4 Application of regulatory mechanisms to decentralized finance

Decentralized Finance (DeFi) is a rapidly emerging area of finance next 239
to traditional centralized financial institutions with decentralized protocols that are blockchain-based or operate on another distributed ledger technology. DeFi leverages the power of smart contracts, which are self-executing contracts which may have the terms of an agreement between a buyer and a seller directly written in code. This technology enables financial transactions to occur without the need for intermediaries such as banks, allowing for faster, cheaper, and more transparent financial transactions (Bergt, 2020). As DeFi continues to grow, it is important to consider how regulatory mechanisms can be applied to ensure its safety and stability. This chapter will explore the application of regulatory mechanisms to DeFi coming from a centralized finance perspective.

The term "*smart contract*" was coined by Szabo (1994): „*A smart contract* 240
is a computerized transaction protocol that executes the terms of a contract. The general objectives of smart contract design are to satisfy common contractual conditions (such as payment terms, liens, confidentiality, and even enforcement), minimize exceptions both malicious and accidental, and minimize the need for trusted intermediaries. Related economic goals include lowering fraud loss, arbitration and enforcement costs, and other transaction costs. Some technologies that exist today can be considered as crude smart contracts, for example POS terminals and cards, EDI, and agoric allocation of public network bandwidth." The name smart contract, which refers to a contract, is rather misleading, especially since a smart contract represents a tamper-proof, self-verifying, and self-executing script. While such a script can indeed also represent a contract in a legal context, since contracts can also be concluded verbally or implicitly, not all smart contracts are actually contracts or even smart for that matter (Bergt, 2020). In the words of Buterin (2018): „*To be clear, at this point I quite regret adopting the term 'smart contracts'. I should have called them something more boring and technical, perhaps something like "persistent scripts."*

In his manifesto on smart contracts, Szabo (1994) suggests that the 241
considerations for smart contracts go even further back to the so-called agoric computing, which has its origins in the 1970s and 1980s (cp. Drexler & Miller, 1988; Miller & Drexler, 1988; Bergt 2020).

4.1 Decentralization shams vs real DeFi

242 DeFi is a distributed-ledger-technology-based or blockchain-based financial infrastructure that offers open, transparent, and secure transactions without relying on intermediaries or centralized institutions. The backbone of DeFi is smart contracts, which are programs executed by a large number of validators and that are stored on a blockchain, ensuring security and transparency. Blockchains essentially solved the double-spending problem of decentralized systems. Smart contracts allow for flexibility and customizable criteria for storing and releasing assets. DeFi may ultimately lead to a more open and resilient financial system (Schär, 2021). Distributed ledger technology enables public, decentralized, and permanent storage of data through token-based transactions, which represent specific economic values (Bergt, 2020, p. 6). Transactions on blockchains are facilitated by decentralized apps, known as smart contracts, which follow "if-then-else" logic (Bergt, 2020, p. 10; Nägele, Bergt, 2018). The various types of transactions on a blockchain include peer-to-peer, human-to-machine, or machine-to-machine (Mehrwald et al, 2019; Bergt, 2021a). Blockchain technology offers public visibility of stored transactions while ensuring permanence and immutability through cryptographic hash functions and decentralization (Bergt, 2020, p. 7). In an ideal scenario, blockchain allows for tamper-proof, distributed record-keeping and transfer of values, while ensuring consensus through cryptographic mechanisms (Böhme et al, 2015; Glaser, 2017; Bergt, 2021a).

243 In the more expansive interpretation of sharing economy (Lessig, 2008) and peer-to-peer markets by Perren and Kozinets (2018), these markets are characterized as instances of lateral exchange markets. A lateral exchange market can be described as a market established via an intermediating technology platform that enables exchange activities among a group of economically equivalent actors (Perren and Kozinets (2018; Bergt, 2021a). These lateral exchange markets or LEM form a higher-level definition including decentralized exchanges or DEX with regard to crypto assets.

4.1.1 Types of blockchains

244 A database refers to a structured storage of data that is simple to access, handle, and modify. Similarly, a blockchain is a digital ledger that stores data in a decentralized and distributed manner, with each block containing

a set of transactions that are linked together in a chain. Like a traditional database, a blockchain allows for the storage and retrieval of data. However, the key difference between a blockchain and a traditional database is the way in which data is stored and secured. In a traditional database, data is stored in a centralized location, such as a server or a data center, and can be accessed and updated by authorized parties with appropriate permissions. In contrast, a blockchain stores data across a network of computers, with each node containing a copy of the entire ledger. This decentralized architecture makes it more secure and resistant to tampering or hacking. In summary, a blockchain can be thought of as a specific type of database that is distributed, decentralized, and secure (Bergt, 2020, p. 7; 2021a; 2021b).

The types of blockchains can be summarized as a matrix of read and write rights, as follows: 245

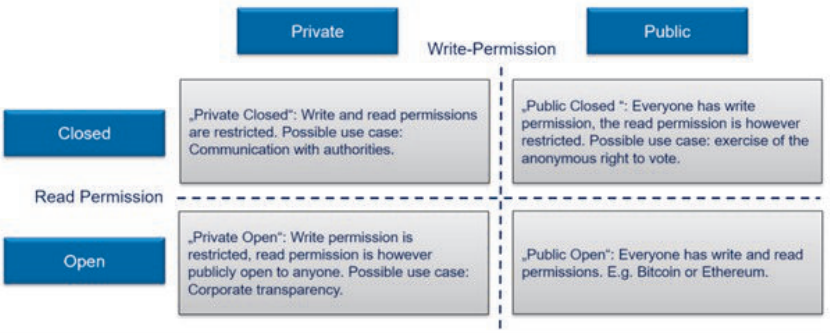

Figure 2: Blockchain type matrix based on read and write rights (Bergt, 2020).

By classifying blockchains based on their read and write rights, we can better understand the different use cases and advantages of each type. For example, public blockchains are more decentralized and provide greater security and transparency, while private blockchains offer greater control and privacy for enterprise applications. 246

Different variations have emerged from these types. On public blockchains anyone can read and write. Public blockchains are open to everyone and allow anyone to participate in the network, read the data, and submit transactions. Examples of public blockchains include Bitcoin and Ethereum. Whereas on private blockchains only designated parties can read and write. Private blockchains are permissioned and only authorized parties can participate in the network, read the data, and submit transactions. 247

Examples of private blockchains include Hyperledger and Corda. There are also consortium blockchains, where a group of designated parties can read and write. Consortium blockchains are similar to private blockchains, but they are controlled by several organizations rather than one individual or entity. Examples of consortium blockchains include R3 Corda and Quorum. Then there are hybrid blockchains. As a combination of public and private blockchains hybrid blockchains combine the features of public and private blockchains, allowing certain data to be kept private while also allowing for public access to some parts of the network. Examples of hybrid blockchains include Dragonchain and Ardor.

4.1.2 The decentralization promise of DeFi

248 The analysis of the allocation of tokens in Decentralized Finance (DeFi) protocols is crucial in understanding the protocols' decentralization efforts. Decentralized Finance (DeFi) is a stack of protocols that is both composable and trust-minimized, built on public blockchain networks, and employs smart contracts to construct publicly accessible and interoperable financial services. Most DeFi protocols issue tokens that represent partial protocol ownership and entitle holders to vote on contract upgrades or parameter changes and participate economically in the protocol's growth. Therefore, token allocation plays a crucial role in the protocols' decentralization efforts because a strongly centralized token distribution can lead to a number of super-users unilaterally modifying the protocol (Nadler & Schär, 2020).

249 Previous academic research on DeFi token distribution is limited, and the few analyses available severely overestimated ownership concentration. Thus, to address this gap, Nadler and Schär (2020) suggested an iterative mapping procedure that enables the separation of combined token possessions from custodial and escrow arrangements and allocates them to the respective ultimate beneficial owners. This approach considers liquidity pools, lending pools, staking pools, and token wrappers, and is applicable for dissecting token ownership, even in cases with multiple layers of nesting.

250 Their data indicated that DeFi tokens tend to have a relatively centralized ownership distribution, which raises important questions regarding protocol decentralization. Specifically, the minimum number of addresses required to achieve a majority might be especially significant for protocols

utilizing token-based governance models, as it could suggest a greater probability of collaboration and centralized decision-making (Nadler & Schär, 2020).

Additionally, the research highlights the constraints of DeFi in terms 251
of transparency. Although DeFi is highly transparent as most data can be found on-chain, gathering and presenting this information in an easily understandable format is difficult. The presence of multiple protocols, high nesting levels, and token wrappers can be too complex for the majority of users and analysts, necessitating the use of advanced analytical tools (Nadler & Schär, 2020).

DeFi represents a fast-expanding financial framework, yet there is a spe- 252
cific danger that elevated ownership concentration and intricate wrapping structures could introduce governance risks, compromise transparency, and generate substantial interdependence that impacts protocol stability. Future studies may utilize the methods presented in this paper to examine token attributes within the realm of governance models, employing the data as a factor for more accurate simulations and game-theoretical governance models (Nadler & Schär, 2020).

4.1.3 DeFi architecture

To understand the various DeFi building blocks and their roles within the 253
DeFi architecture, Schär (2021) suggests adopting a multi-layered approach, whereas it's crucial to note that this framework follows a hierarchical structure, meaning that errors in lower levels will be dragged on to the higher levels. The first layer or settlement layer consists of token standards, which are technical specifications that define how tokens are created, transferred, and interacted with (e.g., on the Ethereum blockchain). Token standards provide a common interface for different smart contracts and applications to communicate and interact with one another, which is essential for creating a highly interoperable financial system. The most widely used token standards in DeFi are ERC-20 and ERC-721 based on the Ethereum protocol, which define fungible and non-fungible tokens respectively and lead over to the second layer or asset layer (Schär, 2021).

The third layer or protocol layer of the DeFi ecosystem is composed of 254
decentralized, peer-to-peer services, like decentralized exchanges (DEXs or Lateral Exchange Markets; LEM), decentralized lending, etc, which enable peer-to-peer trading or lending of cryptocurrencies and other digital assets

without the need for an intermediary. DEXs are a set of smart contracts and allow users to trade directly from their wallets, thereby eliminating the need for custody or custodians or other intermediation (Schär, 2021).

255 The fourth layer in the DeFi ecosystem is the application layer which focuses on customer applications that interface with specific protocols. Typically, the front end of these applications is a web browser-based interface for the interaction with smart contracts, making the protocols more accessible to users. The fifth or aggregation layer s an expansion of the application layer, where aggregators develop platforms for users that connect to multiple applications and protocols. These platforms often provide users with tools to compare and evaluate services, enable them to execute complex tasks by simultaneously connecting with multiple protocols, and present information in an easy-to-understand format (Schär, 2021).

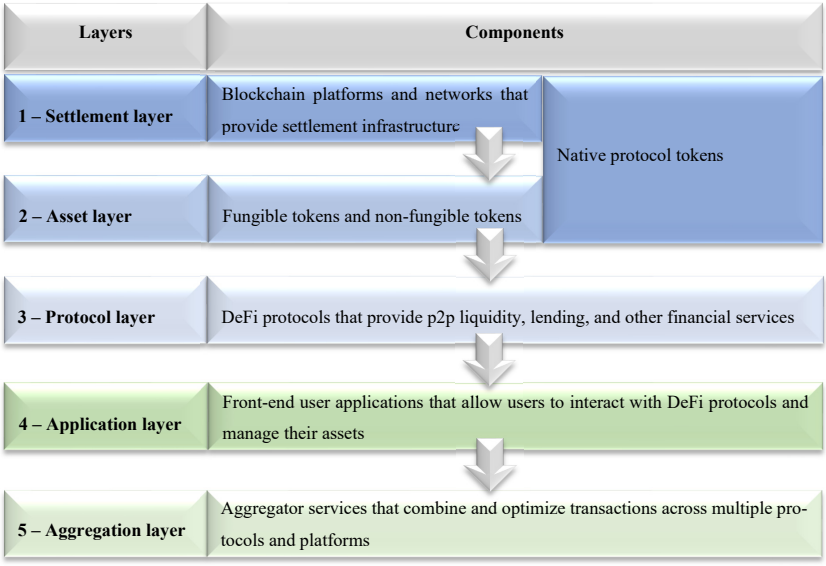

Figure 3: Multi-layered DeFi architecture following Schär (2021).

256 The levels of Schär's (2021) DeFi architecture or DeFi stack may be summarized as follows:

- Layer 1: Settlement layer consisting of the blockchain and native protocol asset for secure ownership and state changes.

- Layer 2: Asset layer consisting of native and additional assets issued on the settlement layer.
- Layer 3: Protocol layer providing standards for particular use-case-scenarios like decentralized exchanges, on-chain asset management, derivatives and debt markets.
- Layer 4: Application layer creating user-oriented applications with web browser-based front ends for easy use.
- Layer 5: Aggregation layer extending the fourth layer with user-focused platforms that link multiple applications and protocols, providing instruments for comparison and rating services, and combining information.

4.1.4 Decentralization shams and other supervisory challenges

Regulating a truly decentralized infrastructure is a questionable task for 257
regulators. However, pursuant to Schär (2021), two aspects demand particular focus: fiat entry and exits points or on- and off-ramps as well as the decentralization theater or decentralization shams. The on-ramps and off-ramps for legal tender are the connection points between the centralized financial system and blockchain-based or decentralized systems. To move assets between these two systems, people have to use regulated centralized financial service providers, who may require background checks on the origin of funds and so forth. Likewise, it is essential to differentiate between genuinely decentralized protocols and projects that merely purport to be decentralized but are under the control of a few individuals or organizations. This kind of "*decentralization theater*" – the term coined by Schär (2021) – can create reliance on centralized operators with little to no supervision, if any. In light of this, it is important for regulators to diligently observe and thoroughly assess DeFi protocols to determine if they are genuinely decentralized (up to layer three pursuant to figure 3 above) or if they are using the DeFi label as a facade to avoid regulation.

As genuine decentralized finance (DeFi) offers an alternative solution 258
by utilizing public blockchain networks to conduct transactions, thereby eliminating the need for intermediaries such as custodians, central clearinghouses, and escrow agents, by using smart contracts stored on public blockchains and executed as part of the system's consensus rules, ensuring that all participants comply with the rules before engaging and verifying the accuracy of the execution, to execute the functions of these intermediaries, it is important to be able to differentiate between true decentraliza-

tion and decentralization shams. In the context of DeFi, smart contracts are mainly utilized to ensure the simultaneous transfer of two assets or to hold collateral in an escrow account, both of which are subject to predefined conditions. This characteristic of DeFi can effectively mitigate counterparty risk, which is the risk of other parties failing to meet their end of the deal, as the assets can only be released if the predefined conditions are met (Schär, 2022).

259 Despite the promising benefits of DeFi, several potential pitfalls also exist. Security concerns, such as smart contract vulnerabilities and attacks on the blockchain network, pose significant risks. Regulatory issues can also pose challenges, given DeFi's inherent decentralized structure. Nonetheless, DeFi may represent a promising solution to the challenges posed by the centralized financial system (Schär, 2022).

260 Although decentralized infrastructure can provide various advantages, many of these aspects may also be achieved through centralized systems. As such, smart contracts, can also be used on both decentralized and centralized infrastructure. In terms of efficiency centralized systems perform better than decentralized infrastructure, although it argued by Schär (2022) that this argument rests on the assumption of trust in intermediaries and that centralized institutions are benevolent, which does not always hold true. Nevertheless, as pointed out under chapter 4.2.2, trust still plays a role in decentralized finance and may shift from intermediaries to intermediating technology platforms.

261 Public blockchains offer several benefits due to their transparency, neutrality, and accessibility. They provide a neutral, independent, and immutable infrastructure for financial transactions as they are not controlled by a single entity. The data is readily available and verifiable, for everyone, including researchers and policymakers, allowing for real-time analysis. Access to public blockchains is not restricted, providing a neutral foundation that cannot discriminate between use cases or stakeholders. Conversely, permissioned ledgers have rules set by a centralized entity, leading to the politicization of the rights to access and use the infrastructure (Schär, 2022).

262 As established, DeFi is built on a layered infrastructure, where certain smart contracts may be deployed on top of it coming with or without restrictions for different reasons. However, such restrictions, if any, can be implemented without compromising the decentralized foundation of the infrastructure. If the core protocol itself would be centralized, it would in turn be impossible to add decentralization in higher layers (Schär, 2022).

Decentralized finance (DeFi) has several challenges and risks that must 263
be taken into account, despite its many advantages. The first challenge is the risk of decentralization shams, where some market players claim to work on decentralized protocols but provide centralized infrastructure instead. People holding admin keys or with a large share of governance tokens can also exert influence on DeFi protocols. The issue of immutability presents a second challenge as it can create new risks such as difficulties in protecting investors and programming errors that can have severe consequences. The complex token wrapping schemes and composability also contribute to shock propagation in the system, which can pose significant challenges to the real economy. The transparency of the blockchain, which is the third challenge, may not be desirable from a privacy perspective and additionally transactions may be intercepted and front-run, resulting in yields being extracted to the detriment of the original principal. Lastly, scaling public blockchains presents the fourth challenge as there is a trade-off between security, decentralization, and scalability due to the costs of decentralized block creation and external hardware costs (Schär, 2022).

Front-running poses a particularly problematic issue from a regulatory 264
point of view and could be a reference point for future policymaking. On the one hand front-running refers to the use of insider-information on the other hand transactions that have not yet been processed may be scanned by front-running bots or AI tools and offer a higher gas fee to ensure that its own transaction is processed before others. This allows it to take advantage of upcoming trades that may influence market prices. While front-running is considered illegal in traditional stock markets due to the use of insider information, these regulations do not necessarily apply to crypto assets and in addition, in the crypto market all information is publicly available through digital ledgers. Therefore, front-running is not considered illegal in this context. Market abuse is the act of using information in a way that harms other financial market investors or gives an unfair advantage to the abuser. This can be done in three ways: by using information that is not available to the public, by spreading false information, or by manipulating financial instrument pricing mechanisms. Elements of market abuse may be applicable to front-running in crypto markets and might be of particular interest of public policymakers. The European Market Abuse Regulation (MAR; (EU) No 596/2014, ELI: http://data.europa.eu/eli/reg/2014/596/oj) identifies three types of market abuse. The first being insider dealing, which involves using confidential information to execute, change or cancel trades or to encourage others to trade using that information. The second

being unlawful disclosure of inside information, by releasing confidential information without the proper authorization and the third being market manipulation, which encompasses a variety of actions intended to distort the performance of the market. Again, the European MAR does not apply to crypto assets, unless they are also financial instruments (i.e., security tokens). However, as crypto assets are undoubtedly part of the financial market, abusive and distorting actions with regard to the performance of crypto markets might be grounds for future regulation.

4.1.5 Interim conclusion

265 Decentralized Finance (DeFi) is a financial infrastructure based on blockchain technology which holds promise for a more open, transparent, and secure financial system. Its backbone is smart contracts, which offer flexibility and customizable criteria for storing and releasing assets, with the potential to lead to a more resilient financial system. However, there are challenges in regulating DeFi, particularly in distinguishing between genuine decentralization and "*decentralization theater*." While it remains questionable whether true DeFi can or should be regulated the emergence of DeFi presents a unique opportunity for public policy makers to explore the potential benefits of decentralized financial systems while also addressing the challenges that arise with regulating such systems. To this end, it is crucial to establish a framework for assessing the degree of decentralization of DeFi protocols.

266 Following Schär (2021), DeFi protocols can be broken down into five layers, with the first three layers (settlement, asset and protocol layer) being the most crucial for ensuring decentralization. Regulators must closely monitor and analyze DeFi protocols to determine if they are genuinely decentralized or if they are using the DeFi label as a facade to avoid regulation. If one of the lower levels in this proposed DeFi architecture is centralized, then decentralization attempts at higher levels are set up to fail. Additionally, there is a need for special attention to be given to fiat entry and exit points, which are the connection points between the traditional centralized financial system and the blockchain-based system, as these are centralized intermediaries bridging the decentralized framework. Regulators must ensure that centralized financial service providers that facilitate asset transfers between these two systems are properly regulated.

In the context of public policy, the rise of decentralized finance (DeFi) presents both opportunities and challenges. On the one hand, DeFi offers a promising solution to the challenges posed by the centralized financial system. It has the potential to promote financial inclusion, reduce transaction costs, and increase transparency and efficiency in financial markets. On the other hand, DeFi also poses several risks, such as security concerns, regulatory challenges, and potential exploitation of vulnerable consumers. 267

To address these challenges, regulators should first and foremost carefully analyze DeFi protocols to determine if they are genuinely decentralized or if they are using the DeFi label as a facade to avoid regulation. Regulators should also pay specific attention to the areas of fiat on- and off-ramps, as these are critical areas intersecting between the centralized and decentralized finance systems to ensure the protection of consumers and financial stability. In other words, legislators should on the one hand in the terms of Hirshleifer and Teoh (2016) avoid bad rules with regard to regulation of true DeFi or at least carefully evaluate any potential consequences before enacting and implementing public policies and on the other hand regulatory and supervisory bodies should scrutinize centralized intermediaries providing financial services with regard to decentralized systems. 268

One potential challenge could be front-running, the act of using insider information or offering a higher fee to prioritize a transaction in financial markets, is illegal in traditional stock markets, but not necessarily in the crypto market where information is publicly available. However, such actions can still constitute market abuse, which is the use of information to harm other investors or gain an unfair advantage. The European Market Abuse Regulation (MAR) identifies and categorizes market abuse into three types: insider trading, market manipulation and unauthorized disclosure of inside information. While MAR may not apply to crypto assets, abusive actions in the crypto market could be grounds for future regulation as it is still a part of the financial market. 269

Lastly, regulators should pursue a regulatory strategy that prioritizes areas of concern based on risk, focusing on the areas of highest risk while allowing for innovation in areas that pose less risk and avoiding bad rules or bad policies. 270

4.2 Emerging markets of DeFi & regulatory approaches, MiCAR and DLT pilot regimes

271 The growth and rapid development of the cryptocurrency market have opened new dimensions in financial investment and decision-making processes. As a result, policymakers and regulatory authorities need to consider how behavioral finance aspects based on heuristic theories, prospect theory and herding among others, affect investment decisions in this market. Studies have shown that investors' choices regarding crypto assets or digital currency types are influenced by the choices of other investors, which in turn, significantly affect investment decisions. The findings also indicate that investors tend to make subsequent investment decisions based on their previous experiences, knowledge, and skills, thereby behaving as speculators in the crypto asset market (Al-mansour, 2017; 2020).

