consensus on fund allocation [36]. Advantages of DAO include decentralization, security, transparency, participation, efficiency, rewards, and flexibility. *MakerDAO* is a successful example of operating DeFi protocols like the *Dai* stablecoin system. Users collateralize crypto assets for stable *Dai* loans, aligning with stablecoin goals and creating value.
4	**DApps:** DApps serve as a practical implementation of DAO in practice. Smart contracts are used primarily in developing DApps, with DeFi being the most prevalent type [14]. DeFi DApps decentralize TradFi services like savings, loans, and insurance. DeFi offers decentralized and secure financial services, including stablecoins, DEXs, lending platforms, and investment funds. These applications use smart contracts on the blockchain for secure transactions and data storage [1].

Product / Services

The DeFi ecosystem is built on Blockchain and smart contract principles. P2P financial transactions enable the seamless exchange of cryptocurrencies for goods or services within the DeFi ecosystem, eliminating the need for intermediaries. We have compiled a summary of the products and services provided by DeFi; shown in Table 2.

Table 2. Product/Service

No	Item & Description
1	**Insurance:** Insurance is financial compensation in the event of a loss, including scenarios such as property damage, injury, or death. In the DeFi ecosystem, insurance achieves cost savings by eliminating intermediaries, reducing administrative costs, lowering premiums, and ensuring efficient and timely disbursement of claims. Using smart contracts and blockchain technology in DeFi made this possible [3], [23].
2	**Yield farming**: Yield farming is storing crypto assets in DeFi protocols to maximize returns. Users leverage automated protocols to generate profits from idle funds, increasing liquidity and benefiting other DeFi services. Platforms like *Compound* offer innovative financial services, allowing users to earn interest on their crypto holdings without risks associated with yield farming [37].
3	**Stablecoins:** Stablecoins maintain a stable value and purchasing power in DeFi applications, serving as a reliable unit of account and medium of exchange for transactions and investments [38]. Popular stablecoins such as *USDT, USDC*, *DAI*, and *BUSD* are widely utilized within the DeFi space [39], [40].
4	**Staking:** Staking resembles a deposit, where investors lock their assets for a specific duration to earn passive income. In the DeFi ecosystem, users lock their crypto assets into smart contracts instead of keeping cryptocurrency funds in their wallets [39].
5	**Lending and borrowing:** Lending and borrowing refer to providing or giving a monetary asset, be it fiat or digital currency, to another party in exchange for a steady income stream. In DeFi, users are capable of lending significant amounts swiftly and anonymously, while borrowers must provide collateral and adhere to predetermined payment terms. Platforms like *Aave, Maker*, and *Compound* utilize smart contracts to automate, eliminating intermediaries and mitigating risks in traditional lending [6], [41].
6	**Payment:** Payments in the DeFi ecosystem empower underbanked and unbanked populations by providing access to financial services, promoting financial inclusion, simplifying payment processes, and maximizing security, efficiency, transparency, and cost-effectiveness. Smart contracts enable direct, intermediary-free agreements and executions between anonymous parties, facilitating decentralized payments in DeFi.[35], [40].
7	**Asset management:** Asset management in DeFi encompasses transparently managing assets with third parties at a low cost. Smart contracts ensure security and enable the investment of investor tokens in other DApps [25], [30], [42]. Blockchain facilitates decentralized asset transactions and registries, enhancing transparency and enabling fast settlement without central authority validation. It encompasses both fungible and non-fungible assets.
8	**DEXs:** Exchanges are digital platforms for asset trading using fiat money or cryptocurrencies. DEXs offer users enhanced control, privacy, and security, surpassing centralized exchanges. DEXs provide liquidity advantages with minimal market price impact. AMM mechanisms determine DEX liquidity. Traders retain full ownership and control over their assets. Popular DEX examples include *Uniswap, SushiSwap*, and *Curve*. [40], [43].

Advantage

DeFi technology enhances operations, improves efficiency, reduces costs, and optimizes overall performance, giving businesses a competitive edge. DeFi's integration with Fintech enhances security, governance and adds value. DeFi offers numerous benefits and features to the financial industry; shown in Table 3.