272 DeFi can replicate several financial services without the need for intermediaries, thereby reducing costs and the potential for errors. Examples of these services include lending markets, exchange protocols, financial derivatives, etc (Schär, 2022).

4.2.1 DAOs, the tokenization of assets and rights and the regulatory goals of MiCAR

273 The process of tokenization is one of the key features of blockchains, enabling the creation of shared and immutable records of ownership, also known as ledgers, which is the prerequisite for any DeFi services. Tokenization involves making additional assets available on these ledgers, making transactions more efficient and assets more accessible to anyone in the world. This has made tokens an essential component of the DeFi ecosystem, where they may be utilized in various decentralized apps and held within smart contracts (Schär, 2021; Roth, Schär, & Schöpfer, 2019).

274 Multiple methods exist for generating public blockchain tokens, however, the majority of tokens are produced on the Ethereum blockchain utilizing the ERC-20 (Ethereum Request for Comments) token standard smart contract template. These tokens are interoperable or fungible (Schär, 2021).

275 Tokenization enables the creation of digital representatives of assets or rights to them, although the primary consideration with tokenized assets is the risk related to the issuer. The token's value hinges on the reliability and trustworthiness of the issuer, and if the issuer is hesitant or incapable

of fulfilling their obligations, the token may lose its value or be traded at a substantial markdown. (Berentsen & Schär, 2018; 2019). From a profit generation perspective this may put tokens dangerously close to one of the four key elements of the Howey test as discussed under chapter 3.5 with regard to US securities law. The same may be argued with regard to the European financial instrument definition under MiFID II insofar as tokens are mass-issued, standardized instruments representing a claim on the issuer at least from an accounting perspective, albeit this discussion seems mostly moot at this point with MiCAR and other specific regulations on crypto assets at the rise.

276 In addition to this there exist various categories of tokens such as governance tokens that serve decentralized autonomous organizations (DAOs), tokens that authorize certain operations in smart contracts, tokens which bear resemblance to stocks or bonds as well as synthetic tokens capable of monitoring the price of any tangible asset, etc which serve different purposes in a DeFi ecosystem (Schär, 2021). However, with governance tokens allowing for participation of token holders in decision-making processes within decentralized autonomous organizations, this creates a risk of blurring the lines to voting rights inherent to simple corporate societies or entities, which would in turn again raise the question with regard to transferable securities.

277 To counter issuer risk, guarantees may be introduced. There are in general primary types of token backing models: No collateral, on-chain collateral and off-chain collateral. On-chain collateral entails locking assets on the blockchain using a smart contract, while off-chain collateral involves physical assets held by an escrow service. On-chain collateral offers the advantage of increased transparency, and smart contracts may ensure claims through collateralization, enabling semi-automated execution of processes. However, such collateral typically consists of a native protocol asset or a related asset, which may be subject to price fluctuations, requiring over-collateralization to mitigate risk. Off-chain collateralized tokens, on the other hand, may help reduce exchange rate risk as it may have a value equal to the tokenized claim, but they introduce counterparty risk and external dependencies. To guarantee the availability of the underlying collateral at all times, regular audits and safety measures are essential. However, these can be expensive and may not always provide complete transparency to token holders. With no collateral, the counterparty risk is the highest and exchange is entirely trust-based (Schär, 2021).

4.2.1.1 Evolution of the theory of the firm, social economy organizations and decentralized autonomous organizations

278 The burgeoning presence of social economy organizations (SEOs) in advanced, developing, and transition economies has generated increasing recognition of their relevance for balanced social and economic development. However, traditional economic theory struggles to provide a comprehensive explanation for their existence, often reducing it to a response to market and state failures (Sacchetti & Sugden, 2002). Borzaga and Tortia (2008) developed a more accurate explanation by first reevaluating the conventional paradigm that views economic actors as driven solely by self-seeking motives. Instead, it acknowledges that individuals are motivated by a range of preferences that extend beyond extrinsic and monetary incentives, including relational, reciprocal, intrinsic, and social preferences (Frey, 1997). These motivations significantly impact entrepreneurial activities and intra-organizational dynamics, particularly in terms of procedural fairness (Borzaga and Tortia, 2008).

279 Borzaga and Tortia (2008) also explored an alternative conception of the theory of the firm (Coase, 1937), rooted in the evolutionary tradition, which views production organizations as governance structures that are not necessarily dedicated to maximizing profit (Sugden & Wilson, 2002). This perspective posits that firms must achieve economic sustainability while considering the motivations and needs of all involved actors, who are often embedded in local contexts. From this vantage point, firms are understood as problem-solving devices that adapt to their environments and utilize localized knowledge to achieve specific production objectives (Sacchetti & Sugden, 2002). Incentive mixes emerge as the primary means by which firms strengthen relationships with their stakeholders and adapt to pursue organizational goals (Borzaga and Tortia, 2008).

280 This evolutionary perspective enables economic theory to incorporate the role of SEOs in economic development, both generally and locally. Borzaga and Tortia (2008) argue that the proliferation of SEOs may contribute to a reduction in transaction costs, thereby promoting economic development. Specifically, SEOs can lower transaction costs in the presence of market failures, particularly when markets are underdeveloped or uncompetitive, or when product-specific high costs arise due to asymmetric information. The multi-stakeholder governance model of SEOs can reduce transaction costs by mitigating information asymmetries and reconciling contrasting objectives. Furthermore, SEOs can lower production costs by

leveraging non-monetary incentives and facilitating exchanges in situations where for-profit firms cannot operate, such as social services or the production of collective goods (Frey, 1997).

281 Additionally, SEOs can foster trust and facilitate the accumulation of social capital, as horizontal coordination and intra-organizational participation may have positive social spillover effects. The importance of local interaction between firms and their environments must also be acknowledged, as this interaction shapes the motivations and demands of stakeholders in relation to the firm's operations. Consequently, firms must consider localized knowledge and the motivations of actors within their locale to effectively adapt incentive mixes and reinforce relationships with stakeholders (Borzaga and Tortia, 2008).

282 The concept of local development employed here encompasses more than merely the growth of aggregate variables like production and employment; it involves the aggregate result of demands and needs expressed by social actors, to which firms must respond. This bottom-up approach to local development, characterized by endogenous objectives expressed at the local level, has been proposed by several authors (Sugden & Wilson, 2002; Sacchetti & Sugden, 2002) and warrants integration into the understanding of the firm and the role of SEOs. SEOs are well-positioned to adopt this perspective, as they tend to emphasize motivations and demands arising from actors within the locality. This focus is less common in organizations with strong hierarchical control, where local actors' motivations and demands are often overlooked (Borzaga and Tortia, 2008).

283 Decentralized Autonomous Organizations (DAOs) represent a new paradigm in organizational structure, utilizing blockchain technology to enable transparent, decentralized decision-making and governance. As with social economy organizations (SEOs), DAOs challenge conventional economic theory and the traditional understanding of the firm. Both SEOs and DAOs contribute to a broader view of organizations that prioritize the needs and motivations of stakeholders beyond purely monetary incentives.

284 A decentralized autonomous organization is an entity formed by regulations embedded within a computer program (e.g., blockchain-based smart contracts), which typically offers transparency, is governed by its members, and remains uninfluenced by a central authority. Broadly speaking, DAOs represent collectively owned communities that operate without a centralized hierarchy (Prusty, 2017; Chohan, 2017).

285 While SEOs focus on fostering social and environmental objectives alongside economic sustainability, DAOs emphasize decentralized gover-

nance through the use of smart contracts and token-based voting systems. This decentralized approach allows for greater stakeholder participation in decision-making processes, aligning with the principles of SEOs that value horizontal coordination and participation. Moreover, DAOs can facilitate the accumulation of social capital by promoting trust and collaboration among stakeholders.

286 However, the key distinction between SEOs and DAOs lies in their underlying structures and technologies. SEOs typically operate within a legal and regulatory framework, with governance structures and incentive mixes that incorporate both monetary and non-monetary incentives. In contrast, DAOs primarily are aimed at being digital entities that function autonomously on blockchain platforms, allowing for global participation and seamless integration with decentralized finance (DeFi) systems.

287 As outlined above, organizations may be understood as social problem-solving vehicles that adapt to their environments and utilize localized knowledge to achieve specific (production) objectives. Given this broad definition DAOs also fall under the economic definition of organizations, and they may be seen as a social contract pursuant to Jean-Jacques Rousseau's understanding (1762), albeit in general without claiming to form a state and negating other existing state formations. If put in a legal context it may consequently be argued that DAOs constitute some form of legal entities under commercial and corporate law like simple societies, where at least two founders join together to pursue a business purpose, or a societal association dedicated to a political, religious, scientific, artistic, charitable, social or other economic or non-economic task, or where an open-ended number of individuals or commercial companies, whose main purpose lies in promoting or securing specific economic interests of their members through mutual self-help, joins together.

288 In the evolving landscape of organizational structures, both SEOs and DAOs present alternative models that challenge the traditional conception of the firm. By prioritizing stakeholder needs, social objectives, and decentralized governance, these organizations contribute to a more inclusive and sustainable economic ecosystem.

289 Decentralized autonomous organizations can be considered an evolution of social economy organizations due to their shared emphasis on stakeholder involvement, social objectives, and innovative governance structures. Both SEOs and DAOs value stakeholder involvement in decision-making processes. While SEOs promote horizontal coordination and participation, DAOs take this concept further by utilizing blockchain technology to en-

able decentralized, transparent, and direct stakeholder participation in governance through token-based voting systems. Similar to SEOs, DAOs can prioritize social and environmental objectives alongside financial sustainability. By integrating these objectives into their organizational structures, DAOs have the potential to advance the social mission of SEOs in a digital and global context. Both SEOs and DAOs contribute to the accumulation of social capital by fostering trust and collaboration among stakeholders (cp. chapter 4.2.2.2). DAOs can expand the reach and impact of SEOs by operating on a global scale, connecting stakeholders from diverse geographical locations, and leveraging decentralized finance (DeFi) systems. This extended reach allows DAOs to address social and environmental challenges across borders and to create new opportunities for collaboration and resource allocation. DAOs can further reduce transaction costs by automating various processes through smart contracts, enhancing the efficiency of SEOs in addressing market failures and promoting economic development. The evolution of SEOs into DAOs aligns with the broader trend of digital transformation and the increasing importance of emerging technologies like blockchain, artificial intelligence (AI), and the internet of things (IoT) in shaping the future of organizations and the economy.

4.2.1.2 Public policy goals of MiCAR and classification of crypto assets

The present chapter examines the EU proposal for a regulation on markets in crypto-assets, more commonly known as MiCA-Regulation or MiCAR (COM/2020/593 final) which is an integral part of the EU Digital Finance package, next to the digital operational resilience regulation (also referred to as digital operational resilience act or DORA; (EU) 2022/2554; ELI: http://data.europa.eu/eli/reg/2022/2554/oj). MiCAR will supposedly be entering into force in 2023 and will be applicable 18 months (respectively 12 months with regard to Title III and IV on asset referenced tokens and e-money tokens) thereafter pursuant to its transition period stipulated in Art 126 MiCAR. This package aims to promote the possibilities of digital finance concerning innovation and competitiveness, while minimizing the associated risks. This package corresponds with the Commission's goals of preparing Europe for the digital era and constructing an economy equipped for the future that advantages its citizens. The Digital Finance package introduces a strategy for the EU financial sector, emphasizing the creation of an EU financial services regulatory framework that is conducive to inno- 290

vation and does not obstruct the implementation of emerging technologies (European Commission, 2020).

291 Crypto assets have emerged as a significant application of blockchain technology within the financial sector. Since the release of its Fintech Action Plan in March 2018, the European Commission has been diligently observing the potential benefits and obstacles presented by crypto assets. The advice issued by the European Banking Authority (EBA) and the European Securities and Markets Authority (ESMA) in January 2019 highlighted the challenges in applying existing EU legislation to crypto-assets and highlighted that provisions in current laws could impede the usage of distributed ledger technology. The EBA and ESMA also highlighted that the majority of crypto assets are not covered by EU financial services regulations, resulting in a lack of consumer and investor protection, as well as market integrity provisions. Moreover, market fragmentation has resulted from recent legislations by Member States on issues related to crypto assets (European Commission, 2020).

292 The advent of 'stablecoins,' a relatively new subset of crypto assets, has attracted attention from the public and regulators worldwide. Although the crypto-asset market is currently limited in scale and does not jeopardize financial stability, the advent of 'global stablecoins' may change this situation by introducing characteristics designed to stabilize their value and take advantage of network effects (European Commission, 2020).

293 The proposal of MiCAR aims to address these concerns by establishing an EU framework that facilitates crypto-asset markets, tokenization of conventional financial assets, and broader adoption of DLT in financial services. The proposal has four general and related goals: legal clarity, encouragement of innovation, safeguarding consumers and investors, and maintaining financial stability. Pursuant to the Explanatory Memorandum of the European Comission the proposal is consistent with existing policy provisions in the policy area and builds on market monitoring and participation in international policy work. It is also consistent with other Union policies, such as those related to the digital age, blockchain technology, the Capital Markets Union (CMU), the SME strategy, and the Security Union Strategy (European Commission, 2020).

294 The proposed MiCAR strives to create a comprehensive framework that supports innovation and fair competition while addressing the risks and challenges associated with the development and use of crypto assets in the EU financial sector.

Among the various DLT applications, crypto assets represent a significant innovation, as they offer numerous advantages to market participants and consumers, according to the European Commission (EC). While some crypto assets are considered financial instruments under MiFID II, most of them remain beyond the reach of current EU financial services regulations (MiCAR, recital 2-3). 295

The lack of a comprehensive EU framework for crypto assets is deemed to hinder market development, lead to missed opportunities in digital services, and create regulatory fragmentation, thus impeding cross-border scaling of crypto-asset service providers and enabling regulatory arbitrage. Furthermore, the growth of certain types of crypto assets could pose challenges to monetary sovereignty and financial stability. Consequently, a harmonized framework at the Union level was proposed to establish specific rules for crypto-assets and related services, facilitate cross-border scaling of crypto-asset service providers, and address potential financial stability and monetary policy risks (MiCAR, recital 4-5). 296

Crypto assets that are classified as financial instruments, such as security tokens, under MiFID II will not be subject to MiCAR, regardless of the technology employed for their issuance or transfer. Additionally, crypto assets issued by central banks or other public authorities should not be subject to MiCAR (MiCAR, recitals 6-7). 297

The legislation adopted in the field of crypto assets follows the difficult goal of furthering innovation and at the same time being future proof. Three distinct sub-categories of crypto-assets will fall under more targeted regulation – utility tokens, electronic or e-money tokens and asset-referenced tokens. Utility tokens are designed for non-financial purposes associated with the functioning of a digital platform and digital services, while asset-referenced tokens strive to preserve a stable value by referencing multiple currencies, commodities, or other crypto-assets, according to the EC. E-money tokens, conversely, are intended to primarily serve as a means of payment and preserve a constant value by referencing a single fiat currency (MiCAR, recitals 8-9). The types of tokens falling under the MiCAR may be visualized as follows: 298

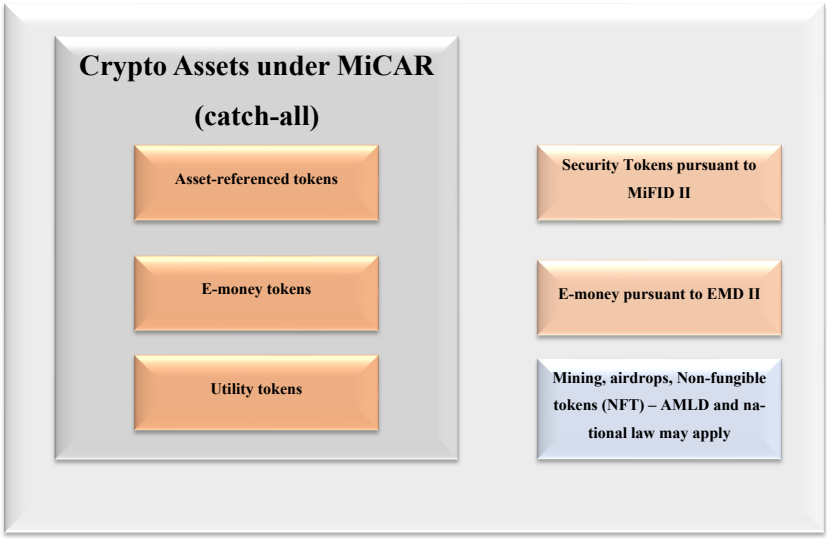

Figure 4: MiCA-Regulation Token Classification, own figure.

299 While asset-referenced tokens, utility tokens and e-money tokens are covered by MiCAR, the regulation does not pertain to tokens classified as financial instruments under MiFID II (security tokens) or e-money under EMD II. Crypto assets are defined in article 3 no 1(2) MiCAR as a "*digital representation of value or rights which may be transferred and stored electronically, using distributed ledger technology or similar technology*". By this catch-all definition, also services with regard to other tokens or coins (BTC, ETH, etc) like trading and custody are regulated. By the process of elimination, considering the token and crypto asset service definitions in Art 3 of MiCAR, it does not apply to airdrops or mining activity with regard to crypto assets. Initially, the treatment of NFTs still left some open questions, as originally the issuance of unique and non-fungible tokens did not constitute a crypto asset issuance pursuant to article 4 no 2(c) of the proposed MiCAR (presumably also given that a public offering in financial market terms implies mass-issued and standardized, thus fungible, instruments), while services with regard to NFTs, like trading or custody, would have potentially fallen under the proposed MiCAR. In the final proposal of MiCAR it was clarified in its article 2 no 2a, that MiCAR is not applicable to unique, non-fungible crypto-assets that cannot be interchanged with other crypto-assets. While the initial proposal would have potentially also

covered emerging markets in the intersecting area of gaming (gambling) and video game markets with regard to NFTs, this is no longer the case with the final proposal. On the other hand, such a broad interpretation, as with the initial proposal, would have ultimately regulated the technology as a whole (e.g., pure technical blockchain-based tokens containing documentary evidence or used in information technology), which would be in contrast to the furtherance of innovation. In any case, jurisdictional national law as well as anti-money-laundering provisions (Directive (EU) 2015/849 or AMLD 5, as amended; ELI: http://data.europa.eu/eli/dir/2015/849/2021-06-30) may still apply to the aforementioned services and also to services with regard to NFTs.

Even though they share some similarities, electronic money and crypto assets referencing a single fiat currency have several significant differences. In order to prevent regulatory arbitrage, stringent conditions should be imposed on the issuance of e-money tokens, including the stipulation that they must be issued either by a credit institution or by an electronic money institution authorized under EMD II (MiCAR, recital 10). 300

In light of the various risks and opportunities presented by crypto-assets, specific rules are laid down for issuers of crypto-assets and entities that provide services with regard to crypto-assets. Crypto-asset service providers are defined as any person providing crypto-asset services on a professional basis, including the operation of trading platforms, exchanging crypto-assets against legal tender or other crypto-assets, and ensuring the custody and administration of crypto-assets on behalf of third parties. Furthermore, to ensure proper monitoring and supervision of all offers to the public of crypto-assets or their admission to trading on a crypto-asset trading platform, regulatory connecting point for the issuance of crypto-assets are natural or legal persons (MiCAR, recitals 11-13, 50). In the initial proposal this was limited to legal entities instead of natural or legal persons and other undertakings, but either way these recitals leave room for interpretation with regard to DAOs, as mentioned under chapter 4.2.1.1, as it generally implies that centralized issuers have to be incorporated as a legal entity or form a legal person or some form of undertaking. However, it leaves the question open whether truly decentralized platforms and the issuance or minting of governance tokens are still possible under this clause as a decentralized architecture may be exposed to a certain degree of centralization before becoming truly decentralized and it is unclear whether this provision is also supposed to capture DAOs (which would effectively impose a ban on them). As one of the goals of the regulation is to further innovation, and 301

it generally only applies to centralized crypto asset service providers, it is assumed that it is not supposed to affect DAOs. Also, by way of implication as outlined before, MiCAR shall not apply to crypto mining or validation activity (e.g., through proof of work or proof of stake mechanisms) and hence does not affect DAOs; likewise, it also does not effect or regulate staking unless the staking takes place as part of the management of crypto assets by a third party (crypto asset portfolio management).

302 In order to safeguard consumers in the realm of crypto assets, focus is put on buyers being well-informed about properties, uses, and hazards associated with the crypto assets they plan on buying. As part of this process, crypto asset issuers have to create, submit to their competent authority, and make public a so-called crypto asset white paper containing mandatory disclosures, which must be fair, clear, and not misleading, while certain exemptions apply to avoid imposing excessive administrative burdens on small and medium-sized enterprises and start-ups (MiCAR, recitals 13-16). Information disclosures in general are suitable for mitigating information asymmetries if the information is actually read and digested by potential buyers.

303 Regarding utility tokens for services not yet operational, the duration of a public offer, as detailed in the crypto-asset white paper, must not surpass 12 months. Before initiating a public offering of crypto-assets in the European Union or European Economic Area (EEA), issuers should notify their competent authority of their crypto-asset white paper and, if relevant, their marketing materials. To minimize unnecessary administrative burdens, competent authorities are not required to approve a crypto asset white paper, but they have the power to request additional information after publication (MiCAR, recitals 17-19).

304 After properly notifying a competent authority about a crypto-asset white paper and, if necessary, marketing materials, crypto-asset issuers are allowed to offer their crypto-assets across the EU and EEA and pursue admission for trading on a crypto-asset trading platform pursuant to the passporting system. Consumer protection is further reinforced by providing consumers who purchase crypto-assets directly from the issuer or a crypto-asset service provider, excluding crypto-assets admitted to a trading platform for crypto-assets, a 14-day withdrawal period following their acquisition (MiCAR, recitals 21-22).

305 Asset-referenced tokens pursuant to the EC pose unique risks to consumer protection and market integrity due to their value stabilization mechanisms and as a result are subject to stricter regulations than other

crypto-assets, including supervision and monitoring of the issuance, after the national competent authority's approval. Public offers of asset-referenced tokens should only be allowed where the competent authority has authorized the issuer and approved the crypto-asset white paper (MiCAR, recitals 25-28).

306 In order to mitigate financial stability risks within the broader financial system, it is proposed under MiCAR that the capital requirements imposed on issuers of asset-referenced tokens are proportional to the magnitude of the issuance of these tokens and determined as a percentage of the reserve of assets supporting their value. Issuers of asset-referenced tokens must further establish and maintain a reserve of assets to stabilize the value of their tokens and ensure prudent management of this reserve. Issuers must invest reserve funds in safe, low-risk assets with little market or credit risk in order to shield token holders from a decline in the value of the assets underpinning the tokens and profits or losses from reserve asset investments have to be borne by the issuer (MiCAR, recitals 36-39).

307 Both, significant asset-referenced tokens and significant e-money tokens, utilized by a considerable number of users, that potentially pose unique challenges concerning monetary sovereignty or financial stability, are subjected to stricter overall requirements as well as higher capital and interoperability requirements as well as liquidity management policies. Issuers also have to have a plan for a smooth wind-down to protect the interests of asset-referenced token holders in the event that the issuer ceases operations or winds down its activities in accordance with national insolvency laws (MiCAR, recitals 42-43, 49).

308 E-money token issuers have to be licensed as credit institution pursuant to CRD IV (2013/36/EU; ELI: http://data.europa.eu/eli/dir/2013/36/oj) or as e-money institution pursuant to EMD II and e-money token holders always have to be granted redemption rights at par value with the referenced fiat currency (MiCAR, recitals 44-45).

309 To ensure consumer protection, it is essential for crypto-asset service providers to establish adequate arrangements for safeguarding client ownership rights for their crypto-asset holdings and they may be held liable for any damages resulting from information communications technology related incidents, such as cyber-attacks or malfunctions (MiCAR, recitals 58-59).

310 In order to maintain orderly crypto-asset market functioning, providers operating trading platforms should implement detailed operating rules, ensure resilient systems and procedures, and adhere to crypto-asset mar-

ket specific pre- and post-trade transparency standards. Trades executed on the platform must be swiftly settled and recorded on the DLT, and providers should maintain a transparent fee structure to prevent market abuse or disorderly trading conditions without obtaining any payment or other compensation for transmission of orders to specific platforms or providers. To ensure consumer protection, crypto-asset service providers that provide advice on crypto-assets are required to initially evaluate their clients' experience, knowledge, objectives, and capacity to endure losses (MiCAR, recitals 60-63).

311 In MiCAR it is proposed to maintain user confidence and market integrity in the crypto-asset market by implementing rules to deter market abuse for crypto-assets traded on a platform to prohibit behaviors that undermine market confidence and integrity, like insider trading, leaking private information without permission, and other manipulating of the market for crypto-assets (MiCAR, recital 64).

312 MiCAR, through its article 80, addresses market manipulation more concretely, prohibiting activities that give misleading signals, set abnormal or artificial prices, or use deceptive practices. It also covers behaviors such as securing a dominant position, disrupting the functioning of trading platforms, and voicing opinions on crypto assets without disclosing conflicts of interest. By tackling market manipulation, MiCAR aims to promote fair trading conditions and protect investors. As outlined in chapter 4.1.4, in the context of DeFi and behavioral finance, it is crucial to create a regulatory framework that mitigates biases and prevents potential market manipulations. MiCAR is addressing this with regard to centralized financial intermediaries in crypto markets which are bridging the centralized and decentralized finance world. Avoiding bad regulation in the public policy context helps to maintain the balance between fostering innovation in the crypto-assets market and safeguarding the financial ecosystem's stability and integrity. While the issue is addressed in MiCAR, it does not explicitly mention frontrunning in the given context. However, the regulation targets market manipulation and deceptive practices, which could potentially encompass frontrunning-like activities. Frontrunning, in the context of crypto-assets and DeFi, typically involves a party using privileged information or exploiting transaction ordering to gain an unfair advantage over other market participants. While not explicitly mentioned, the broader scope of MiCAR's prohibition on market manipulation may implicitly cover such activities to ensure fair trading conditions and protect investors. However, while centralized intermediaries under MiCAR may fall under this regu-

lation, this issue still remains unsolved for true DeFi. Additionally, the same methodology may essentially be used to exploit traditional trading in financial instruments through the use of artificial intelligence.

313 Due to the cross-border nature of crypto asset markets, EU national financial market supervisory authorities may cooperate to detect and deter legal framework infringements for crypto-assets and markets. In order to prevent supervisory arbitrage among member states, the EBA oversees issuers of significant tokens. The EBA sets up a college of supervisors for these issuers, which includes all competent authorities associated with relevant entities and service providers in charge of managing and safeguarding crypto assets, operating trading platforms, and so on. This college fosters collaboration and information sharing among members and provides non-binding opinions on supervisory actions or modifications in authorization regarding issuers and pertinent entities offering services or activities connected to significant tokens (MiCAR, recitals 65-69).

314 In order to prevent interference with market participants offering services and activities related to crypto assets issued prior to MiCAR's implementation, transitional provisions apply to such service providers (MiCAR, recital 77).

In the Permanent Representatives' Committee meeting on 05th October 2022 the final compromise text was endorsed which brought further amendments to the proposed MiCAR draft to be enacted (Counsel of the European Union, 2022, 13198/22, EF 293, ECOFIN 965, CODEC 1428; MiCAR Draft).

315 For one, environmental, social and governance aspects were included in the final proposal as consensus mechanisms used for transaction validation in crypto assets may have environmental impacts and in order to mitigate these effects, environmentally friendly solutions should be employed, and adverse impacts should be identified and disclosed by issuers and service providers. Additionally, it was noted that the global nature of crypto-assets markets necessitates international efforts to promote convergence in their treatment through organizations like the Basel Committee, the Financial Stability Board and the Financial Action Task Force (MiCAR Draft, recital 5a-5c). Most importantly however, the regulation shall not apply to unique and non-fungible crypto assets, such as digital art and collectibles, product guarantees, or real estate, while naturally, fractionalized NFTs shall not be considered unique and non-fungible any longer (MiCAR Draft, recital 6c). Additionally, digital assets that cannot be transferred to other holders are excluded from the scope of the regulation, such as loyalty schemes where

points can be exchanged only with the issuer or offeror (MiCAR Draft, recital 8a).

316 In the final proposal it is clarified that the MiCAR applies to natural and legal persons, as well as other undertakings including services which are performed by them at least partially in a decentralized manner, whereas fully decentralized crypto asset services as defined in MiCAR do not fall under its regulatory scope (MiCAR Draft, recital 12a). It is further clarified that certain exemptions apply to crypto assets that are offered for free (e.g., airdrops), created as a reward for maintaining distributed ledger technology or regarding the verification of transactions within the framework of consensus building mechanisms, or those representing the purchase of goods or services within a limited network. The final proposal of MiCAR als notes that simply admitting crypto-assets to a trading platform or publishing bid and offer prices does not constitute an offer to the public (MiCAR Draft, recitals 14b-15a). Furthermore, MiCAR does not cover the regulation of borrowing and lending activities involving crypto assets (MiCAR Draft, recital 63e).

317 The core sentiments of MiCAR aim to establish a robust regulatory framework for crypto assets in the EU and EEA, ensuring market integrity, financial stability, and investor protection. It does not target true DeFi but is aimed at centralized financial intermediaries which provide services with regard to crypto markets bridging the centralized and decentralized systems by seeking to strike a balance between regulation and fostering innovation. While the proposed EU regulation on crypto-assets aims to establish a comprehensive framework for the issuance and operation of crypto-assets, ensuring market integrity, financial stability, and investor protection there are a few aspects that could be further explored or clarified, taking into consideration behavioral finance and public policy implications, whereas in the public policy context a focus should be put on avoiding bad regulation instead of enacting good rules for bad players:

- Behavioral biases and heuristics in regulatory decision-making: The regulation does not explicitly address how regulators will account for their own potential biases in decision-making when developing and implementing regulatory standards for crypto assets. Recognizing and addressing such biases could improve the effectiveness of regulation in achieving its stated objectives. It is proposed that policymaking institutions and the members involved should in general implement a proce-

dure containing mechanisms to counter potential decision-making biases in the legislative process.

- Investor protection: The regulation emphasizes the importance of investor protection but could better address how the needs and biases of retail investors will be considered in the designing of regulatory technical standards and implementing technical standards. For instance, the regulation could elaborate on how disclosure requirements in crypto-asset white papers will be tailored to ensure that retail investors can easily understand and assess the risks associated with crypto assets.
- Financial literacy and education: The regulation does not explicitly mention the role of financial literacy and education in promoting responsible investment in crypto assets. Given the complex nature of crypto-assets and the potential risks involved, promoting financial literacy and education among investors could be an essential component of the public policy context.
- Market manipulation and fraud: While the need for legal certainty and prevention of market abuse in the context of the crypto asset market is highlighted in recital 64a MiCAR, the regulation could further detail how the competent authorities will work together to address the potential for market manipulation and fraudulent activities in the crypto asset markets, considering that these risks are often exacerbated by behavioral biases such as herding, fear of missing out and overconfidence and also address frontrunning behaviors more directly. The potential impact of social media and smart contracts on market manipulation should also be considered. The regulatory framework should address the unique challenges posed by the rapidly evolving crypto-asset landscape and its intersection with technology.
- Impact on innovation: The regulation seeks to establish a consistent legal framework for crypto assets to ensure market stability and investor protection. However, the potential impact of the regulation on innovation and the development of new crypto-asset technologies should be considered analyzed further as striking a balance between regulation and fostering innovation is critical in the public policy context.
- International coordination: The regulation mainly focuses on the EU context and does not explicitly address the importance of international coordination and cooperation in regulating crypto assets. Given the global nature of crypto asset markets, increased collaboration between international regulatory bodies could strengthen the effectiveness of the regulation and mitigate potential regulatory arbitrage.

318 In summary, the EU regulation on markets in crypto assets appears to be a comprehensive framework. However, further consideration of behavioral finance and public policy implications could enhance the effectiveness of the regulation in attaining its objectives, specifically in areas such as investor protection, financial literacy, and fostering innovation.

4.2.1.3 Interim conclusion

319 Both social economy organizations (SEOs) and decentralized autonomous organizations (DAOs) challenge traditional economic theory by prioritizing stakeholder needs, social objectives, and innovative governance structures. SEOs and DAOs emphasize diverse motivations, horizontal coordination, and local interaction, promoting trust, collaboration, and social capital accumulation. While SEOs focus on social and environmental objectives in addition to economic sustainability, DAOs extend this approach through decentralized governance and blockchain technology, facilitating global participation and seamless integration with decentralized finance systems. These alternative organizational models contribute to a more inclusive and sustainable economic ecosystem and showcase the potential for digital transformation in addressing contemporary social and environmental challenges. DAOs may be argued to be a further evolutionary step from SEOs.

320 On a different topic, the regulatory goals of MiCAR, in respect to the EU Digital Finance package, aspire to support innovation and competition in the realm of crypto assets while managing the risks involved. The European Commission has recognized the significance of crypto assets in the financial industry as well as the need for a comprehensive EU framework to prevent market fragmentation and regulatory arbitrage. MiCAR proposes a harmonized approach, classifying crypto-assets into three sub-categories: e-money tokens, utility tokens and asset-referenced tokens. While the regulation does not apply to tokens considered transferable securities under MiFID II or e-money under EMD II, it does provide a legal structure to facilitate cross-border scaling and address potential financial stability and monetary policy risks. The regulation seeks to strike a balance between promoting innovation and maintaining a future-proof legislative environment.

321 Considering the various risks and opportunities associated with crypto-assets, specific regulations have been established for crypto asset issuers and service providers. These rules cover a range of professional services,

including trading platform operation and crypto-asset custody. To ensure proper oversight, crypto-asset issuers must be legal persons, although questions remain regarding decentralized platforms and governance tokens, while it is presumed that they do not fall under the scope of MiCAR. Crypto asset issuers must create and disclose white papers to inform potential buyers about risks and features of the assets. Utility tokens have specific duration requirements, and asset-referenced tokens face more stringent regulations due to their value stabilization mechanisms. E-money token issuers must be licensed and provide redemption rights at par value. Crypto-asset service providers must safeguard client ownership rights and adhere to operating rules for trading platforms. MiCAR also addresses market manipulation to promote fair trading conditions. Additionally, EU supervisory authorities cooperate to maintain market integrity and stability. Amendments to MiCAR include environmental, social, and governance considerations and exclusions for unique, non-fungible crypto assets.

In conclusion, the MiCAR initiative intends to establish a thorough 322
regulatory structure for crypto assets within the EU and EEA, focusing on market integrity, financial stability, and investor protection. The proposal primarily targets centralized financial intermediaries while attempting to balance regulation with innovation. Despite the comprehensive nature of the framework, aspects such as regulatory decision-making biases, retail investor needs, financial education, market manipulation, innovation impact, and international coordination warrant further exploration and clarification. By addressing these behavioral finance and public policy concerns, the regulation's effectiveness in achieving its objectives can be enhanced, with particular emphasis on investor protection, financial literacy, and promoting innovation.

4.2.2 Regulated markets, lateral exchange markets, decentralized exchanges and trust in intermediating technology platforms

As centralized crypto exchanges (CEX) have the problem of requiring 323
traders to deposit assets on an exchange, through which users relinquish direct control over their assets and place trust in the exchange operator, decentralized exchanges (DEX) have gained traction as deceptive or incompetent centralized exchange operators or intermediaries may seize or misplace assets. This creates a single point of vulnerability and an ongoing risk of being targeted by malicious third parties (Schär, 2021). Before delv-

ing into the intricacies of peer-to-peer based decentralized exchanges, let's first have a look at conventional regulated markets and trading facilities.

4.2.2.1 Traditional regulated markets

324 On a regulated market or trading facility the buying and selling interests with regard to financial instruments are brought together. The matching or aggregation of interests in relation to financial instruments requires three elements. The first criterion is that an intermediary, for example, the operator of a multilateral trading facility (MTF) or organized trading facility (OTF) acts as an intermediary between the participants buying and selling interests. This intermediary is interposed in a way that, during the execution of the transaction, there is no exposure to any market risks and execution takes place simultaneously. The intermediary thus acts as a risk-free intermediary (risk component based on the multilateral intermediation). The second essential characteristic focuses on a temporal element, whereby both processes – the purchase and sale orders – are executed simultaneously and are final. The often-cited so-called atomic swaps akin to decentralized exchanges thus *de iure* also exist in traditional markets and trading venues. The EU Settlement Finality Directive (98/26/EC; ELI: http://data.europa.eu/eli/dir/1998/26/oj) aims to ensure that once a transaction has been entered into the system, it cannot be unwound, reversed or challenged by a third party and is also unaffected by insolvency. With regard to the third and final element, the transaction must be concluded by the intermediary in such a way that, apart from a transparently communicated commission or fee for the transaction, no profit or loss is generated from the transaction itself (element of remuneration) (Art 4 no 1(38) MiFID II; Bergt 2020, p. 238).

325 An exemplary transaction on a trading facility typically looks like this (Bergt, 2020, p. 228 et seq.; Bergt, 2021b, p. 55):

1. A commercial transaction is concluded between two trading members (authorized financial intermediaries) on a multilateral trading facility (MTF) through the MTF's trading platform, possibly to fulfill an underlying order from an end customer (economic buyer or seller).
2. The transaction (the aggregated interests) is transmitted by the MTF to the clearing house (central counterparty; CCP).
3. Clearing takes place between the clearinghouse and the clearing members.

4. A reconciliation is made between the clearing members and the trading members (determination of reciprocal claims).
5. The clearinghouse (CCP) sends instructions to the settlement platform (central securities depository or CSD).
6. The settlement platform (CSD) then effects the actual transfer of the financial instruments involved in the transaction and also ensures the actual transfer of the corresponding funds; settlement takes place on a book-entry basis (dematerialized financial instruments).
7. Finally, there is a reconciliation between the members of the CSD and the clearing members.

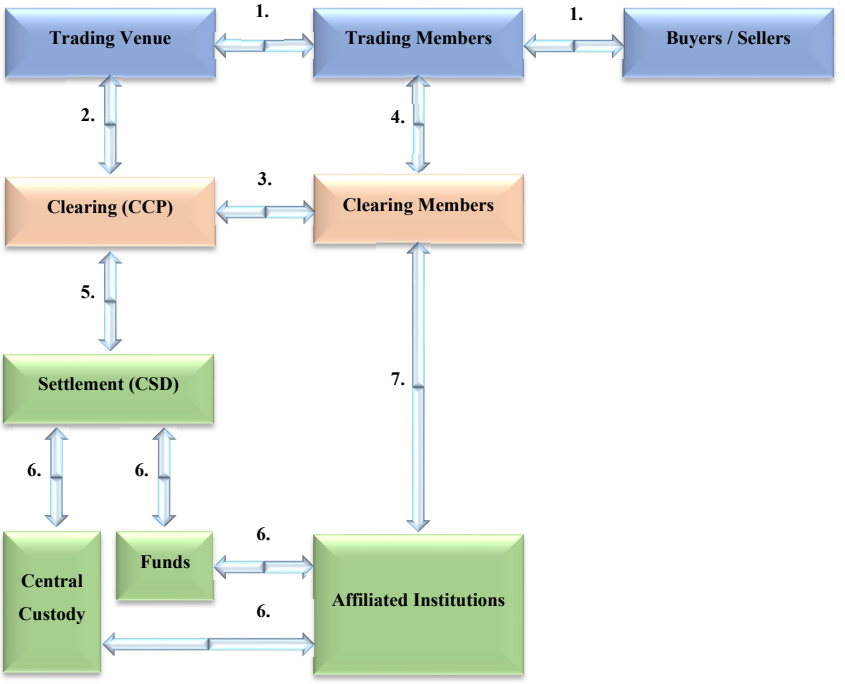

Figure 5: Trading facility or stock exchange functioning based on Bergt (2020, p. 228; 2021b, p. 55).

In contrast to this, truly decentralized, technological exchange platforms allow peers to directly participate on exchanges and initiate their own trades. Peers on such a DEX maintain sole authority over their assets up until the trade is settled, which occurs through a smart contract, thus 326

also mitigating counterparty credit risk (Schär, 2021). Through distributed ledger technologies, it may be possible to at least partially replace the many required intermediaries due to existing regulatory complexity by technology (intermediating technology platforms) to prevent market failures and to lower costs (Bergt, 2020, p. 244). However, it should not be overlooked that, economically speaking, crypto markets are still inefficient markets that allow for arbitrage trading and market manipulation as found by Griffin and Shams (2020), which should be mitigated on a public policy level as previously pointed out under chapter 4.1.4: *"By mapping the blockchains of Bitcoin and Tether, we are able to establish that one large player on Bitfinex uses Tether to purchase large amounts of Bitcoin when prices are falling and following the printing of Tether. Such price supporting activities are successful as Bitcoin prices rise following the periods of intervention. Indeed, even 1% of the times with extreme exchange of Tether for Bitcoin have substantial aggregate price effects. The buying of Bitcoin with Tether also occurs more aggressively right below salient round-number price thresholds where the price support might be most effective […]. Overall, our findings provide support for the view that price manipulation can have substantial distortive effects in cryptocurrencies. Prices in this market reflect much more than standard supply/demand and fundamental news. These distortive effects, when unwound, could have a considerable negative impact on cryptocurrency prices. More broadly, these findings also suggest that innovative technologies designed to bypass traditional banking systems have not eliminated the need for external surveillance, monitoring, and a regulatory framework as many in the cryptocurrency space had believed. Our findings support the historical view that dubious activities are associated with bubbles and can contribute to further price distortions.*"

4.2.2.2 Trust in intermediating technology platforms

327 Schär (2021) argues that decentralized exchange protocols remove the trust requirement by allowing users to retain sole control over their assets until the trade is completed. While no trust in a financial intermediary is required anymore it may be argued that a shift of trust in intermediating technology platforms may take place, which has to be assessed more deeply.

328 Blockchain has been considered as an intermediating technology that can facilitate disintermediation and enable true peer-to-peer transactions in sharing economy contexts, provided sufficient trust is built (Mehrwald et al., 2019; Hawlitschek et al, 2018; Bergt, 2021a). However, it should be noted

that trust in intermediaries is not entirely obsolete and that a completely trust-free system is likely an illusion (Hawlitschek et al., 2018).

The sharing economy or lateral exchange market (LEM) as defined 329
under chapter 4.1 is characterized by a system of trade and exchange that ideally generates added value to the parties involved (Belk, 2014a; Belk, 2014b; Mehrwald et al., 2019; Bergt, 2021a), has evolved to incorporate internet-based platforms that facilitate lateral exchange markets (LEMs), which are intermediating technology platforms connecting equivalently positioned economic actors (Perren and Kozinets, 2018; Mehrwald et al., 2019). These LEMs enable bilateral exchanges, such as human-to-human or human-machine-human transactions and have the potential to replace financial intermediaries in the form of intermediating technology platforms for example based on smart contract systems on blockchains (Bergt, 2020, p. 248; Mehrwald et al., 2019).

However, the utilization of blockchain technology for such purposes 330
raises legal and regulatory questions as already pointed out and also when dealing with tokenized securities and financial instruments (Bergt, 2020, p. 377; Bergt 2021a; Bergt et al 2019, p. 117). Furthermore, while blockchain may reduce regulatory and transaction costs, it still faces challenges related to slow transaction speeds, scalability, and the potential high costs of development and implementation (Bergt, 2021a). Ultimately, trust remains a critical aspect of adopting blockchain-based systems in sharing economies (Mehrwald et al., 2019).