Table 3. Advantage

No	Item & Description
1	**Benefits:** DeFi holds the potential to revolutionize business operations, streamlining processes, improving efficiency, lowering costs, and enhancing overall performance. Integration with Fintech offers substantial advantages, such as heightened security and governance, adding significant value.
2	**Self-Custody:** Third parties control the assets in TradFi. DeFi warrants self-custody, granting users complete control over their assets and data. Eliminates the requirement for third-party permissions, fostering trust by giving users full visibility and control over their assets [11].
3	**Accessibility:** TradFi services have complex requirements, limiting global access, especially for individuals in remote areas. In contrast, the DeFi ecosystem offers accessibility through the internet connection, cryptocurrency wallet, and smartphone, eliminating identity-based discrimination and promoting openness. It fosters broader participation, facilitates faster transactions, and benefits individuals from diverse backgrounds. [11], [25].
4	**Low Cost:** TradFi services are expensive, involving significant funds for research and development to sustain competitiveness in an expanding market. Operational expenses, such as employee salaries and administration. DeFi offers low-cost services by implementing smart contracts that remove the need for intermediaries like financial institutions and banks. Transparency reduces the requirement for external audits and verification, common expenses in TradFi services. DeFi service providers enable investors to adapt to changing circumstances while minimizing expenses through task automation and lower fees [29].
5	**Security:** In financial business, trust is paramount, and security plays a crucial role in establishing a safe environment that minimizes the risk of asset theft and information compromise. DeFi offers enhanced security compared to TradFi through smart contracts and blockchain technology. Makes it significantly more challenging to manipulate or steal user assets [3], [14].
6	**High liquidity:** High liquidity allows the company to readily fulfill its short-term debt obligations. Liquidity pools and yield farms incentivize investors with high returns within a short duration, serving as promotional mechanisms for projects [13]. Consequently, this contributes to the high liquidity in DeFi.
7	**Feature:** DeFi platforms and applications incorporate a wide range of technical elements, protocols, and functionalities, providing users with the framework to engage in decentralized financial activities. Various characteristics within DeFi enable user participation in these activities. Here are some examples of features found in DeFi.
8	**Programmability:** Programmability allows for modifying, embedding, or reducing predefined code instructions. Smart contracts in DeFi platforms facilitate automated operations by modifying programs based on programmatic business logic. DeFi platforms utilize smart contracts to automate execution and drive the creation of innovative financial instruments and digital assets, facilitating easy modification and creation of new programs [44]. Emphasizing security, this system operates according to its programmed rules and is immune to manipulation, offering superior security compared to TradFi systems[23].

9	**Tokenization:** Tokenization is a process that converts physical assets into digital tokens using blockchain technology. Tokenization is undiscovered in TradFi. The DeFi ecosystem implements a standardized framework for asset tokenization [9]. Introduce diverse asset classes, enhance accessibility, optimize operational efficiency, lower costs, and accelerate transaction speed in the financial industry [45]. The Ethereum Request for Comments-20 (ERC-20) standard has emerged as the widely adopted choice for asset tokenization in DeFi, offering comprehensive asset coverage.
10	**Governance:** TradFi relies on centralized governance, while DeFi embraces decentralized governance. DeFi establishes rules and decision-making mechanisms involving token holders in protocol updates, fund allocations, and rule changes. Blockchain-based governance balances accountability and decentralization, encompassing on-chain and off-chain structures. [46].
11	**Transparent:** TradFi basically does not support transparent transactions. DeFi ensures transparency by operating on blockchain technology, where all transactions, data, and codes are openly accessible to all participants. Eliminating the need for private agreements, centralized control, and confidential operations. DeFi enables users to investigate and comprehend the regulatory framework of financial assets and products. Users can transparently monitor all transactions, fostering heightened trust within the DeFi industry compared to TradFi. [11], [23], [25], [47].

Risks

In the finance ecosystem, fraudulent activity and excessive risk-taking are prevalent due to their monetary nature, as money becomes the target of a crime. DeFi implements similar stringent controls and procedures as banks to address crime targeting, despite its slower real-time adoption compared to its theoretical potential [48]. To gain the trust of individuals, DeFi applications must overcome several major risks. These major risks have been included in the DeFi mapping characteristics; shown in Table 4.