According to Blau (2017), economic institutions like impersonal markets 331
and contracts are designed to separate exchange concerns and specify obligations, allowing for rational calculations. In contrast, social exchange involves unspecified obligations that depend on trust for fulfillment, as they cannot be enforced without a binding contract (Blau, 2017). Established economic institutions and contractual relationships create trust, while inefficient markets, legal shortcomings, and unenforceable agreements undermine it.

Trust refers to a collection of beliefs between individuals which include 332
qualities such as benevolence, integrity, sincerity, honesty, competence, expertise, and predictability, or a willingness to be vulnerable to others' actions (Dakduk et al., 2020 with further references). Mehrwald et al. (2019) explain that trust represents behavioral intentions that increase vulnerability to other parties under conditions of interdependence and vulnerability, given trustworthiness (also compare Bergt, 2021a). Trust is essential in lateral exchange markets, including blockchain-based markets,

because transactions between parties typically occur only once, with no ongoing business relationships (Gefen & Straub, 2004).

333 In peer-to-peer markets, trust is considered the currency, as it is one of the most important factors for participation, platform success, and transaction completion and fulfillment (Hawlitschek et al, 2016a; Strader and Ramaswami, 2002, quoted after Mehrwald et al., 2019). Trust also plays a critical role in intermediating technology platforms such as blockchain-based platforms, a decentralized peer-to-peer markets built upon them. Trust is generally viewed as the most effective mechanism for reducing complexity and vulnerability (Corbitt et al., 2003; Bergt, 2021a).

334 In traditional business-to-consumer commerce, the primary trust target is the vendor (vertical trust level) and the product. In peer-to-peer markets, new trust targets emerge, and others take on more significant roles. Trust in peers (similar to a vendor but on a horizontal trust level) becomes a new target, while trust in the platform gains a more independent character from trust in the traditional vendor (Hawlitschek et al., 2016b; Bergt, 2021a; Mehrwald et al., 2019).

335 Gefen (2000) posits that consumer trust in an e-commerce vendor depends on the perceived trustworthiness of the vendor, based on Luhmann's (1979) concept of trust as a social complexity-reducing mechanism (as quoted pursuant to Gefen and Straub, 2004). This mechanism involves a willingness to depend on a vendor, assuming they will fulfill their obligations (Gefen and Straub, 2004). This model can be applied to peer-to-peer markets, where more recent studies by Costello and Reczek (2020) reveal that peer-focused marketing increases consumers' willingness to pay, as they empathize with the provider, a phenomenon they refer to as the "empathy lens." This willingness to pay also indicates trust in the peer, although the studies focused on a marketing perspective (Bergt, 2021a).

336 The concept may be extrapolated from centrally operated peer-to-peer markets to intermediating technology platform economies, although further research in this area is necessary to solidify this notion. The transition from centrally operated markets to intermediating technology platforms, such as those utilizing blockchain technology, involves a shift in trust dynamics that warrants further investigation (Bergt, 2021a).

337 The role of trust in intermediating technology platforms is critical, as these platforms intersect with peer-to-peer markets, and trust in the platform significantly impacts the users' willingness to engage in transactions (Hawlitschek et al., 2016a; Strader and Ramaswami, 2002; Mehrwald et al., 2019; Bergt, 2021a). Trust in the platform is regarded as a predictor

of trust in peers (Mehrwald et al., 2019), which implies that users' level of platform trust significantly affects their trust in other users within the platform ecosystem.

The fundamental elements of trust can be categorized into ability, integrity, and benevolence. Ability encompasses a platform's capacity to effectively, securely, and reliably match buying and selling interests of participants, process transactions, and offer an intuitive graphical user interface (Hawlitschek et al., 2016c; Bergt, 2021a). Integrity and benevolence address aspects such as fees, data privacy, order authenticity, and potential user support (Mehrwald et al., 2019). 338

In the context of intermediating technology platforms, trust in the platform may replace trust in other peers (vendors) with regard to ability, integrity, and benevolence since transactions are executed through pre-defined rules encoded in smart contracts. Consequently, the trust required for the intermediating technology platform, or trust in technology, would be greater (Bergt, 2021a based on Mehrwald et al., 2019). Further evidence is required to test this thesis. 339

Moreover, trust in peer networks can also be generated without traditional intermediaries, through a phenomenon referred to as "*consociality*" (Mehrwald et al., 2019). Pursuant to Perren and Kozinets (2018) consociality refers to the presence of social participants within a network – physically or virtually – which may offer a chance for social engagement between these individuals. Consequently, trust among equivalent economic actors may rely on structural assurances and intermediation in peer-to-peer markets. Thus, intermediating technology platforms can enhance consumer trust by ensuring that providers will not engage in opportunistic betrayal (Perren and Kozinets, 2018; Bergt, 2021a). 340

According to Comer et al. (1999), product trust is the conviction that a product or service will perform its intended functions as perceived by the purchaser. In sharing economy platforms, products are typically presented in digital environments, and on intermediating technology platforms, the product is often virtual (e.g., tokens representing rights or values). Consequently, the product must exhibit the agreed-upon and promised attributes (Bergt, 2021a). Hawlitschek et al. (2016b) suggest that trust related to the product plays a unique role in the context of consumer to consumer (C2C) sharing economy platforms. 341

While blockchain technology is not inherently "trust-less," it may act as a mediator with an effect on trust (institution-based trust and trust in peers) in peer-to-peer markets, influencing both structural assurance beliefs and 342

opportunistic behavior. Although intermediating technology platforms may be able to significantly impact trust creation and perception, trust in the platform (institution-based trust) is still necessary for incentivizing consumption intentions or market interaction, this arguably holds true for the settlement layer, asset layer and protocol layer on the one side as well as the application and aggregation layer (as centralized interfaces or bridges between centralized and decentralized systems) pursuant to Schär's (2021) DeFi architecture as described in chapter 4.1.3. Issues such as programming errors in smart contracts, malicious activity exploiting faulty code, slow transaction speeds, and scalability problems may diminish trust in these platforms.

343 Although blockchain technology may replace trust in intermediaries to some extent by shifting it to trust in the platform, it is essential to recognize that trust in technology is still required for peer-to-peer markets, such as blockchain-based systems or lateral exchange markets based thereupon. Further research is needed to understand trust mechanisms and effects in and on peer-to-peer markets in the form of blockchain-based decentralized technology platforms, and the role of "*trusted interfaces for blockchain-based sharing economy ecosystems*" as it was called by Hawlitschek et al. (2018).

344 Trust mechanisms should be further analyzed also with regard to the different layers of the DeFi architecture, the bridging-role intermediaries play between centralized and decentralized finance, true DeFi and also decentralization shams. Even with regard to truly decentralized levels of a platform, peers participating on it are willing to be vulnerable to others' actions as truly decentralized layers of a decentralized architecture may still be prone to errors etc and it may thus be argued that trust will always play a role throughout the DeFi architecture – where there is the opportunity of consociality – a chance for social engagement – there will be trust.

4.2.2.3 Lateral exchange markets in the form of blockchain-based decentralized exchanges (DEX)

345 A need exists for platforms where individuals can exchange their digital assets, enabling them to modify their holdings based on their preferences and risk tolerance, as well as adjusting their portfolio distribution. Typically, transactions involving crypto assets take place through centralized exchanges, which offer relative efficiency but also have certain disadvantages. In order to trade on a centralized platform, participants must first

transfer their assets to the exchange, relinquishing direct control over their assets and placing their trust in the centralized financial intermediary, the exchange operator. This scenario exposes traders to potential risks, including asset confiscation or loss due to dishonest or incompetent exchange operators, and the vulnerability of centralized exchanges to malicious actors targeting them as a single point of attack (Schär, 2021).

346 Decentralized exchange protocols aim to address these. Users are not required to transfer their funds to a centralized exchange and maintain sole possession of their assets until the transaction is completed. The trade is executed atomically (instead of on a quid pro quo basis where the respective consideration is exchanged consecutively step by step) which carries out both sides of the transaction in a single, inseparable operation, thus reducing counterparty credit risk. Depending on the specific implementation, the smart contract can take on additional functions, making many intermediaries, such as escrow services, central counterparty clearinghouses (CCPs), and central securities depositories (CSDs), obsolete (Schär, 2021; Bergt, 2020, p. 244).

347 Initial decentralized exchanges, like EtherDelta, functioned as isolated systems with no interoperability between different implementations. They lacked shared liquidity, leading to low trading volumes and wide bid/ask spreads, high network fees, and inefficient processes for transferring funds among decentralized exchanges. However, a recent shift towards open exchange protocols has improved the structure of decentralized exchanges by establishing standards for asset trading, allowing exchanges built on these protocols to access shared liquidity pools and other protocol functionalities. Crucially, other DeFi protocols can utilize these marketplaces to exchange or liquidate tokens when necessary (Schär, 2021).

348 Schär (2021) compared various types of decentralized exchange protocols, including decentralized order book exchanges, constant function market makers (CFMMs), smart contract-based reserve aggregation, and peer-to-peer (P2P/OTC) protocols. Decentralized order book exchanges can be designed using various methods, characterized by either on-chain or off-chain order books. On-chain order books are fully decentralized, with each order being stored in the smart contract. However, this approach necessitates a blockchain transaction for every action, resulting in higher costs and slower processing. Off-chain order books, on the other hand, are managed and updated by centralized third parties known as relayers. These relayers supply takers with the necessary information to choose an order

they wish to match. The predominant protocol using this approach is 0x (Warren & Bandeali, 2017, Schär, 2021).

349 Constant Function Market Makers (CFMMs) are liquidity pools within smart contracts that hold a minimum of two crypto assets in reserve, permitting users to deposit tokens of one kind and withdraw tokens of another kind. Examples of such platforms include Balancer, Bancor, UniSwap and Curve (Schär, 2021).

350 Smart contract-based reserve aggregation brings together liquidity reserves through a smart contract, allowing major liquidity providers to join and offer prices for specific trading pairs. Kyber Network is a notable example of this approach (Luu & Velner, 2017; Schär, 2021).

351 Peer-to-peer (P2P) protocols, also referred to as over-the-counter (OTC) protocols, utilize a two-step method in which participants search the network for counterparties to trade a specific pair of crypto assets, then negotiate the exchange rate between themselves. After agreeing on a price, the transaction is executed on-chain through a smart contract. AirSwap, proposed by Oved and Mosites (2017), is the most well-known implementation of a decentralized P2P protocol (Schär, 2021). This approach offers a more efficient and secure trading environment by facilitating bilateral negotiations between parties and executing trades through smart contracts. Distinct from other protocols, offers can only be accepted by the negotiating parties, which prevents third-party frontrunning by monitoring the pool of unconfirmed transactions (mempool). To enhance efficiency, the process is typically automated, and off-chain indexers can be used for peer discovery, acting as directories for advertising particular trading intentions. It is essential to point out that these indexers only facilitate connections, with prices still being negotiated on a peer-to-peer basis (Schär, 2021).

4.2.2.4 DLT Pilot Regime

352 The European Commission's pilot regime on market infrastructures based on distributed ledger technology (DLT Pilot Regime; Regulation (EU) 2022/858; ELI: http://data.europa.eu/eli/reg/2022/858/oj) is part of a broader digital finance package aimed at facilitating and advancing digital finance's potential while mitigating risks. This package is in line with the Commission's priorities to make sure that the EU embraces and drives the digital revolution with forward-thinking European businesses at the vanguard, benefiting European consumers and businesses pursuant to the initial proposal's explanatory memorandum. This pilot regime is accompanied

by other legislative proposals addressing crypto-assets, digital operational resilience, and amendments to certain EU financial services rules (Proposal DLT Pilot Regime, (COM/2020/594 final; 2020/0267 (COD)), European Commission explanatory memorandum).

353 One of the identified priority areas in the digital finance strategy is to guarantee that the EU's financial services regulatory framework supports innovation and does not hinder the adoption of new technologies. The pilot regime, in conjunction with MiCAR, seeks to provide appropriate consumer and investor protection, establish legal certainty for crypto-assets, facilitate the use of blockchain, DLT, and crypto-assets by innovative firms, and maintain financial stability (Proposal DLT Pilot Regime, explanatory memorandum).

354 The DLT pilot regime aims to establish legal certainty, promote innovation, ensure consumer and investor protection, and maintain financial stability. Moreover, the pilot regime aligns with the Union's policies aimed at creating a Capital Markets Union (CMU), as it addresses the underused potential of crypto-assets and calls for increased legal certainty and clear rules for their use. The DLT pilot regime, based on Article 114 of the Treaty on the Functioning of the European Union (TFEU), seeks to enable experimentation through exemptions for using DLT in the trading and post-trading of crypto assets that qualify as financial instruments, where current legislation excludes or limits their use. Introducing a unified EU pilot regime for the experimentation of DLT market infrastructures would allow firms within the EU to maximize the existing framework's potential. This regime is designed to eliminate regulatory barriers that could hinder the growth of DLT market infrastructures, potentially driving the transition to tokenized financial instruments and DLT market infrastructures, fostering innovation, and bolstering the global competitiveness of the EU. The European Commission deems the pilot regime approach the most proportional to the objectives for the time being, given the lack of substantial evidence supporting more extensive, lasting alterations to the current financial services infrastructure to accommodate DLT usage. (Proposal DLT Pilot Regime, explanatory memorandum).

355 The DLT pilot regime in general aimed to enable a DLT or blockchain-based market infrastructure equivalent to the one depicted in figure 5 above for investment firms and market players (stock exchange for security tokens). The pilot regime seeks to enable the development of a secondary market that is more secure and dependable for crypto-assets qualifying as financial instruments, ensure consistency and a level playing field across

the EU, and permit actual use cases to aid in accumulating the expertise and data required for enacting a definitive EU regulatory structure.

356 crypto assets are classified as financial instruments under MiFID II, the existing EU financial services legislation was not crafted with DLT and crypto assets in consideration. The tokenization of financial instruments presents potential efficiency enhancements in trading and post-trading areas, yet the lack of market infrastructures utilizing DLT impedes the sustainable expansion of the primary market for these crypto assets. This regime allows temporary exemptions from certain requirements under the Union's financial services legislation that may otherwise hinder the development of DLT-based solutions for trading and settling transactions involving crypto assets representing securities (Proposal DLT Pilot Regime, recitals 3-5).

357 The pilot framework introduces a DLT market infrastructure that can be either a DLT securities settlement system or aDLT multilateral trading facility (DLT MTF). A DLT MTF is a multilateral trading facility administered by an investment firm or market operator authorized under MiFID II. It is subject to all provisions and standards imposed by EU financial services legislation on a multilateral trading facility, except when granted exemptions by its national competent authority. Given the potential of DLT to streamline trading and settlement activities, a DLT MTF should be allowed to perform certain activities typically performed by central securities depositories (CSDs) when granted relevant exemptions. A DLT securities settlement system on the other hand is a system for settling financial instruments maintained by a CSD authorized pursuant to the CDSR (Central Securities Depositories Regulation) and granted specific permissions under the pilot framework (Proposal DLT Pilot Regime, recitals 7-10).

358 Incorporating distributed ledger technology (DLT) in the financial landscape has the potential to streamline and integrate trading and settlement processes almost in real-time, allowing consolidation of trading and post-trading services and activities. Nevertheless, current regulations do not account for such combinations, focusing on risk specialization and unbundling to encourage competition. The pilot regime is not supposed to be a justification for a complete overhaul of the financial market infrastructure landscape or the separation of trading and post-trading activities. Nonetheless, due to the potential advantages offered by DLT in combining trading and settlement, the pilot regime also introduces a dedicated DLT market infrastructure known as the DLT TSS (DLT Trading and Settlement System). A DLT TSS can be either a DLT MTF (DLT Multilateral Trading

Facility) that combines the services of a DLT MTF and a DLT SS (DLT Securities Settlement System) or a DLT SS that combines these services and is operated by a CSD (Central Securities Depository) with specific permission under the pilot regime. Given the unique nature of a DLT TSS, investment firms or market operators and CSDs must comply with additional requirements (DLT Pilot Regime, recitals 14--17). The pilot regime may thus be seen as a regulatory sandbox trial run to harness the potential advantages of DLT trading and settling systems and gain experience for all market participants while doing so.

359 To maintain financial stability and foster innovation within a sound regulatory environment, tokenized transferable securities are limited to illiquid shares and bonds for DLT MTFs or DLT securities settlement systems under the pilot regime and they are not to admit sovereign bonds. Furthermore, no sovereign bonds may be listed for trade on DLT market infrastructures, and they may not be recorded on the distributed ledger (Proposal DLT Pilot Regime, recital 12).

360 A DLT MTF may request temporary exemptions from regulation otherwise required by traditional regulated markets or MTF, from the competent authority, provided it meets the conditions and additional requirements associated with such exemptions to address new risks arising from DLT usage. Financial instruments traded on an MTF are to be registered with an authorized Central Securities Depository (CSD) under CSDR. However, recording and settling transactions on a distributed ledger may impose redundant overlays on the trade lifecycle of financial instruments managed by a DLT market infrastructure. Therefore, DLT MTFs may seek exemption from the book-entry requirements and recording with a CSD if it meets equivalent requirements applicable to a CSD (Proposal DLT Pilot Regime, recitals 14-15).

361 DLT MTFs must ensure simultaneous payment and delivery of DLT transferable securities (delivery versus payment) (compare already Bergt, 2020, p. 168, FN 394). Cash transactions shall be settled with money from the central bank when practicable and available; otherwise, commercial bank money, settlement coins (tokenized commercial bank money), or e-money tokens. DLT MTFs must also limit counterparty risk by establishing strict criteria for credit institutions used for cash payment settlements. Under the upcoming MiFID III, a DLT MTF can request a temporary derogation from intermediation obligations and provide access to retail investors (a standard MTF is only allowed to provide access to participants which are institutional financial intermediaries), provided adequate

investor protection safeguards are in place and retail investors are fit and proper preventing money laundering and terrorism financing purposes (Proposal DLT Pilot Regime, recitals 16-17).

362 DLT market infrastructures must meet additional requirements compared to traditional market infrastructures to mitigate risks arising from DLT usage or the novel way in which they carry out their activities. Permissions and exemptions are granted on a temporary basis, lasting six years maximum from the date of the specified authorization, while competent authorities can withdraw specific permissions or exemptions if a flaw is discovered in the underlying technology (Proposal DLT Pilot Regime, recitals 27-37).

363 In conclusion, the DLT pilot regime aims to foster innovation in distributed ledger technology within the financial sector while ensuring market stability and investor protection. It aims to provide a regulatory framework that accommodates emerging technologies without stifling growth. Behavioral finance may play a role in understanding the adoption and risk-taking behavior of market participants in this context. As always, avoiding bad regulation is crucial, as it allows for a balanced approach that supports innovation while mitigating potential risks, promoting financial stability, and maintaining a level playing field for all market participants.

364 From a behavioral finance and public policy perspective, the discussion of the DLT pilot regime can be critiqued on several fronts. The introduction of DLT market infrastructures may lead to the emergence of new systemic risks if not adequately monitored and managed. These risks could stem from the interconnectedness of DLT market infrastructures with traditional financial institutions or the potential for technological issues to cascade across markets. Systemic risks refer to the potential for failures in one segment of the decentralized ecosystem to cascade and disrupt the broader financial system. The interconnected nature of decentralized platforms can magnify these risks, as the failure of a single platform or smart contract may have far-reaching consequences.

365 On another note, as it is a pilot regime overemphasis is put on potential flaws and risks. The focus on withdrawing specific permissions and exemptions in case of flaws or breaches in the underlying technology might discourage innovation and experimentation in the DLT space. Instead, it is recommended to encourage a proactive and constructive approach to resolving issues, promoting continuous improvement and learning, rather than solely focusing on punitive measures. There is also insufficient focus on investor behavior as the discussion does not adequately address how

investor behavior might be influenced by the introduction of DLT market infrastructures and the associated risks, such as potential herd behavior, overconfidence, or panic selling in the face of technological issues, which is not the case for traditional regulated markets or MTF on which as no retail investors are allowed on these market infrastructures in contrast to a DLT MTF. To mitigate issues in this regard, behavioral finance insights, focusing on investor education, disclosure requirements, and other mechanisms to encourage responsible investment behavior, may be implemented into the design of the DLT pilot regime.

Furthermore, there is also uncertainty regarding the post-pilot period. 366
The discussion leaves open various possibilities for the future of the DLT pilot regime, including extension, modification, or termination. This uncertainty could create hesitancy among market participants to fully commit to DLT market infrastructures. Clearer indications of the potential outcomes and criteria for evaluating the success of the pilot regime, reducing uncertainty and facilitating long-term planning for market participants, should be provided in this regard.

While from a behavioral finance perspective, the DLT pilot regime ac- 367
knowledges the growing importance of distributed ledger technology in the financial sector and aims to create a regulatory sandbox for fostering innovation, it is crucial to consider the implications of this regime on market participants' decision-making, risk-taking behavior, and adoption of new technologies.

The DLT pilot regime may create an uneven playing field between regu- 368
lated DLT market infrastructures (DLT MTF or DLT securities settlement systems) and non-regulated DeFi platforms like decentralized exchanges (DEX) or lateral exchange markets (LEM). While the pilot regime intends to provide a controlled environment for DLT-based systems, it might inadvertently incentivize market participants to favor less-regulated DeFi platforms, leading to potential financial instability. To address this concern, regulators should ensure that the DLT pilot regime is flexible and adaptable, allowing for a level playing field between centralized and decentralized platforms. This not only involves continuous monitoring of the market and the regulation along with reporting pursuant to article 10 of the DLT Pilot Regime, but also periodic revisions of the regulatory framework based on the industry's evolution.

Lastly, cognitive biases as well as heuristics may impact the decision- 369
making process of market participants engaging with DLT-based systems as already previously pointed out. This might lead to excessive risk-taking

or an irrational preference for decentralized platforms over regulated ones. Policymakers should consider incorporating investor education and awareness initiatives to mitigate the influence of such biases.

4.2.2.5 Interim conclusion

370 While centralized crypto exchanges (CEX) require users to relinquish direct control over their assets, decentralized exchanges (DEX) have emerged as an alternative, allowing users to maintain control through peer-to-peer transactions. Traditional regulated markets involve multiple intermediaries for transactions, whereas decentralized exchanges use distributed ledger technologies and smart contracts to mitigate risks and reduce costs. Despite the potential advantages of DEXs, crypto markets remain susceptible to inefficiencies, arbitrage trading, and market manipulation. As a result, it is crucial to recognize the need for continued surveillance, monitoring, and regulatory frameworks within the crypto market to address potential market failures and maintain a fair trading environment.

371 Decentralized exchange protocols and blockchain technology have the potential to reduce the need for trust in traditional financial intermediaries by allowing users to maintain control over their assets. However, trust remains a critical aspect of these systems, shifting towards intermediating technology platforms and peers within the sharing economy. The role of trust in these platforms significantly impacts users' willingness to engage in transactions and influences their trust in other users within the ecosystem. Trust in the platform (institutional trust) encompasses aspects such as ability, integrity and benevolence, with blockchain technology potentially increasing trust in the platform while replacing trust in peers (or vendors due to a shift of vertical trust to a horizontal trust model). Despite these advancements, trust remains essential for peer-to-peer markets like blockchain-based systems or lateral exchange markets, like trust in technology or the platform. Further research is necessary to understand trust mechanisms and effects within blockchain-based decentralized technology platforms and the different layers of the DeFi architecture.

372 Lateral exchange markets in the form of blockchain-based decentralized exchanges (DEX), while having drawbacks themselves, are more inclusive as they are generally open to anyone, they allow users to maintain control over their assets throughout the trade process and they are rendering at least some of the traditional intermediaries unnecessary. DeFi market infrastructures are still less efficient than traditional markets, yet they manage

to handle certain aspects better than centralized markets and offer other opportunities, some maybe still unthought of at the moment. As with most disruptive innovations DeFi markets may be overestimated in the short term and underestimated in the long term due to potential exponential growth of performance. If this was the case, now might be the sweet spot for financial intermediaries and other financial market players to cannibalize their own business and expand their DeFi capabilities pursuant to Christensen's (1997) innovators dilemma.

While early decentralized exchanges faced limitations, such as low transaction volumes and high network fees, the development of open exchange protocols has improved liquidity and streamlined the trading process. Various types of decentralized exchange protocols have been implemented, including decentralized order book exchanges, smart contract-based reserve aggregation, constant function market makers, and peer-to-peer (P2P/OTC) protocols. Each of these approaches offers unique advantages, with the overall goal of providing a more secure, efficient, and decentralized trading environment. 373

In line with public policies on financial markets, the European Commission's DLT Pilot Regime is part of a broader digital finance package aimed at fostering innovation in distributed ledger technology (DLT) within the financial sector while ensuring market stability and investor protection. This initiative seeks to provide legal certainty, support innovation, and maintain financial stability by allowing experimentation with DLT in trading and post-trading of crypto assets that meet the criteria to be considered securities. The pilot regime is intended to facilitate the development of DLT market infrastructures, potentially catalyzing the shift to tokenized financial instruments and bolstering the EU's global competitiveness. 374

While the pilot regime aims to balance innovation with risk mitigation, it may be critiqued for overemphasizing potential flaws and risks and their regulation, which may discourage innovation and experimentation in the DLT space. Additionally, there could be more focus on investor behavior and the potential impact of DLT market infrastructures on market participants as DLT market infrastructures, due to their inherent inclusiveness, are in general open to anyone, while on centralized market infrastructures only institutional intermediaries or institutions may participate. To address these concerns, a more proactive and constructive approach to resolving issues, as well as incorporating behavioral finance insights, may be considered in the design of the DLT pilot regime, as behavioral biases and heuristics may impact investors' decision-making processes when engaging 375

with DLT market infrastructures, leading to excessive risk-taking or irrational preferences. Policymakers should consider incorporating investor education and awareness initiatives to mitigate the influence of such biases, ultimately promoting responsible investment behavior and stability in the financial sector.

376 Concludingly, the DLT Pilot Regime recognizes the significance of distributed ledger technology in the financial sector and aims to create a regulatory sandbox for innovation. However, the current discussion leaves open various possibilities for the future of the pilot regime, leading to potential uncertainty and hesitancy among market participants. Clearer indications of potential outcomes and criteria for evaluating the pilot's success should be provided to reduce uncertainty and facilitate long-term planning. From a behavioral finance perspective, the pilot regime's implications on market participants' decision-making, risk-taking behavior, and adoption of new technologies should be considered. There is a risk of creating an uneven playing field between regulated DLT market infrastructures and non-regulated DeFi platforms, which may inadvertently incentivize market participants to favor less-regulated platforms (DeFi markets) and lead to potential financial instability. Regulators should ensure that the DLT pilot regime is flexible and adaptable, allowing for a level playing field between conventional regulated markets and DLT trading facilities through continuous monitoring and periodic revisions of the regulatory framework.

4.2.3 Crowdfunding Services & emerging markets of DeFi lending

377 Crowdfunding, as a nascent and yet promising mode of finance, has caught global attention. It enables entrepreneurs to tap into a diverse pool of investors, democratizing access to funding and fostering innovation. Acknowledging this, the European Union (EU) introduced Regulation (EU) 2020/1503 on European crowdfunding service providers (ECSP) for business. The Crowdfunding Regulation provides a comprehensive legal framework for the operation of crowdfunding platforms within the EU. It encompasses two distinct types of crowdfunding: lending-based and investment-based. The former involves the offering of a direct loan agreement, whereas the latter involves transferable securities, including shares and bonds associated with the crowdfunding project.

378 To ensure investor protection and market transparency, the regulation introduces specific requirements for crowdfunding service providers. Key

among these are licensing obligations, operating conditions, transparency rules, and measures to manage conflicts of interest. Importantly, it also introduces a 'passporting' provision, allowing platforms authorized in one Member State to provide services across the entire EU. Crowdfunding service refers to the process of connecting investors and project owners for business funding through a crowdfunding platform. This service may include the following activities:

- Facilitating the provision of loans.
- Placing of transferable securities and admitted instruments for crowdfunding purposes without a firm commitment basis and the reception and transmission of client orders in relation to those financial instruments.

The Regulation applies to crowdfunding offers provided to businesses with a consideration of up to €5 million, calculated over a period of 12 months per project owner. It excludes offers directed exclusively to consumers. The primary objective of the Crowdfunding Regulation is to establish a harmonized and conducive environment for crowdfunding activities across the EU. By providing clear operational guidelines and investor protection measures, it seeks to enhance market integrity, foster cross-border crowdfunding activities, and enable the growth of innovative businesses. 379

Moreover, by addressing market fragmentation, the regulation facilitates the single market's completeness for financial services, aligning with the broader goal of building a Capital Markets Union (CMU) in the EU. signifies an important step in the EU's journey towards financial digitalization and democratization. 380

Following our discussion on traditional crowdfunding models, let us now transition into the realm of decentralized finance (DeFi) and its unique lending systems. In the DeFi ecosystem, loans are a crucial component with an extensive range of protocols that facilitate the lending and borrowing of crypto assets. Decentralized lending platforms are distinguished by their lack of identification requirements for both borrowers and lenders. This characteristic ensures unrestricted access to the platform for any individual seeking to either borrow funds or supply liquidity to generate interest (Schär, 2021). 381

To protect the lender's interests and deter the borrower from absconding with the money, two main approaches are utilized. First, credit can be granted with the stipulation that the loan is repaid atomically, meaning that the borrower receives, uses, and returns the funds within a single 382

blockchain transaction. If the borrower does not repay the money (along with interest) by the conclusion of the transaction's execution cycle, the transaction becomes void and its outcomes, including the loan, are reversed. These types of loans are commonly referred to as flash loans, which pose an intriguing yet highly experimental application with the potential to become an integral part of DeFi lending as they offer efficient instruments for arbitrage and portfolio restructuring (Schär, 2021).

383 Secondly, loans can be completely backed by collateral. This collateral is kept in a smart contract and is only freed when the debt has been settled. Collateralized loan platforms can be divided into three types: collateralized debt positions, peer-to-peer collateralized debt markets and pooled collateralized debt markets. Collateralized debt positions involve loans that use newly minted tokens, while debt markets employ existing tokens and require a pairing between a borrower and a lender (Schär, 2021).

384 DeFi applications offering collateralized debt positions enable individuals to generate and distribute new tokens that are backed by collateral. A user must lock crypto assets in a smart contract to generate these tokens. The creation of tokens is determined by the target price of the generated tokens, the value of the crypto assets acting as collateral, and the desired collateralization ratio. These freshly generated tokens effectively function as fully collateralized loans without the need for a counterparty, allowing individuals to acquire liquid assets while maintaining market exposure through the collateral (Schär, 2021).

385 This concept can be illustrated using MakerDAO as an example, a decentralized protocol that issues the USD-pegged Dai stablecoin. Initially, a user deposits ETH into a smart contract, known as a collateralized debt position (CDP) or vault. They then invoke a contract function to produce and withdraw a specific number of Dai, effectively locking the collateral. The current process requires a minimum collateralization ratio of 150 percent, which means that for every 150 USD worth of ETH secured in the contract, the user can create up to 100.00 Dai. Outstanding Dai is subject to a stability fee, theoretically corresponding to the maximum interest rate of the Dai debt market. This rate is determined by the community of MKR token holders, the governance token for the MakerDAO project. To close a CDP, the owner must repay the outstanding Dai and the accrued interest to the contract. Once the debt is settled, the smart contract allows the owner to withdraw their collateral. If the borrower defaults on the loan or the collateral's value falls below the 150 percent threshold, the smart contract initiates the liquidation of the collateral at a potentially discounted

rate (equivalent to the failure of meeting a margin call). Interest payments and liquidation fees contribute to the reduction of the total MKR supply by partially burning MKR. In return, MKR holders bear the residual risk associated with negative ETH price fluctuations, which could result in collateral being insufficient to maintain the USD peg. In such cases, fresh MKR tokens are minted and sold at a discounted price. Consequently, MKR holders have a vested interest in the system's stability and should strive to maintain a healthy ecosystem (Schär, 2021).

Borrowing existing crypto assets from others is another possibility of De- 386
Fi lending (collateralized debt markets), as opposed to creating new tokens (collateralized debt positions). This approach necessitates a counterparty with an opposed interest. To put it another way, in order to borrow ETH, someone else must be ready to lend ETH. All loans must be completely collateralized, with the collateral being secured in a smart contract to reduce counterparty risk and protect the lender. Various methods can be employed to match lenders with borrowers, generally falling into two categories: P2P and pooled matching. P2P matching entails liquidity providers lending crypto assets to specific borrowers, with lenders only earning interest upon successful matching. The benefit of this method is that the stakeholders can reach consensus on a fixed interest rate and a specified time period. Pooled loans, on the other hand, utilize variable interest rates influenced by market forces of supply and demand dynamics. After depositing their funds, lenders immediately start earning interest because all of their funds are combined into a singular smart contract-based lending pool. The utilization rate of the pool, however, governs interest rates. As a result, loans will be more inexpensive when liquidity is plentiful and more expensive when liquidity is scarce. The ability to change maturity and size while keeping a high level of liquidity for individual lenders is another benefit of lending pools (Schär, 2021).

Numerous lending protocols exist, including dYdX, Aave and Com- 387
pound. including Aave, Compound, and dYdX among the most well-liked examples. In the DeFi ecosystem as of September 2020, Dai accounted for over 75% of all loans. (Schär, 2021).

4.2.4 Decentralized derivatives – a growing trend in the DeFi ecosystem

Decentralized derivatives, which can be categorized into asset-based and 388
event-based derivative tokens, derive their value from a variety of sources

such as an underlying asset's performance, an event's result, or another variable. These derivatives often necessitate an oracle to monitor the variables in question, resulting in dependencies and centralized components; however, these dependencies can be mitigated by employing multiple independent data sources within the derivative contract (Schär, 2021).

389 Asset-based derivative tokens, a development of the collateralized debt position (CDP) model (cp. Chapter 4.2.3), have prices that function based on the performance of an underlying asset. These tokens can represent a range of assets, such as tokenized representations of shares, precious metals, or other crypto assets, and the risk of falling below a specific collateralization ratio increases with the underlying asset's volatility. Synthetix, a well-known derivative token platform, operates in a manner that allows the total debt pool of all participants to fluctuate based on the total price of all synthetic assets that are still outstanding, ensuring the fungibility of tokens with identical underlying assets. Inverse tokens, where the price is decided by an inverse function of the performance of the underlying asset within a given price range, are a notable example of asset-based derivative tokens, offering users short exposure to crypto assets (Schär, 2021).

390 On the other hand, event-based derivative tokens' prices depend on any observable variable not linked to an asset's performance. These tokens are founded on objectively observable variables with known potential outcomes, specified observation times, and resolution sources. By locking for example one ETH in a smart contract, users can purchase an entire set of sub-tokens for a given event, with each sub-token representing a potential outcome. The sub-tokens may then be exchanged individually, and upon market resolution, the crypto assets of the smart contract are divided among the winning outcome's sub-token holders. Consequently, without distortions in the market, the ETH price of each sub-token is supposed to match with the probability of the associated outcome (Schär, 2021).

391 Nonetheless, these event-based derivative tokens introduce external dependencies and potential vulnerabilities due to the reliance on the trustworthiness of the resolution source. Malicious reporters can unilaterally influence the tokens, with potential attack vectors involving inaccurate or deceptive question specifications, incomplete outcome sets that make the event irresolvable, and untrustworthy or fraudulent resolution sources.. In addition, these kinds of tokens may also be on the verge of gaming, and accordingly gaming regulation. Augur, a popular event-based derivative token implementation (Peterson et al., 2019), employs a multi-stage resolution and disputing process aimed at minimizing dependency on a single

reporting source. In cases where token holders disagree with the specified reporter, they can initiate a dispute that ultimately ought to bring about an accurate result (Schär, 2021).

4.2.5 DeFi portfolio management and investment schemes

On-chain asset management, akin to traditional portfolio management and investment funds, primarily serves the purpose of portfolio diversification, enabling individuals to invest in a collection of crypto assets and use various tactics without managing individual tokens. A key distinction between on-chain funds and their traditional counterparts is the absence of a custodian, with the crypto assets being held in a smart contract instead. This arrangement allows investors to retain control over their assets, liquidate or withdraw them, and monitor the token balances of the smart contracts at any moment (Schär, 2021). 392

Smart contracts employed in on-chain asset management can adhere to a range of simple strategies, such as semi-automatic portfolio weight rebalancing and trend trading using moving averages or rely on one or more fund managers for active management. In the latter scenario, smart contracts ensure that asset managers act in the investors' best interests and abide by the pre-defined strategy and risk profile established in the contract. Consequently, smart contracts can address numerous principal-agent issues and enforce regulatory requirements on-chain, potentially reducing fund setup and auditing costs (Schär, 2021). 393

Upon investing in an on-chain fund, an investor receives fund tokens issued by the corresponding smart contract, which signify partial ownership of the fund enabling token holders to redeem or liquidate their share of the assets. The fund tokens are burned, the underlying assets are traded on a decentralized exchange, and the investor receives the ETH equivalent of their share of the basket when they decide to exit their investment (Schär, 2021). This resembles the equivalent of the redemption of a fund share and the associated capital reduction in the case of a stock corporation with variable capital (SICAV) with regard to centralized finance. 394

There are multiple on-chain fund protocol implementations, such as the Set Protocol, etc, which are all limited to ERC-20 tokens and Ether and mainly rely on third-party protocols and price oracles. These dependencies can be quite significant (Schär, 2021). 395

4.2.6 The role of crypto asset mixers as privacy enhancing protocols and financial intermediaries

396 Contrary to popular belief, maintaining privacy on public blockchains is a challenging task. Despite their permissionless nature, such blockchains are entirely transparent, with all confirmed transactions being publicly visible as the history of the blockchain is accessible and recorded. Using pseudonymous addresses helps to hide the identities of users but privacy concerns remain prevalent. Should anyone manage to associate an individual with a specific blockchain address, that individual's entire transaction history and activities become observable ((Nadler & Schär, 2023).

397 So-called Crypto asset mixers or tumblers, also known as privacy-enhancing protocols, are a prevalent approach to achieving some degree of privacy on public blockchains. These mixers pool deposits from various persons, who then withdraw funds using new addresses without revealing the connection between deposit and withdrawal addresses. Consequently, such mixers remove the apparent connection between transactions (Nadler & Schär, 2023).

398 Although there are legitimate uses for privacy-enhancing protocols due to the transparency of public ledgers, evidence exists that these tumblers are employed in money laundering and concealing illicit activities. For instance, the Tornado Cash mixer has attracted regulatory scrutiny due to its association with funds originating from illegal activities. In August 2022, the OFAC (U.S. Treasury's Office of Foreign Asset Control) added the smart contracts of Tornado Cash on the SDN (Specially Designated Nationals and Blocked Persons) sanctions list, penalizing any engagement with the protocol (Nadler & Schär, 2023). This poses another possible, yet far reaching, way of regulating DeFi, by putting the respective protocols or smart contracts and anyone interacting with them under sanction. As this comes close to regulating or rather banning the technology or its applications and legit use cases remain, a more fine-grained and fine-meshed assessment at the level of users and their respective interaction with the protocol and the interactions economic background would seem a more reasonable and prudent approach.

399 In the realm of crypto asset mixers, differing levels of technological sophistication exist, ranging from the simplest custodial models to more complex non-custodial mixers. The custodial model relies on a centralized service provider to facilitate the mixing process, where individuals transfer assets to a public deposit address and privately specify a recipient address.

While seemingly functional, with custodial mixers users must rely on the service provider's fulfillment of obligations, proper handling of assets, and commitment to preserving privacy by eliminating identifying data (Nadler & Schär, 2023).

In contrast, non-custodial crypto asset mixers leverage distributed cryp- 400
tographic systems, allowing for the verification of a withdrawal's validity without revealing the link between deposits and withdrawals. As such, these mixers do not necessitate sharing identifying information and eliminate liquidity risks, since the funds are locked and inaccessible for other uses. Consequently, non-custodial mixers may function as an independent and immutable infrastructure, free from centralized control. A fundamental issue with non-custodial privacy enhancing protocols is balancing two opposing objectives: maintaining anonymity by not storing information linking deposits and withdrawals, while ensuring that only those who deposited crypto assets can initiate withdrawals and each deposit can be withdrawn only once. This can be achieved through smart contracts, hash functions, merkle trees and zkSNARKs (Nadler & Schär, 2023).

Hash functions serve as checksums and cryptographic fingerprints, map- 401
ping input data to fixed-length output. Crucial for ensuring data integrity and validating secret knowledge, hash functions must be one-way and collision-resistant, making it infeasible to find multiple inputs for a given output or derive input from output. Merkle trees address the inefficiency of using hash values to demonstrate an element's part of an input vector, providing more efficient means for hash-based integrity proofs. By hashing elements pairwise and iteratively until a single output value (the Merkle root) is obtained, Merkle trees enable efficient inclusion proofs, particularly for large input vectors (Nadler & Schär, 2023).

zkSNARKs (zero-knowledge, succinct, non-interactive argument of 402
knowledge) offer a means to demonstrate knowledge of a secret value without revealing it. These proofs are non-interactive, thus not requiring any direct interaction between the prover and the verifier, and succinct, allowing for efficient verification in terms of data size and verification time. A proof is considered to be zero-knowledge if it doesn't disclose any information beyond the fact that a statement is true, without revealing the secret value or any other related information. zkSNARKs have been applied in various privacy-enhancing technologies, including non-custodial crypto asset mixers like Tornado Cash, as a powerful tool for preserving anonymity within public blockchain networks (Nadler & Schär, 2023, with further references).

403 Users can thus present cryptographic evidence that their withdrawal transactions are linked to prior deposits without divulging the details of their transaction history. It is proposed by Nadler & Schär (2023) that through cryptographic proofs individual may protect their public chain privacy while maintaining compliance with regulatory requirements, such as AML and CFT measures by showing a financial intermediary the corresponding cryptographic proof, allowing analysis as if one had never used privacy enhancing protocols. Vice versa, this proof may not be provided in case it discloses the association with illicit activities. This may facilitate a balance between privacy and transparency, permitting legitimate users to preserve their anonymity while ensuring that malicious actors face significant challenges in using these technologies for illicit purposes (Nadler & Schär, 2023).

404 Regulated financial intermediaries won't accept the assets unless a client is able and willing to show evidence of its source. Similar to this, merchants that sell products or services beyond a set legal threshold are obligated by law to record these transactions and are strongly compelled to ask for proof of origin. Otherwise, they risk breaking the law and running into problems if they try to use assets for which they are unable to identify the source (Nadler & Schär, 2023).

Honest actors can partially maintain their anonymity as a result of this procedure, while dishonest actors must incur high search and matching costs to find a counterparty prepared to accept the assets without requesting proof of origin. This is analogous to how money transactions are processed. One must show confirmation of the moneys' origin in order to deposit larger sums of legal tender with financial intermediaries or utilize them to make large cash payments for goods or services. Due to their immutable transaction history, blockchain-based non-custodial crypto asset mixers provide easier and more trustworthy verification than cash transactions. (2023; Nadler & Schär).

405 A significant challenge arises when assets deposited in non-custodial crypto mixers may be withdrawn to any wallet without the possibility of rejection or blocking, even if the recipient (mentally) refuses to accept assets from a crypto mixer. Notably, it is illegal to accept money from sanctioned entities. Bad actors may exploit this by first sending assets to a sanctioned non-custodial crypto asset mixer and then withdrawing and forwarding these assets, in whole or in part, to other individual's wallets, making it impossible for observers to ascertain if the receiving party interacted with the protocol. Furthermore, individuals receiving assets this way cannot

prove their non-involvement since it is impossible to show that they do not possess the cryptographic proof (Nadler & Schär, 2023). Consequently, the burden falls upon the receiving party to take action and attempt to resolve the situation, while it is not their burden of proof and the legal principle *negativa non sunt probanda* may apply, which states that a party making a claim has the burden of providing evidence to support that claim, rather than the other party being required to prove that the claim is false.