Table 4. Risk

No	Item & Description
1	**Technical risks:** DeFi faces security risks, including technical and deliberate hacks [49-56]. Dynamic blockchain protocols and a lack of standardized bug-fixing procedures contribute to these risks [48]. To establish trust in DeFi, ensuring the reliability and security of smart contracts and blockchain protocols is crucial.
2	**Smart contracts risks:** Smart contracts in DeFi are risky due to code bugs and errors. For example, an attacker exploited a *Qubit Finance* smart contract bug to steal $80 million worth of assets [51]. Decentralized and deterministic smart contract execution offers advantages, but coding mistakes can introduce vulnerabilities that enable fund draining, operational disruptions, or protocol dysfunction [25].
3	**Miner risks:** Miner risks are a potential security concern for blockchain systems. Miners can prioritize lower-fee transactions over higher-fee ones, which can lead to malicious actions targeting specific transactions. [49], [52-56].
4	**Transaction risks:** Disruptions in the underlying blockchain network give rise to transaction risks, including successful attacks, double-spending, high transaction costs, and insufficient capacity, which can affect the application layer. The Ethereum 2 update, enhancing network performance and transitioning to PoS consensus, aids DeFi in mitigating transaction risks. [49].
5	**Financial risks:** DeFi faces financial risks like liquidity, market, and credit risks. Disruptions in one market can have a cascading effect on DeFi, leading to the

	depletion of funds. DeFi services often offer incentives such as interest, To support loans or payments within liquidity pools and deposits [49], [30].
6	**Liquidity risks:** Liquidity risk in DeFi refers to the possibility of inadequate funds to appropriate the value of a financial asset. Market makers play a crucial role in liquidating under-collateralized loans. If liquidation incentives are ineffective, counterparties and liquidity providers may face unexpected default risks. Growing blockchain adoption attracts liquidity and ensures sustainable DeFi development. [49], [30].
7	**Market risks:** DeFi market risk refers to the potential decline in asset value due to factors such as investor behavior, market conditions, and new information. Ease of fund transfer and complex DeFi instruments elevate the risk of exploitation by protocol creators, exchange operators, or third-party manipulators. Regulatory oversight is essential in mitigating these risks [49], [30].
8	**Credit risks:** Credit risk refers to the probability of counterparties defaulting on their obligations to a financial instrument. In DeFi, credit risk poses a distinct challenge due to the volatility of underlying digital assets, resulting in under-collateralization. Easy credit creation leads to excessive leverage, and algorithmic interest rate determination can introduce inaccuracies. The absence of fixed identities in a pseudonymous network further complicates the assessment of creditworthiness [49].
9	**Operational risks:** DeFi operational risk is the risk of financial losses due to inefficiencies or failures in internal processes, systems, personnel, or external factors [49].
10	**Composability risks:** DeFi's composability allows for the creation of complex applications. Still, it also introduces the risk of financial contagion, where issues in one protocol can spread to interconnected protocols, posing a potential risk to the entire ecosystem [28], [49].
11	**Key management risks:** Key management involves the risk of losing private keys, which is critical as the security of cryptographic systems relies on their protection. Lost private keys result in fund and asset loss[49].
12	**Legal and regulatory risk:** DeFi protocols face legal and regulatory risks due to the possibility of illicit activities and noncompliance with regulations. Lead to government intervention and prohibition of DeFi protocols. The absence of well-defined regulations makes it difficult for users to report incidents. However, aligning governance mechanisms with financial regulations contradicts the fundamental principles of decentralization [48-56].

4.2 Discussion

Our comprehensive analysis explores the dimensions of DeFi, including Benefits, Risks, Product/Services, and Technology, offering detailed explanations of associated benefits and risks. The interconnection between products/services, technology, and benefits introduces interdependent risks within DeFi. We recognize the study's limitations arising from the dynamic nature of technology. As DeFi evolves, there are potential emerging aspects and innovations, including technology-driven new products/services, which will bring new benefits and risks. Despite these risks, DeFi surpasses TradFi by providing transparency, low fees, accessibility, and enhanced confidence. Our study aims to enhance understanding of DeFi's role, promote adoption by financial institutions and banks, and foster further development in the field.

5 Conclusion

The Mapping Characteristics of DeFi analyzes interrelationships within dynamic DeFi ecosystems, enhancing understanding and mapping. Our study presents a holistic view, highlighting crucial elements and the state of DeFi during the research period. Transparent transactions in DeFi offer advantages for monitoring and building confidence in assets. While DeFi challenges TradFi in cost-effectiveness and transaction efficiency, a collaboration between the two is feasible. The DeFi mapping Characteristics serves as a valuable tool for researchers, industry professionals, and enthusiasts exploring the complex DeFi space. It enables informed decision-making on adoption, development, and regulation, promoting understanding and further research in DeFi. Our paper contributes as a reference to facilitate comprehension and encourage DeFi development advancement.

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