406 One possible solution proposed by Nadler & Schär (2023) involves disposing of the tainted assets in a publicly observable manner, such as sending the same amount as the assets received to a recognized burning wallet on the blockchain—a wallet address for which the private key is in no one's possession. Although imperfect, as it still imposes mandatory measures and transactional fees on the receiver, this method may in theory at least prevent third parties from freezing other party's wallets or causing legal issues. The OFAC previously addressed this type of attack called "dusting" and stated that they will not prioritize enforcement regarding these transactions to unaware receiving parties. Since sellers have no control over the source of the assets they receive or the identity of the buyer, additional issues arise in smart contract protocols that function as open marketplaces with auctions or peer-to-peer sales. To mitigate this issue, marketplaces may need to restrict participants and only allow users with verified identities (Nadler & Schär, 2023).

407 Sanctions aim to prompt behavioral changes in sanctioned entities. However, smart contract systems are in general immutable by design and thus incapable of altering their functioning. In this context, sanctions effectively become a ban on the protocol. Since the code for smart contracts is publicly accessible on the blockchain, anyone can simply copy it and launch a fresh instance of any protocol at a different address, making regulatory efforts against particular smart contract addresses at best a band-aid solution. It can be difficult to tell if anything is a functioning copy of an approved protocol or a new implementation that needs additional inquiry and treatment, which makes minor code variations even more problematic (Nadler & Schär, 2023). Thus, regulating protocols or the technology itself does not seem to have a lot of merit, also considering that when exchanging crypto assets back to legal tender, in general, financial intermediaries will have to be approached, which in turn have to analyze the source of funds and conduct due diligence. For fraudulent activities and injured parties this may still pose a long and weary process due to non-optimized enforcement on a global level. In addition, any crypto assets stemming from fraudulent

activities may potentially be left untouched in a crypto tumbler for long periods of time, ultimately with the potential of ruining injured parties (e.g., causing insolvency) and raising concerns with regard to the statute of limitations for criminal liability of the perpetrator and the relative permanence of storage in smart contracts.

408 While non-custodial blockchain based tumblers or privacy enhancing protocols represent a disruptive development that demonstrates the potential of zero-knowledge proofs by offering good actors to keep their transaction history private while utilizing public blockchains in a manner similar to other electronic payment systems, the risks are substantial and should not be underestimated (Nadler & Schär, 2023). While regulating or banning the technology would be drastic and also does not seem to be an effective and viable solution, centralized financial intermediaries can be drawn to responsibility if they are involved when converting crypto assets to legal tender, which requires them to conduct due diligence duties on the source of funds, etc. However, non-optimized global enforcement may lead to lengthy processes for fraud victims. Crypto assets from fraud may also sit in tumblers for extended periods, potentially causing insolvency for affected parties and raising concerns about the statute of limitations for criminal liability due to quasi permanent storage in smart contracts.

4.2.7 DORA – digital operational resilience

409 The rapid digitalization of the financial sector has increased reliance on information and communication technology (ICT) systems while also heightening ICT risks, such as cyber threats and ICT disruptions. The European Systemic Risk Board (ESRB) (DORA, 2022, recital 3) highlighted that the interconnectedness and interdependencies of financial entities and ICT systems could lead to systemic vulnerabilities, enabling localized cyber incidents to spread throughout the entire financial system. Despite international and national initiatives, "*ICT risk continues to pose a challenge to the operational resilience, performance, and stability of the Union financial system.*" (DORA, recital 5). This has led to the enactment of Regulation (EU) 2022/2554 of the European Parliament and of the Council of 14 December 2022 on digital operational resilience for the financial sector (also known as digital operational resilience act or DORA; ELI: http://data.europa.eu/eli/reg/2022/2554/oj) which will be applicable early in 2025 pursuant to its article 64 (DORA, recitals 1-5).

The Single Rulebook and European system of financial supervision have not included an adequate framework with regard to ICT or operational risks, resulting in unharmonized national legislation. This has caused inconsistencies and challenges for financial institutions and intermediaries with international operations, which can hinder the smooth functioning of the internal market in financial services and distort competition between financial entities (DORA, recital 9). Considering the significant links between online and offline resilience of financial organizations, a consistent strategy for the robustness of such entities shall be established through DORA. Providers of cloud computing services are regarded as a subset of the digital infrastructure covered under DORA. All crucial ICT third-party service providers, including cloud computing service providers providing ICT services to financial firms, are subject to the Union Oversight Framework created under DORA (DORA, recitals 19-20). 410

The increasing reliance on outsourcing and the concentration of ICT third-party service providers has led to potential systemic risks in the financial sector, and national mechanisms have proven insufficient in equipping financial supervisors with appropriate tools to address such risks. To address these concerns, an Oversight Framework is being established, pursuant to which financial entities' essential ICT third-party service providers are continuously monitored while maintaining client privacy and security. Both intra-group and external provision of ICT services should be subject to the same regulatory framework, although the risk assessment should account for the higher level of control over intra-group providers (DORA, recitals 19-20). 411

Sharing threat and vulnerability intelligence among financial firms on a regular basis is essential for the efficient detection and prevention of ICT threats. The ability of financial firms to prevent and lessen the effects of ICT-related incidents is strengthened by increased awareness of cyber dangers. Such intelligence sharing has been hampered, nevertheless, by ambiguity regarding compliance with data protection, antitrust, and liability regulations. Additionally, the existing status of information sharing is constrained and dispersed, with the majority of exchanges of information being local and the absence of uniform Union-wide policies. Therefore, DORA's primary objective is to strengthen communication channels (DORA, recitals 32-33). 412

The Regulation addresses risks arising from all varieties of ICT services in an effort to maintain a high level of operational digital resilience for the financial sector. With rare exceptions, the definition of ICT services 413

is broad and includes digital and data services delivered regularly through ICT systems to internal or external consumers. (DORA, recital 35). Financial enterprises having less requirements or exemptions under sector-specific Union law, such as small, unaffiliated investment firms and other smaller institutions, are subject to a streamlined ICT risk management framework in accordance with the concept of proportionality (DORA, recital 42).

414 This Regulation encourages a balanced approach to addressing the risk of ICT third-party concentration by being adaptable and incremental. Financial institutions should carefully review their contracts to see whether there is a chance of concentration risk developing. This assessment should include in-depth evaluations of subcontracting agreements, especially when done with ICT third-party service providers based in a third country. (DORA, recital 67).

415 The Union's financial ecosystem is now intrinsically dependent on certain ICT services offered by ICT service providers due to the digital revolution of the financial services industry, which has resulted in an unprecedented level of use and reliance on ICT services. Given the extensive reliance on vital ICT third-party service providers and the interdependence of the information systems used by different market operators, there are direct and potentially serious risks to the Union financial services system should these providers be impacted by major cyber incidents or operational disruptions (DORA, recital 79).

416 Critical third-party ICT service providers should be able to offer ICT services from anywhere in the globe, not just from locations in the EU, according to the oversight framework. However, the Lead Overseer should be able to exercise their necessary oversight capacities in third countries, provided the crucial ICT third-party service provider in question consents and the competent third-country authorities concur (DORA, recital 83).

417 Competent authorities must refrain from adopting any individual actions to monitor the risks posed by crucial ICT third-party service providers in order to avoid duplications and overlaps and must instead rely on the judgment of the relevant Lead Overseer (DORA, recital 93).

418 In addition to DORA, the proposal for a Regulation of the European Parliament and of the Council on information accompanying transfers of funds and certain crypto-assets (recast) (TFR; COM(2021) 422 final, 2021/0241 (COD)) has been made which aims to establish a regulatory framework for enhancing the traceability and transparency of cross-border fund transfers and certain crypto-asset transactions. This proposal is designed to combat money laundering, terrorist financing, and other finan-

cial crimes by ensuring that financial institutions and crypto-asset service providers collect, retain, and transmit adequate and accurate information about the sender and beneficiary of transactions.

The recast proposal seeks to update and streamline existing regulations, 419
taking into account the rapidly evolving financial landscape and the emergence of new technologies, such as cryptocurrencies and other digital assets. By doing so, the regulation aims to strengthen the overall anti-money laundering and counter-terrorism financing (AML and CTF) framework within the European Union.

From a behavioral finance and regulatory public policy perspective, the 420
discussion on the Digital Operational Resilience Act (DORA) raises several points that warrant further analysis, as the critical role of behavior in determining the effectiveness of risk management in cybersecurity practices with regard to ICT should be recognized in order to design strategies that influence the decision-making process and incorporate nudge-based interventions that promote desirable behaviors among financial entities and individuals. This could include simplifying compliance processes, using framing techniques to present information effectively, and leveraging social norms and incentives to drive behavioral change. For example more secure default settings in hardware, software, and applications to reduce the likelihood of human error or inaction could be established on a regulatory level. On an operational level, organisations may also implement mechanisms to simplify complex cybersecurity information, establish secure default settings, frame cybersecurity risks effectively, promote positive cybersecurity social norms, provide timely reminders for security actions, offer incentives for secure behaviors, give feedback and track progress, use gamification for training and awareness, and optimize choice architecture for secure decisions

It should also be acknowledged that one size does not fit all and it 421
is necessary to ensure that regulations can be tailored to the unique characteristics and risk profiles of individual financial entities, striking a balance between harmonization and customization. Likeweise, proportionality principles should be applied to ensure that smaller financial entities are not overwhelmed by extensive regulations and in order to scale down regulatory requirements based on size, complexity, and risk exposure. In addition, a cost-benefit analyses to evaluate the potential impacts of regulatory measures on financial entities should be conducted. This would help analyzing and ensure that the advantages of enhanced resilience outweigh the expenses of compliance and administrative burdens.

422 Lastly, the discussion mentions avoiding duplication and overlaps with existing regulations, where there is a risk of creating inconsistencies, contradictions, or conflicts with other regulatory frameworks, such as GDPR. A more thorough analysis of the interaction between DORA and other relevant regulations is needed and a holistic approach to financial regulation that considers the interconnectedness of risks, and the broader financial ecosystem should be adopted. This includes examining the interaction between various regulatory frameworks and ensuring consistency and coherence in the regulatory landscape.

423 By focusing on these aspects, the design and implementation of financial regulations can be improved, resulting in a more effective, efficient, and adaptive regulatory environment that promotes financial stability and operational resilience. Through architecting nudge-based interventions, policymakers and organizations alike may encourage individuals and businesses to adopt more secure practices and reduce their exposure to ICT risks.

4.2.8 Global financial regulation?

424 The intricate web of international financial regulation has continued to evolve in response to the increasing complexity and interconnectedness of global financial markets. There have been various approaches and mechanisms used to address the challenges of financial regulation, including hard law, soft law, and intermediate arrangements, extending on the debate of the global financial crisis of 2007-2008 and its implications for regulatory reform as well as the diverse methods that have been proposed and implemented to achieve stability and mitigate risks in the international financial system (Arner & Taylor, 2009).

425 In the face of global financial crises, the European Union (EU) has been at the forefront of efforts to develop more effective supervisory and regulatory mechanisms. The establishment of a working group chaired by Jacques de Larosière, in response to the financial crisis, led to the proposal of two major recommendations that significantly influenced the legal development of European financial integration. These recommendations included the creation of the ESRB (European Systemic Risk Board) and the ESFS (European System of Financial Supervision), which aimed to enhance macroprudential supervision and harmonize regulatory standards within the EU (Arner & Taylor, 2009).

As the need for better coordination and regulation in global capital markets has become increasingly apparent, various proposals for a global financial regulator have emerged. While proponents argue that such an agency would reduce regulatory arbitrage and be less susceptible to political pressures, critics contend that the feasibility of a global financial regulator is questionable due to the preservation of national sovereignty and the difficulties in reconciling differences in legal systems and enforcement powers (Arner & Taylor, 2009). 426

The myriad of regulatory approaches that have been proposed and implemented to address the challenges of global finance can be categorized as traditional hard law, uncoordinated domestic responses, and intermediate arrangements. Each approach has its merits and drawbacks, with hard law and international organization-based approaches often facing political and practical obstacles, while purely soft law cooperative arrangements have proven inadequate in preventing and resolving global financial crises. Consequently, recent discussions have gravitated towards intermediate arrangements, such as the Financial Stability Board (FSB), which seeks to strike a balance between the extremes of the regulatory spectrum (Arner & Taylor, 2009). 427

The FSB, which emerged from the strengthening of the Financial Stability Forum, represents a compromise between hard law and soft law approaches in international financial regulation. By incorporating elements of peer review and external monitoring, the FSB aims to enhance coordination and prevention efforts. However, the FSB's effectiveness in addressing cross-border financial institution failures and facilitating burden-sharing remains uncertain, as it lacks the ability to impose binding obligations on its members (Arner & Taylor, 2009). 428

In 2023 the European Commission has launched a regulatory sandbox to support innovative use cases involving Distributed Ledger Technologies (DLT), such as blockchain. The sandbox will provide a pan-European framework for regulatory dialogues, increasing legal certainty for innovative blockchain solutions. The sandbox will operate from 2023 to 2026, and its goal is to facilitate cross-border dialogue between regulators and supervisors on one hand, and companies and public authorities on the other (Launch of the European Blockchain Regulatory Sandbox, 2023). 429

Proponents of a more formal and binding arrangement as outlined above by Arnter & Taylor (2009) argue that the current approaches to international financial regulation, which are largely based on soft law and voluntary cooperation, have proven to be insufficient in preventing and managing 430

financial crises. They believe that a formal, binding framework would lead to better coordination, enforcement, and compliance among countries, thus enhancing the overall stability of the international financial system. A binding arrangement could potentially address some of the issues that have arisen in past financial crises, such as burden-sharing in the event of cross-border bank failures. The establishment of a formal treaty or international organization, with clearly defined rules and dispute resolution mechanisms, may create a more predictable and equitable system for managing crises. On the other hand, critics argue that implementing a formal and binding arrangement could face significant political and practical obstacles. Sovereignty concerns and the diversity of national financial systems and legal frameworks may make it difficult to achieve consensus on a single, unified approach to financial regulation. Additionally, the enforcement of binding rules and agreements could prove to be challenging, given the complex and interconnected nature of the global financial system.

4.3 Further behavioral finance and regulatory public policy aspects in the context of DeFi and new developments

431 As technology continues to advance, the application of regulatory and public policy based on investment psychology and behavioral finance becomes increasingly important in ensuring investor protection and maintaining market integrity. Balancing the need for intervention with the risk of stifling innovation is a delicate task. The following areas provide opportunities to apply regulatory and public policy insights from investment psychology without undermining the fundamental principles of DeFi.

- Enhancing transparency and disclosure: Regulators can work to improve the transparency of platform operators, services and products with regard to crypto assets and centralized intermediaries between centralized and decentralized systems by requiring clear and comprehensive disclosures of risks, fees, and underlying mechanisms. By using findings from investment psychology, regulators can design disclosure requirements that effectively communicate critical information and enable investors to make informed decisions without overly burdening DeFi platforms.
- Promoting financial education and awareness: Policymakers can leverage insights from investment psychology to develop financial education programs that raise awareness of the risks and opportunities associated with DeFi investments. These programs can help investors recognize and

counteract common cognitive biases, fostering more prudent decision-making and reducing the potential for herd behavior and market manipulation.

- Encouraging responsible innovation: Regulators can support responsible innovation in DeFi by creating frameworks that allow for experimentation while maintaining investor protection. Regulatory sandboxes and innovation hubs can provide a controlled environment for centralized intermediaries providing services on the bridge between centralized and decentralized systems to test new products and services while engaging with regulators, promoting collaboration and knowledge-sharing without stifling innovation.
- Implementing risk-based regulations: Policymakers can design regulations that are proportionate to the risks posed by different service providers with regard to crypto assets and services bridging the gap of centralized and decentralized finance, using insights from investment psychology to identify potential areas of vulnerability. This approach ensures that higher-risk activities are subject to more stringent oversight, while less risky activities can operate with fewer regulatory burdens, thereby maintaining a balance between investor protection and innovation.
- Facilitating international cooperation: Given the global nature of DeFi, regulators can collaborate with their counterparts in other jurisdictions to harmonize regulatory standards and share best practices. By working together to address common challenges and risks, policymakers can develop a coherent and coordinated approach to DeFi regulation that accounts for the insights of investment psychology without unduly restricting innovation.

4.3.1 Perceived risk and uncertainty in decision research and implications for public policy and behavioral finance

Numerous academic studies on risk perception-focused research have been carried out since the middle of the 1970s in a variety of social science domains, including non-financial areas (Ricciardi, 2008). Early efforts on risky behaviors activities laid the academic groundwork for "*psychological aspects of risk perception studies in behavioral finance, accounting, and economics.*" (Ricciardi, 2008). "*This research on risky and hazardous situations was based on studies performed at Decision Research*", a company founded 432

in 1976 by Paul Slovic that specialized in risk perception and it identified certain psychological behavioral risk traits that could be applied in the context of making financial and investing decisions. These studies examined risk perception and documented specific behavioral risk characteristics (Ricciardi, 2008).

433 How investors processes information and numerous behavioral finance theories, aspects and problems with the potential of affecting how individuals perceive risk in the context of decision making processes are key themes in the literature on risk perception. "*Heuristics, overconfidence, prospect theory, loss aversion, representativeness, framing, anchoring, familiarity bias, perceived control, expert knowledge, affect (feelings), and worry*" (Ricciardi, 2008) are some of the theories on behavioral finance which influence a person's risk perception with regard to various financial services and products (Ricciardi, 2008).

434 The study of perceived risk was inspired by findings of novices and professionals frequently disagreeing on what constitutes risk and how risky various sorts of technologies and hazards were. "*Researchers at Decision Research, especially Paul Slovic, Baruch Fischhoff, and Sarah Lichtenstein, developed a survey-oriented research approach for investigating perceived risk*" in the 1970s and 1980s that is still widely used today (Ricciardi, 2008).

435 Decision research has been influencing a wider number of academic fields, including behavioral finance, accounting, and economics, since the early 1990s. With regard to risk perception studies in the area of financial and investment decision-making, Decision Research academics started applying numerous behavioral risk characteristics (cognitive and emotional concerns), discoveries, and research methodologies from social sciences. This risk perception research has also been expanded by academics outside the Decision Research group in the fields of financial psychology, behavioral accounting, economic psychology, and consumer behavior (Ricciardi, 2008).

436 Since the 1960s, perceived risk has been a topic of interest to explain consumer behavior (Bauer, 1960). Within consumer behavior, perceived risk is the consumer's belief about the risk associated with buying products or services from a certain vendor, regardless of whether the risk is real or imagined. This concept shares similarities with behavioral finance in terms of the decision-making process (Cox & Rich, 1964). Bauer (1960) was among the first to introduce the idea of perceived risk, arguing that consumer behavior involves risk due to the potential for unanticipated consequences, some of which may be unpleasant. This notion of risk becomes

especially relevant when considering high-cost purchases Cox and Rich (1964) offered a more specific definition of perceived risk describing it as a function of consequences (financial risk) and uncertainty (subjective feelings of potential gain or loss) (Ricciardi, 2008).

437 Similar to the emphasis on downside risk in behavioral finance, marketing research frequently focuses on the possible negative effects of perceived risk (Stone & Gronhaug, 1993). Financial, product performance, social, psychological, physical, and time/convenience loss are a few of the elements of perceived risk that have been found (Jacoby & Kaplan, 1972; Tarpey & Peter, 1975; Ricciardi, 2008). Tarpey and Peter also examined perceived risk in relation to maximizing perceived gain and net perceived return, drawing similarities to modern portfolio theory's positive relationship between risk and return (Ricciardi, 2008).

438 Risk perception is affected by a variety of variables, including personal experiences, background, and understanding (Slovic, 1988). Perceived risk has been found to play a larger role in decision-making in several industries than actual risk. Risk perception research spans various academic disciplines, primarily in the social sciences, with psychology playing a significant role (Ricciardi, 2008).

439 Numerous disciplines, including behavioral accounting, consumer behavior, marketing, and behavioral finance, all make extensive use of the notion of perceived risk. These academic fields look at how people react to risk according on their emotions, beliefs, and attitudes, as well as the influence of social norms and group dynamics. Due to a lack of reliable information, people frequently mistake the danger connected with certain activities, which can result in inaccurate judgements or actions (Ricciardi, 2004, 2005).

440 Risk perception is a multidimensional and interdisciplinary concept that goes beyond objective risk measurements (e.g., variance) or purely behavioral perspectives (e.g., heuristics) (Weber, 2004). Risk is inherently subjective and relative, as individuals' perceptions of risk may vary significantly. Perceived risk involves evaluating a risky situation based on instinctive and complex decision-making, personal knowledge, and external information sources (Sitkin & Weingart, 1995).

441 Ultimately, perceived risk is an individual's assessment of the propensity for risk, or the potential for exposure to loss, danger, or harm, connected to a particular activity. Numerous factors, such as intuitive heuristics, perceived average losses over time, situational characteristics, associations with risk sources, credibility and trust in risk-handling institutions, media

coverage, other people's opinions, and personal experiences with risk, can have an impact on this assessment (Renn, 1989; Ricciardi, 2008).

442 Despite the abundance of studies on risk and investor perception, many academic investigations fail to offer a clear definition of "*perception*" or address the concept in a comprehensive manner (Ricciardi, 2008). This lack of clarity can be misleading for readers who expect a thorough exploration of the subject. While perception is a fundamental concept in behavioral sciences and organizational behavior, it is often overlooked or underutilized in traditional finance research. Gooding (1973) has provided one of the few extensive discussions on perception within the context of finance, and only a handful of economists, such as Schwartz (1987, 1998) and Weber (2004), have substantively addressed the concept (Ricciardi, 2008).

443 The term perception of, or perceived risk, denotes a qualitative or subjective element that is frequently disregarded by academics in finance, accounting, and economics. Organizational behavior researchers have offered two perspectives on perception: one emphasizing a complex cognitive process resulting in a unique picture which may be divergent from reality, and the other highlighting its role in selecting and organizing environmental stimuli to create meaningful experiences for the perceiver (Ricciardi, 2008, with further references).

444 Perception is essential for understanding behavior since it is the process through which stimuli affect individuals, allowing them to arrange and analyze sensory information so they can make sense of their environment (Gregory, 2001). Perception relies on an individual's knowledge and past experiences, and it can sometimes lead to misinterpretations or illusions (Ittelson & Kilpatrick, 1951, pp. 50, 55). Two distinct definitions of perception from a psychological standpoint are discussed, one focusing on the discriminatory process among stimuli, and the other on the experiential aspect of perception (Ricciardi, 2008).

445 The academic literature reveals a variety of interpretations of perception across different fields of psychology (cp. Ricciardi, 2008). A similar challenge exists with the varying interpretations of risk across various disciplines. The following basic characteristics of perception should be taken into account by researchers in finance and investments (Ricciardi, 2008):

- A person's perception is based on their prior encounters with events, situations, or activities that are comparable to the one at hand.
- People pay attention to various aspects (pieces of information) of the same circumstance.

- A fundamental tenet of perception is that people can only digest a finite quantity of information at once in order to develop opinions or come to conclusions about a given circumstance, event, or activity.
- The innate tendency of humans is to categorize and structure data in order to comprehend it.
- When an environmental stimulus does not reach a, it also does not affect their actions. However, if they perceive a stimulus as genuine, even if it is factually incorrect, it will shape their behavior.
- The process by which each person observes reality and forms a particular knowledge, perspective, or viewpoint is known as perception.
- What a person thinks they perceive may not actually exist.
- A person's actions depend more on how they perceive reality than on reality itself.

Risk perception, or perceived risk, refers to the subjective judgements 446
individuals employ when evaluating risk and the degree of uncertainty involved. Perception serves as a mechanism that enables people to categorize and comprehend their sensory experiences, allowing them to assess their environment by recognizing actions or objects rather than mere factors or traits. Numerous investigations into perceived risk and risk-taking behavior, carried out by social scientists, have been utilized in different business environments. The groundbreaking research on hazardous activities and risk-related behavior, initiated by the Decision Research organization, established the basis for contemporary studies on risk perception in fields such as behavioral finance, accounting, and economics. The influential findings of Decision Research, along with those of other social scientists, revealed several key points about perceived risk (Ricciardi, 2008):

- Risk is frequently rated differently by novices and specialists for a variety of risky behaviors and potential threats.
- Based on a variety of behavioral risk indicators, including dread, worry, familiarity, and controllability, perceived risk is quantifiable, predictable, subjective (qualitative), and descriptive.
- Information from sources which are trusted is given greater credence than that from sources which are distrusted.
- Cultural theory has looked into how culture affects risk assessments rather than only focusing on an individual's psychology.
- Perceived risk and perceived benefit are inversely correlated.
- Risk takes into account emotion (affect) as a crucial part of judgment and decision-making.

- External variables, like media attention, can affect one's perception of and appraisal of risk.

447 Classic decision-making underpins standard finance, which is founded on the concept of rationality, wherein investors make financial decisions. Standard finance has historically dismissed the idea that psychological factors can impede individuals from making the most rational decisions. In contrast, behavioral finance is predicated on the idea that investors make decisions in accordance with behavioral decision theory and bounded rationality. When making decisions, for instance, investors display cognitive and affective (emotional) elements in assessing risks and evaluating specific investment products or services (Ricciardi, 2008). With regard to public policy such bounded rationality likely also applies to regulatory policymaking in the financial markets, as it is also a decision-making process.

448 The literature on risk perception in the social sciences has shown that a variety of cognitive and affective (emotional) elements affect a person's risk perception for non-financial judgments. Several of these cognitive and affective components are also present during financial decision-making processes. These factors shape how investors perceive risk with regard to various financial products and services (e.g., tax planning, selecting financial consultants, etc) (Ricciardi, 2008). It is hypothesized that such risk perception also plays a role in public policymaking when it comes to regulation of financial markets (with potential other motivators, such as radiating confidence, ability to act, raising popularity, gaining voters and ensuring re-election, etc).

449 The advent of Decentralized Finance (DeFi) has added new dimensions to risk perception in the financial industry. DeFi is a system of financial services and applications built on blockchain technology, offering users more control, transparency, and accessibility to financial tools. However, decentralized systems also come with new and evolving risks, such as smart contract vulnerabilities, regulatory uncertainties, scams built on faux decentralization etc.

450 Applying the concepts of risk perception in the context of DeFi can help better understanding the variables affecting decision-making processes of investors within this emerging sector. Some of the key behavioral finance theories and ideas which may impact a person's perception of risk in DeFi include:

- Heuristics: Investors might rely on mental shortcuts to simplify complex DeFi protocols, potentially leading to misjudgements of the underlying risks.
- Overconfidence: As the DeFi ecosystem evolves rapidly, investors may overestimate their understanding of novel technologies and underestimate potential risks.
- Prospect theory and loss aversion: Investors might be more sensitive to potential losses than gains in DeFi, leading to risk-averse behavior, even when the expected returns may be significantly higher.
- Familiarity Bias: Users may preferentially invest in DeFi protocols they are more familiar with, even if those protocols might not offer the best risk-return profiles or investors unexperienced in centralized financial markets may prefer DeFi even though it does not suit their risk-return profile.
- Perceived control and expert knowledge: In the DeFi landscape, users have more control over their investments compared to traditional finance. This perceived control may affect their risk-taking behavior and investment decisions.
- Affect and worry: The emotional aspects of investing in DeFi, including fear of missing out (FOMO), fear of potential loss, and excitement about the potential for financial gains, can impact risk perception and decision-making.

Considering these factors, it is crucial to further study risk perception within the DeFi context to identify potential biases and improve the decision-making process for investors in this rapidly evolving financial landscape as there is almost no research and correspondingly only few data on the perceived risk within the DeFi context. By understanding how individuals perceive and react to risks in DeFi, researchers and policymakers alike can develop better tools, educational resources, and risk management strategies to mitigate potential pitfalls and promote informed decision-making. 451

It also has to be noted that the financial system is inherently complex and constantly evolving, making it difficult to model and regulate effectively. The conventional approaches employed to manage this complexity may not always be successful, leading to the exploration of simpler methods as complementary tools. Financial systems may also be better characterized by uncertainty rather than risk because of the existence of numerous unpredictable factors (Aikman et al., 2021). The distinction between risk and uncertainty, as put forth by Knight (1921), is important to consider when 452

designing financial regulations. Conventional methods for modelling and regulating financial systems often focus on risk, which may not adequately capture the full range of uncertainties faced by the system. In the context of risk, the result is unknown, but the probability distribution that dictates the outcome is known. Conversely, uncertainty is marked by not only an unknown outcome but also an indeterminate probability distribution. In this context, simpler approaches could be more effective at addressing the inherent uncertainties in financial systems (Aikman et al., 2021).

453 One of the main arguments for incorporating simplicity into financial regulation is its potential to complement existing, more complex methods. For instance, the analysis of "*capital requirements against potential losses and the empirical evidence on bank failures during the global financial crisis*" suggest that simple rules can indeed yield valuable results in what is called the less is more effect, as complex models may yield more accurate results than a heuristic approach in case of risk but once uncertainty is introduced, heuristics may actually fare better than complex models (Aikman et al., 2021). Furthermore, simpler approaches can enhance transparency, communicability, and accountability, thereby reinforcing macroprudential policies' signaling channel of (Giese et al., 2013).

454 Simpler regulatory regulations may have benefits, but there are drawbacks as well. One worry is that these laws might be open to arbitrage, gaming, and circumvention. It is crucial to remember that simplicity does not always imply a single-minded focus on a certain variable. For instance, combining simple indicators can assist in determining bank exposure without adding needless complexity. Furthermore, no matter how complex the laws are, there is always a chance for gaming and arbitrage. In fact, intricate stipulations may make it more difficult to recognize and treat problematic gaming activities. Simpler methods might help identify gaming and make it easier to combat it. (Aikman et al., 2021).

455 Simpler regulatory approaches offer several benefits, including reducing the resources directed towards compliance, promoting better understanding and communication among stakeholders, and improving internal governance and market discipline. In addition, they may contribute to a more efficient financial system by redirecting resources towards productive activities instead of unproductive regulatory arbitrage (Friedman, 2010; Aikman et al., 2021).

456 While simple rules are not a panacea, they can play a crucial role in complementing complex approaches to financial regulation. Emphasizing simplicity in financial regulation may lead to better outcomes for society

by addressing the challenges posed by uncertainty, improving transparency and accountability, and promoting the efficient allocation of resources (Aikman et al., 2021). With regard to DeFi or it's potential regulation this should be kept in mind, and it needs to be differentiated whether regulation is supposed to address risks or uncertainties, as simpler approaches in regulation may be more flexible and effective in case of the latter phenomena, in accordance with Friedman's (1953) postulated "as if" approach, which posits that, even if the assumptions of a model do not fully reflect the complexity of human behavior or the real world, the model can still be considered valuable if it generates reliable predictions..

A key argument for adopting a pragmatic approach, where behavioral 457
factors are incorporated into economic models also lies in its potential to address important economic questions. By combining insights from psychology and other social sciences, this approach can help identify new policy tools, generate better predictions for existing policies, and offer fresh welfare (in reference to Pigou's social welfare, 1920) implications. Model uncertainty is a central issue that arises when incorporating behavioral factors into economic models. By acknowledging the existence of uncertainty, researchers can adapt their models to optimize expected welfare in response to policy tools like nudges or subsidies. In situations where model uncertainty exists, nudges can provide a more robust means of correcting internalities than for example tax incentives because they work effectively when agents make behavioral mistakes and have no impact when they do not (Chetty, 2015).

4.3.2 Choice architecture, framing effects, and default options in DeFi policy

It is essential to clarify the involvement of cognitive biases in financial 458
decision-making, particularly with regard to DeFi. Cognitive biases are systematic deviations from rational decision-making that can significantly impact investors' behavior, leading to market inefficiencies and suboptimal outcomes.

Confirmation bias is one of these cognitive biases, which happens when 459
people disproportionately look for or interpret information in a way that supports their pre-existing ideas. In the context of DeFi, confirmation bias can lead investors to overlook or downplay risks associated with a particular project or asset, resulting in ill-informed investment decisions.

Additionally, confirmation bias can contribute to the formation of asset bubbles, as investors become overly optimistic and ignore warning signs of overvaluation.

460 Herd mentality, which refers to investors' propensity to mirror other people's actions, often driven by social influence or fear of missing out, also has an impact on financial decisions. In DeFi markets, herd mentality can exacerbate price volatility and facilitate the rapid spread of both investment fads and panic selling. For instance, when a large number of investors simultaneously flock to a new DeFi platform or crypto asset, the resulting demand surge can artificially inflate asset prices, leading to unsustainable market conditions and potential crashes.

461 The already discussed anchoring effect is a cognitive bias in which individuals make choices that are overly dependent on the anchor, a first piece of information. In the DeFi space, anchoring can manifest in various ways, such as investors basing their valuation of a new token on its initial offering price or historical performance, even if market conditions or fundamentals have significantly changed. This can result in mispriced assets and suboptimal investment decisions.

462 By understanding how these cognitive biases affect financial decision-making, regulators and policymakers can better anticipate potential market inefficiencies and design public policies that mitigate their adverse effects. In the context of DeFi, this entails crafting regulatory frameworks that account for the behavioral tendencies of market participants, promote transparency, and encourage more informed decision-making. By understanding the cognitive biases and heuristics that influence financial decision-making, regulators can also design more effective public policies that nudge investors towards better outcomes without restricting their choices.

463 Some policy interventions that leverage behavioral economics to shape investor behavior and improve market outcomes could include elements of choice architecture, framing effects and default options. Designing the environment in which decisions are made with the intention of influencing those decisions without restricting options is known as choice architecture. In the context of DeFi, choice architecture could be used to present investment options in a way that encourages more informed decision-making. For example, a DeFi platform could display the most relevant information, such as fees, risks, and potential returns, more prominently, helping investors to better assess the trade-offs associated with different investment choices.

In general, complex and lengthy disclosure documents can be overwhelming for investors, leading them to ignore important information or rely on cognitive shortcuts to make decisions. By simplifying disclosures and presenting information in a clear, concise, and standardized format, it can be made easier for investors to understand the risks and rewards associated with DeFi investments. This can help to reduce information asymmetry and promote more informed decision-making. 464

Decision making is also impacted by so-called framing effects. Framing is the method by which information is presented, which can significantly impact decision-making (Kahneman and Tversky, 1979). Framing effects may be leveraged to influence investor behavior in the DeFi space. For example, presenting potential losses more prominently than potential gains could counteract investors' natural tendency towards loss aversion, encouraging them to consider the risks associated with an investment more carefully. 465

In addition, default options may be integrated by design. Default options are pre-selected choices that take effect unless an individual actively decides to change them. In the context of DeFi, default options could be used to promote more prudent investor behavior. For example, a DeFi platform could set default investment settings to more conservative options, such as lower leverage levels or more diversified portfolios, nudging investors towards less risky choices while still allowing them the freedom to opt for higher-risk alternatives if they wish, enabling a more diversified total asset portfolio. 466

By incorporating behavioral insights into policy design, regulators can craft more effective public policies that address the unique challenges posed by the DeFi ecosystem. This can lead to improved investor behavior, enhanced market stability, and ultimately, a more robust and resilient financial system. Nevertheless, the question persists, on which level such policies should be implemented as true DeFi systems are in lack of a regulatory subject, and the above suggestions may therefore be rather seen as best practice policies for such truly decentralized infrastructures. However, centralized intermediaries bridging the gap of the centralized and decentralized economic and finance systems may be required to impose such rules. 467

It is crucial to address the potential conflict between innovation and regulation, particularly in the rapidly evolving DeFi space. Regulators face the delicate task of maintaining a balance between fostering innovation and ensuring adequate protection for investors. On one hand, DeFi has the potential to revolutionize financial services by offering increased accessibility, efficiency, and transparency. By fostering innovation, regulators can help 468

drive the development of new financial products and services that benefit a broader range of market participants. However, the decentralized nature of DeFi also presents unique risks and challenges, such as vulnerability to hacks, fraud, and market manipulation. As a result, regulators must ensure that investor protection measures are in place to maintain trust in the financial system and minimize the potential for harm.

469 The potential conflict between innovation and regulation arises when regulatory efforts inadvertently stifle innovation or drive market activity to less-regulated jurisdictions. For example, overly stringent regulations might limit innovation as they can hinder the growth and development of DeFi projects, as startups may struggle to navigate complex compliance requirements or bear the costs associated with regulatory compliance. This can result in fewer innovative solutions reaching the market and reduced competition in the financial services sector. This may also drive market activity to less-regulated jurisdictions as overly restrictive regulations can incentivize DeFi projects and investors to relocate to jurisdictions with more lenient regulatory environments. This can lead to regulatory arbitrage, where market participants exploit differences in regulatory standards across jurisdictions, potentially undermining the intended goals of regulation and exposing investors to greater risks due to the inherently global nature of DeFi systems.

470 To strike a balance between fostering innovation and ensuring investor protection, regulators should adopt a measured, risk-based approach. This could involve tailoring regulation to specific risks and encouraging regulatory collaboration. By focusing on the most significant risks posed by DeFi activities, regulators can target their efforts more effectively and minimize the impact on innovation. This might include addressing concerns related to consumer protection, market integrity, and financial stability. Regulators should work closely with DeFi stakeholders, including industry participants, academics, and other policymakers, to better understand the emerging technology and its implications. This can help to create a regulatory environment that supports innovation while addressing potential risks. In order to prevent the mentioned regulatory arbitrage and ensure a level playing field, regulators should work towards harmonizing regulatory standards across jurisdictions. This can be achieved through international cooperation, knowledge sharing, and the development of common regulatory frameworks.

471 Regulators must remain adaptable in their approaches to regulation to keep pace with the fast-changing landscape. They should be prepared to

update their regulatory frameworks and supervisory practices as new technologies, platforms, and risks emerge. This can help to strike a balance between promoting innovation and ensuring investor protection, financial stability, and market integrity. One way to foster adaptability in regulation is through the use of regulatory sandboxes. These controlled environments allow innovators to test their products and services under the supervision of regulators, while also providing regulators with valuable insights into emerging trends and potential risks. Regulatory sandboxes enable a more iterative, collaborative approach to regulation, facilitating knowledge exchange between regulators and the industry participants. Additionally, international cooperation is crucial in the context of DeFi, given the borderless nature of decentralized finance. As DeFi platforms and services often operate across multiple jurisdictions, a fragmented regulatory environment (with centralized financial intermediaries or on- and off-ramps between decentralized and centralized systems as a connecting point) can lead to regulatory arbitrage, where market participants exploit differences in regulatory standards across countries.

To address this issue, regulators should engage in international cooperation and knowledge sharing for developing common guidelines and principles, fostering a more coordinated global response to the harmonization of regulatory standards and ensure a consistent approach to the regulation of DeFi peers or market participants. Regulators could also establish bilateral agreements and memoranda of understanding with their counterparts in other jurisdictions to facilitate cross-border supervision, enforcement, and information sharing. 472

4.3.3 Potential for herding and mass contagion in AI-driven investment decisions

The Industrial Revolution, which began in the late 18th century, represented a monumental shift in the way societies functioned. It introduced mechanized production, changing the dynamics of work by gradually replacing manual labor with machines. This transition had significant implications, both positive and negative, on society. On one hand, the Industrial Revolution was a time of increased productivity and economic growth. Machines could produce goods more efficiently and in higher volumes than human laborers, leading to a substantial rise in overall production. On the other hand, the mechanization of labor brought about significant social 473

and economic disruptions. Many manual laborers lost their jobs, leading to displacement, suffering, and inequality. While these individuals eventually found new employment opportunities as society adjusted, the transition period was tumultuous and marked by social unrest.

474 Fast forward to the 21st century, and we are experiencing a similar transition, often referred to as the Fourth Industrial Revolution or the age of artificial intelligence (AI). AI technologies are increasingly replacing not just manual labor but also cognitive tasks once thought to be the exclusive domain of humans. As with the first Industrial Revolution, AI is producing both positive and negative effects. On the positive side, AI has the potential to significantly increase productivity and efficiency. It can perform tasks more accurately and quickly than humans, and unlike humans, it doesn't tire or require breaks. It can analyze vast amounts of data in milliseconds and come up with insights that would take humans hours, days, or even years.

475 Yet, just as with the introduction of machines in the Industrial Revolution, the rise of AI also brings challenges. People for example may be afraid that AI could lead to job losses, particularly in sectors where cognitive tasks are dominant. Lawyers, accountants, teachers, journalists, customer service representatives—these are all professions that could potentially be replaced, to some degree, by AI. This echoes the fears of manual laborers during the Industrial Revolution. AI's influence is unlikely to result in a net loss of jobs but rather in a transformation of the job market. New roles will emerge that we can barely imagine today, just as the workers in the 18th century couldn't have imagined the types of jobs that the Industrial Revolution would create. The challenge will be to manage this transition in a way that minimizes hardship and inequality, just as it was during the Industrial Revolution.

476 Another challenge are machine biases. Biases are prevalent in algorithm-based applications such as machine learning, deep learning, or large language model algorithms. This is also referred to as machine bias, which refers to the tendency of machine learning algorithms to produce unfair or discriminatory results. This bias can arise when the algorithms are trained on biased or incomplete data, or when they incorporate biased assumptions or features. While machines do lack the ability to think critically, they can still learn and make decisions based on patterns and correlations in the data they are trained on. If that data is biased, for example, if it contains more examples of one race or gender than another, the machine may learn to associate certain characteristics or behaviours with that group, leading to discriminatory outcomes. In the legal system, machine bias can have

serious consequences. For example, a machine learning algorithm used to predict the likelihood of reoffending or granting parole may be biased against certain groups, such as minorities or people from low-income neighbourhoods. This could lead from unequal treatment to wrongful imprisonment.

Similarly, algorithms used to evaluate job candidates or credit applications may discriminate against certain groups, perpetuating inequality and limiting opportunities for some individuals, reinforcing the need for fair and transparent algorithms. Therefore, it's important to ensure that the algorithms used are developed and trained with unbiased data and assumptions or that super-code is implemented locking out the biased information in the algorithm-based decision making, and that they are subject to ongoing testing and evaluation to detect and correct for any potential biases. 477

The rapid advancements in artificial intelligence (AI) have also brought significant changes to the landscape of investment decisions. However, it needs to be established, what is deemed artificial intelligence. Already in 1984, Ken Thompson in "*Reflections on Trusting Trust*" illustrated the idea that a computer can learn through a hypothetical scenario involving a self-replicating program. Thompson (1984) describes a program that, when executed, examines its own source code and modifies it to include a replication function. The program then compiles the modified source code and executes the resulting binary, creating a copy of itself. Thompson (1984) notes that the original program did not include any code for self-replication, and yet, through its ability to examine and modify its own source code, it was able to learn this new behavior. He argues that this ability to modify its own source code is what makes a computer truly "*programmable*" and enables it to adapt and improve over time. Thompson (1984) goes on to describe how this ability to learn and adapt can be used to create more sophisticated programs, including ones that can learn from their own experiences and modify their behavior accordingly. In simple words, computers may learn in the sense that they can modify their own behavior based on their experiences and interactions with the environment, and that this ability is what enables them to become more intelligent and capable over time. 478

AI-driven investment strategies, including robo-advisors, algorithmic trading, and machine learning models, have become increasingly prevalent in the financial sector. However, the use of AI in investment decision-making raises important concerns about the potential for mass contagion and 479

herd mentality effects, which could amplify existing biases and contribute to market inefficiencies.

480 Mass contagion refers to the rapid spread of behaviors, emotions, or ideas through a population, often driven by social influence or information cascades. In the context of AI-driven investment decisions, mass contagion can manifest in several ways. Algorithmic trading systems that rely on similar data sources or employ comparable strategies may generate correlated trading signals, causing a self-reinforcing feedback loop that amplifies market trends and machine learning models may learn from and perpetuate existing market biases, particularly if their training data is not representative or diverse. This may lead to investors blindly following the recommendations of AI-driven robo-advisors or trading algorithms, without critically evaluating the underlying rationale for their decisions.

481 Herd mentality is the propensity of people to follow the behaviors or beliefs of a group, often driven by the fear of missing out or the desire to conform. In AI-driven investment decisions, it is hypothesized that herd mentality can exacerbate the effects of mass contagion, as market participants may be more inclined to trust AI-generated advice or signals, assuming that the majority of other investors are also following similar strategies. This can lead to a self-reinforcing cycle, where AI-driven investment decisions contribute to market trends, which in turn influence the behavior of other investors, further amplifying the initial trend.

482 All of the aforementioned effects must be subjected to further evidence-based research as the mass contagion and herd mentality effects in AI-driven investment decisions may have significant implications for financial markets, including increased volatility, the formation of asset bubbles, and the misallocation of capital.

483 Irrespective of the further required analytical analysis, potential risk mitigation strategies could include the diversification in AI-driven investment strategies. Policymakers and market participants can promote the development and use of diverse AI-driven investment models to reduce the potential for correlated trading signals and market contagion. It should also be ensured that AI models are trained on diverse and representative data to help minimizing the risk of perpetuating existing biases or contributing to mass contagion effects and that such models include some sort of fail-safe switch to avoid systemic risks.

484 Furthermore, encouraging transparency in AI-driven investment algorithms can help investors to better understand the rationale behind their recommendations, fostering more informed decision-making and re-

ducing the potential for herd mentality and financial education programs that emphasize the potential risks and limitations of AI-driven investment strategies may help investors to make more informed choices and avoid blindly following the crowd.

485 The mass contagion effects arising from AI-driven investment decisions can have far-reaching consequences, potentially leading to systemic risks and global-scale failures in financial markets. The possibility of a widespread financial system failure is referred to as systemic risk, often caused by the collapse of a single institution or the propagation of financial distress through interconnected networks. Mass contagion in AI-driven investment decisions can increase systemic risk in several ways such as high levels of correlation among AI-driven investment strategies potentially leading to a simultaneous unwinding of positions during periods of market stress, exacerbating price movements and causing a liquidity crunch. Furthermore, self-reinforcing feedback loops created by mass contagion through AI-driven investment decisions can contribute to the formation of asset bubbles, which can subsequently burst and lead to financial crises. In addition, if a large number of investors rely on AI-driven investment decisions, an unforeseen failure in a widely used AI model or algorithm could trigger a rapid sell-off, causing severe market disruptions and potentially destabilizing the entire financial system.

486 The interconnected nature of global financial markets means that mass contagion in AI-driven investment decisions can easily spread across borders and asset classes, creating cascading failures that amplify the initial shocks. The following factors can contribute to the propagation of mass contagion effects:

- Cross-border spillovers: AI-driven investment decisions can lead to highly correlated trades across multiple countries, causing financial contagion to spread rapidly through global networks.
- Contagion across asset classes: If AI-driven investment decisions are highly correlated across different asset classes, a shock in one market segment can quickly transmit to other segments, creating a domino effect that exacerbates financial distress.
- Interconnectedness of financial institutions: The growing reliance on AI-driven investment strategies by major financial institutions can increase the risk of contagion, as the failure of a single institution or model can have ripple effects throughout the financial system.

487 To mitigate the risk of global-scale failures resulting from mass contagion in AI-driven investment decisions, policymakers and market participants should consider the following strategies:

- Implement robust stress-testing and scenario analysis: Financial institutions should be required to conduct regular stress tests and scenario analyses to assess their vulnerability to mass contagion effects and ensure that they have adequate capital buffers and risk management practices in place.
- Monitor and regulate AI-driven investment strategies: Regulators should closely monitor the development and use of AI-driven investment strategies, implementing appropriate regulations to reduce the risk of mass contagion due to robo-advisors and ensure the robustness of financial systems.
- Foster international cooperation: To address the cross-border and interconnected nature of financial markets, regulators should work together to harmonize regulatory standards, share information, and coordinate their response to potential global-scale failures arising from mass contagion in AI-driven investment decisions.

488 By understanding the risks associated with mass contagion in AI-driven investment decisions and implementing appropriate mitigation measures, policymakers and market participants can minimize the likelihood of global-scale failures and promote the financial system's resiliency and stability.

4.3.4 The role of behavioral economics in public policy and its challenges

489 Empirical research is frequently used by economists to resolve important policy issues, such as the effects of real wage changes on the labor market. However, these empirical investigations can be narrowly inductive, with little attention paid to the underlying theory of consumer behavior. One criticism of behavioral economics is its reliance on laboratory studies. While experimental economics, a subset of behavioral economics, tests biases in controlled environments with theoretical simulations, there is a growing body of research examining financial markets with real-world metrics. For example, biases identified in laboratory studies were also present in high-stake situations (Camerer & Loewenstein, 2002). Similarly, Iyengar and Lepper (2000) and Iyengar et al. (2003) found that choice overload

occurred in both small items, such as jam in supermarkets, and more significant decisions, like selecting US 401K pension plans (McAuley, 2013).

Knowledge of psychological underpinnings in consumer behavior has long been essential to marketing. Behavioral economics challenges the assumptions of advertisers, while also providing strategies such as offering cashback rather than discounts, based on prospect theory's findings on reference-point dependence. Although explicit references to behavioral economics in public policy are relatively rare, government policies are influenced by an implicit understanding of behavioral economics. McAuley (2013) names, money illusion, self-control failures, and hyperbolic discounting as having influenced policies in Australia and prospect theory also having been used to support the expansion of government programs. By supporting decision-makers in creating more cost-effective interventions and avoiding inefficient or expensive initiatives, behavioral economics can dramatically impact public policy. According to McAuley (2013), the New Zealand Ministry of Economic Development's policy-related guidance offers helpful recommendations on how behavioral economics research might influence public policy (McAuley, 2013). 490

To direct public policy initiatives, Camerer et al. (2003) suggested the asymmetric paternalism principle. This principle suggests that regulations should provide significant benefits to those who are making errors by correcting them while imposing minimal harm on those who make rational decisions. For instance, in the credit card market, sophisticated and disciplined consumers, making rational decisions use their credit cards optimally, while undisciplined consumers may accumulate high-interest debt due to hyperbolic discounting. Behavioral biases can shape entire markets, resulting in cross-subsidies that favor one group over another. Asymmetric paternalism can inform policy responses, such as mandating "*credit card issuers to warn of the consequences if only minimum payments are made*". Consequently, it may be argued that behavioral economics and likewise behavioral finance has long influenced various aspects of society, including marketing and public policy. Integrating its findings into microeconomics and adopting principles such as asymmetric paternalism can help create more effective and evidence-based policies (McAuley, 2013). 491

It has been suggested that guiding individuals towards judicious choices congruent with their biases could be achieved by establishing defaults, while still preserving their autonomy to select alternative options. McAuley (2013) provides an illustrative example of such default policies or opt-in vs opt-out model regarding the New Zealand 'Kiwisaver' pension, wherein 492

the default enrolls workers into a pension scheme that deducts a certain percentage of their earnings, yet they retain the option to opt out (McAuley, 2013).

493 However, in policy implementation it is also important to consider possible side or negative effects. Extrinsic rewards have been observed to frequently diminish intrinsic motivation, commonly known as "*crowding out*". Governments may explore providing financial incentives in order to promote civic action, such as volunteer work, however doing so may reduce intrinsic motivation (McAuley, 2013).

494 Behavioral economics like behavioral finance, with its empirical focus, reinforces the importance of ex ante and ex post evaluations in public policy, cautioning that consumer and producer responses to interventions may deviate from microeconomic assumptions (Camerer et al., 2003). For instance, in 2002, the US Department of Housing and Urban Development proposed that mortgage broker commissions be disclosed in home loan proposals. However, research by the Federal Trade Commission found that such disclosure tends to draw customers' focus away from the loan's true value, leading to inferior decisions (Lacko & Pappalardo, 2004). This effect needs further study also with regard to disclosure of kickbacks in the financial markets from banks to investment managers for brokering financial products.

495 Addiction results in an inelastic demand curve at some point of positive consumption, with individuals often expressing a desire to escape this entrapment (McAuley, 2013). Gamification mechanisms in DeFi or service provider platforms bridging the centralized and decentralized systems, also with regard to emerging gaming markets due to NFTs, may give rise to addictive behaviors. Another challenge for public policy in this regard lies in designing interventions that target addictive behavior without imposing undue burdens on people who don't require external controls.

496 In the realm of behavioral economics, research has consistently demonstrated that people have an inherent desire for fairness in their interactions, emphasizing not just their personal welfare but also the underlying equality of an exchange, in the field of behavioral economics (e.g., ultimatum games, dictator games, and legal disputes over minor stakes). fairness is acknowledged as a constraint on immediate self-interest in behavioral economics, which also provides explanations in terms of group benefits. People build social capital by punishing those who act unfairly, for instance, by paying a net cost to avoid an unfair agreement. According to social evolution theories, societies with high stocks of social capital outperform those with-

out them. Therefore, failing to consider consumers' desire for fairness may result in public policy failures (McAuley, 2013).

Furthermore, McAuley (2013) proposes that usage charges in general 497
can result in high political costs if not managed sensitively. According to prospect theory, individuals resent paying for previously free services even if offset by tax reductions, as the utility of the reduction is lower compared to the disutility of moving from a free to a paid plan. Concerns for transactional fairness may also prompt resentment if people perceive cross-subsidies or inequities in user charges (McAuley, 2013).

It is challenging to include envy, a particular facet of fairness concern, 498
in traditional economic models. Elster (1991) distinguished between two types of envy: weak envy, characterized by the disutility experienced when observing another's unshared gain, and strong envy, involving a willingness to incur personal costs to bring down another person. In repeated prisoners' dilemma situations, participants frequently prioritize punishing the opposing side for prior wrongdoings at the expense of their own welfare (Camerer, 2003).

Risk-related biases also present challenges in public policy. For example, 499
individuals often struggle to conceptualize and compare low-probability risks, demonstrate heightened awareness of vivid risks, exhibit framing biases, display pseudo certainty, and exhibit over-optimism. These biases raise questions about the allocation of public risk-reducing resources based on objective or perceived risks and whether government organizations ought to attempt to make an effort to account for individual biases in risk management. However, public policy faces the challenge of whether to allocate regulatory resources based on perceived or actual risk and whether to educate citizens to adopt a more rational approach to risk, even if it might be politically disadvantageous (McAuley, 2013).

Behavioral economics research reveals that, under certain conditions, an 500
excessive array of choices can lead to consumers making no decision at all, which results in a deadweight loss (Iyengar & Lepper, 2000). In response to choice overload, strong interventions, such as restricting entry into specific markets or employing default options that guide consumers towards particular products while allowing easy switching, could be considered. However, these approaches may have competition implications and could stifle innovation in certain markets (McAuley, 2013).

Overall, behavioral economics and behavioral finance offer valuable in- 501
sights into human behavior and decision-making processes, challenging traditional microeconomic assumptions and contributing significantly to

public policy, marketing, and finance. By integrating findings from behavioral economics and adopting principles like asymmetric paternalism, policymakers can design more cost-effective and evidence-based interventions, minimizing the risk of ineffective or high-cost policies. While it is crucial to consider possible side or negative effects in policy implementation, behavioral economics' empirical focus highlights the importance of ex ante and ex post evaluations. Issues such as fairness, envy, addiction, and risk-related biases present unique challenges for public policy, also considering that the same decision-making issues are prevalent in the policymaking process itself, necessitating a careful balance between addressing these concerns and promoting competition and innovation. Ultimately, behavioral finance has the potential to enhance our understanding of consumers', financial market participants' and policymakers' behavior and shape more effective, informed policies across various aspects of society.

4.4 Interim conclusion

502 The widespread accessibility of DeFi protocols enables the creation of a truly open and inclusive financial system. DeFi presents further opportunities, such as enhanced efficiency, transparency, accessibility, and composability of financial infrastructure. The efficiency gains stem from centralized institutions or intermediaries with smart contracts, which can act as custodians, escrow agents, and central counterparty clearinghouses (CCPs) or as central securities depository (CSD). DeFi applications offer unparalleled transparency due to the public observability of transactions and the on-chain analysis of smart contract code (Schär, 2021). However, the transparency also raises issues of frontrunning practices.

503 However, DeFi is not without its risks, which include errors in programming or execution of smart contracts, operational security, reliance on external data and protocols, which may introduce centralization risks, and scalability issues. The deterministic and decentralized nature of smart contract execution, while advantageous, can be vulnerable to coding errors, which may lead to vulnerabilities and potential attacks permitting unintended usage. Operational security concerns may be raised by the usage of admin keys as well as malicious or corrupted keyholders, which may be mitigated to some degree through multi-signature mechanisms. Lastly, the label "decentralized" may prove misleading or straight-out fraudulent in certain instances (Schär, 2021).

The openness and composability of DeFi, while offering exciting possibilities, also create significant dependencies and potential ripple effects throughout the entire DeFi ecosystem. Regulators are concerned about illicit activities associated with crypto assets and must carefully balance the need for intervention against the risk of stifling innovation. In summation, the realm of DeFi provides intriguing prospects and harbors the potential to establish an authentically open or inclusive, public and transparent as well as unalterable and final financial infrastructure. Owing to the many interoperable programs and systems that DeFi comprises, every transaction can be independently verified, and data is readily available for users and researchers to review (Schär, 2021). 504

4.4.1 Decentralized organizations, tokenization as well as centralized and decentralized market infrastructures under the EU digital finance package

To conclude, social economy organizations (SEOs) and decentralized autonomous organizations (DAOs) have both challenged traditional economic models by emphasizing stakeholder needs, social objectives, and innovative governance structures. In a way, DLT-based DAOs may be seen as the next evolutionary step in the organizational development. 505

In parallel, the EU Digital Finance package, including the Markets in Crypto Assets Regulation (MiCAR) and the Distributed Ledger Technology (DLT) Pilot Regime, aims to balance innovation with risk mitigation in the realm of crypto assets. While the former prioritizes the regulation of centralized crypto asset service providers acting as a relay or beacon to true DeFi markets, the latter seeks to enable a pilot regime for DLT market infrastructures for token-based financial instruments or security tokens equivalent to traditional stock exchanges, regulated markets or trading facilities, taking the unique properties of distributed ledger technology into account. However, both initiatives face challenges. Challenges from a behavioral finance perspective may be seen trust mechanisms, investor behavior, and potential regulatory biases. To maximize their effectiveness, further research and proactive approaches should be considered, alongside investor education initiatives and continuous monitoring of the rapidly evolving landscape. By doing so, a more inclusive and sustainable economic ecosystem could ideally be achieved, showcasing the potential for digital 506

transformation in addressing contemporary social, economic and regulatory challenges.

4.4.2 DeFi lending, derivatives, portfolios and privacy enhancing protocols

507 DeFi lending is a crucial component of the ecosystem, with various protocols that facilitate loans and borrowing. Decentralized lending platforms do not have identification requirements, ensuring unrestricted access for users. To safeguard lenders and borrowers, two primary strategies are employed: atomic loans, also known as flash loans, and fully secured loans using collateral.

508 Collateralized loan platforms can be divided into three types: collateralized debt positions, P2P collateralized debt markets and pooled collateralized debt markets. DeFi applications offering collateralized debt positions enable users to create and issue new tokens backed by collateral.

509 Alternatively, borrowing existing crypto assets from others can be achieved through collateralized debt markets, which require a counterparty with opposing preferences. To match lenders with borrowers, P2P and pooled matching methods are employed, each with its own advantages and disadvantages.

510 Decentralized derivatives are also a growing trend in the DeFi ecosystem, with two main categories: asset-based and event-based derivative tokens. Asset-based derivative tokens derive their value from an underlying asset, while event-based derivative tokens depend on observable variables unrelated to asset performance. The latter type of tokens may be on the verge of gaming markets, depending on the economic model behind it (decentralized gaming or gambling).

511 In addition, on-chain asset management, similar to traditional portfolio management, enables users to diversify their investments without managing individual tokens. A key difference is the absence of a custodian, as crypto assets are held in smart contracts. These contracts can follow various strategies or rely on fund managers for active management. Investors receive fund tokens that represent partial ownership and can redeem or liquidate their share.

512 Another central topic in the DeFi space is privacy on public blockchains, which is difficult to achieve due to their transparent nature, where all transactions are publicly visible. Crypto asset mixers, or tumblers, are a common approach to improving privacy, as they pool crypto asset deposits and allow

withdrawals without revealing the connection between addresses. However, these mixers can also be used for money laundering and concealing illicit activities, leading to regulatory scrutiny.

513 Non-custodial crypto asset mixers leverage distributed cryptographic systems to maintain anonymity and eliminate liquidity risks. These mixers can strike a balance between privacy and transparency, enabling legitimate users to preserve anonymity while making it difficult for malicious actors to use the technology for illicit purposes through disclosure of cryptographic proofs. However, there are still challenges in ensuring funds from sanctioned entities don't end up in the hands of unsuspecting recipients. While regulating or banning the technology might not be effective, involving centralized financial intermediaries when converting crypto assets to legal tender can help enforce due diligence and mitigate risks. Nevertheless, inefficient global enforcement can result in long processes for fraud victims. Fraudulent crypto assets may remain in tumblers for extended periods, potentially leading to insolvency for impacted parties and raising concerns about criminal liability statutes due to the near-permanent storage in smart contracts.

4.4.3 Additional EU digital finance packages

514 The rapid digitalization of the financial sector has increased reliance on information and communication technology (ICT) systems, exposing the financial system to risks such as cyber threats and ICT disruptions. To address these challenges and enhance "*the operational resilience, performance, and stability of the Union financial system*" (DORA, 2022), the Digital Operational Resilience Act (DORA) has been enacted. With the use of DORA, critical ICT third-party service providers will be continuously monitored in order to create a cogent strategy for the resilience of critical entities, such as cloud computing service providers.

515 Effective detection and prevention of ICT risks require regular sharing of threat and vulnerability intelligence among financial entities. DORA seeks to strengthen communication channels, maintain a high level of digital operational resilience, and promote a balanced solution to ICT third-party concentration risk. Furthermore, the proposal for a Regulation on information accompanying transfers of funds and certain crypto assets (TFR) aims to establish a regulatory framework for enhancing traceability and transparency, combating money laundering and terrorist financing.

516 From a behavioral finance and regulatory public policy perspective, it is crucial to recognize the role of behavior in determining the effectiveness of risk management in cybersecurity practices. Nudge-based interventions can be designed to promote desirable behaviors among financial entities and individuals. Regulations should be tailored to unique characteristics and risk profiles, applying proportionality principles and conducting cost-benefit analyses. Lastly, a holistic approach to financial regulation should be adopted, ensuring consistency and coherence in the regulatory landscape, ultimately leading to a more effective, efficient, and adaptive regulatory environment.

4.4.4 Behavioral finance and regulatory public policy implications

517 Individuals' cognitive biases and affective influences play a significant role in financial markets. Common biases, such as hyperbolic discounting with regard to monetary gains and losses, shifting in reference-points, limited search for information due to confirmation bias, erroneous understandings of inflation, etc, can contribute to market anomalies. These biases are often exacerbated by emotional and social factors, which is why it may be challenging for people to make rational financial decisions. Social norms and cultural conventions are also deeply ingrained in financial organizations, making it challenging to change traditional market practices (Gärling et al., 2009).

In the rapidly evolving DeFi landscape, understanding cognitive biases and their impact on financial decision-making is critical. Biases such as confirmation bias, herd mentality, and the anchoring effect can lead to market inefficiencies and suboptimal outcomes. Regulators and policymakers should consider these behavioral tendencies when designing public policies to mitigate adverse effects, promote transparency, and encourage informed decision-making in the context of DeFi or service providers bridging centralized and decentralized finance.

518 Behavioral economics can inform policy interventions through choice architecture, framing effects, and default options. By presenting investment options in a way that encourages informed decision-making, choice architecture can help investors better assess the trade-offs associated with different investment choices. Simplifying disclosures and presenting information in a clear, concise, and standardized format can reduce information asymmetry and promote informed decision-making. Framing effects can also

influence investor behavior; for example, presenting potential losses more prominently than potential gains could encourage investors to consider risks more carefully. Additionally, incorporating default options considering diversified investments can promote prudent investor behavior while maintaining freedom of choice.

However, implementing these policies in truly decentralized systems 519
may be challenging due to the lack of a regulatory subject. Centralized intermediaries bridging centralized and decentralized financial systems may be required to impose such rules. Regulators must strike a balance between fostering innovation and ensuring investor protection and remain adaptable to keep pace with the rapidly changing DeFi landscape.

Regulatory sandboxes can offer an iterative, collaborative approach to 520
regulation, facilitating knowledge exchange between regulators and industry participants. Additionally, international cooperation is essential for harmonizing regulatory standards across jurisdictions and preventing regulatory arbitrage in the context of decentralized finance. By engaging in international cooperation and knowledge sharing, regulators can develop common guidelines and principles, fostering a more coordinated global response to regulation in the context of DeFi.

Another concern is the growing prevalence of AI-driven investment 521
strategies, such as robo-advisors, algorithmic trading, and machine learning models, which has led to apprehensions regarding the potential for mass contagion and herd mentality effects, which could amplify existing biases and contribute to market inefficiencies. Mass contagion, the rapid spread of behaviors, emotions, or ideas through a population, and herd mentality, the tendency of individuals to follow group actions or beliefs, can manifest in AI-driven investment decisions by creating correlated trading signals and self-reinforcing feedback loops that amplify market trends.

These potential effects necessitate further research to understand the im- 522
plications for financial markets, including increased volatility, asset bubble formation, and capital misallocation. To mitigate risks, diversification in AI-driven investment strategies, ensuring AI models are trained on diverse and representative data, and promoting transparency in investment algorithms can help reduce the potential for correlated trading signals, market contagion, and herd mentality. Financial education programs can also assist investors in making informed choices and avoiding blind conformity with algorithmic or AI-based trading decisions.

Mass contagion effects in AI-driven investment decisions has the poten- 523
tial to lead to unforeseen systemic risks and global-scale failures in finan-

cial markets due to interconnectedness, cross-border spillovers, contagion across asset classes, and the reliance of financial institutions on AI-driven strategies. Policymakers and market participants should consider strategies like robust stress-testing and scenario analysis, monitoring and regulating AI-driven investment strategies, and fostering international cooperation to mitigate the risk of global-scale failures and promote financial system stability and resilience.