

# THE EVOLUTION OF THE SETTLEMENT PROCESS IN CAPITAL MARKETS

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FROM **TRADITIONAL** TO **DECENTRALIZED** FINANCE



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This paper reflects the complementary expertise of Cetif Advisory, spin-off of the Research Center on Technology, Innovation and Finance of Cattolica University of Milan, and Hercle srl in investigating the benefits and challenges Decentralized Finance offers in the field of Capital Markets.



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Since 1990, Cetif (Research Center on Technology, Innovation and Financial Services at the Catholic University of Milan) has been carrying out studies and promoting research on innovation and on strategic & organizational change in the financial and insurance sectors.

From January 2020, Cetif evolves to fulfill the third mission of the Catholic University in order to transfer to its clients all the value generated from its research center. Thus is born Cetif Advisory, a spinoff of Cetif, which focuses on end-to-end consulting, from analysis to implementation of solutions from various areas (Blockchain & DLT, Artificial Intelligence).



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Headquartered in Milan, Hercle is a leading European digital assets broker-dealer and market maker providing institutions, corporate treasuries, token issuers, and Virtual Assets Service Providers (VASPs) with digital assets liquidity.

Hercle provides end-to-end solutions to support investors, institutions and payment services across the whole trade life cycle, and leverages its low-latency technology, battle-tested operational framework and algorithms to execute market neutral strategies while providing bid-ask liquidity and tightening the spreads

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# EXECUTIVE SUMMARY

**The evolution of the settlement process in capital markets has undergone significant changes over the years.**

Traditionally, the settlement process in capital markets was manual and involved multiple intermediaries, resulting in increased costs, risk, and longer settlement times. The introduction of digital technology in the 1980s paved the way for electronic settlement, which reduced the time and costs associated with manual processes. However, the continued reliance on intermediaries and central authorities left the system vulnerable to risks such as counterparty and operational risks.

With the rise of blockchain technology and cryptocurrencies, DeFi has emerged as a new paradigm in the settlement process. DeFi leverages decentralized networks and smart contracts to create a trustless and transparent settlement process. This eliminates the need for intermediaries and central authorities, reducing costs, increasing efficiency, and reducing risk.

One of the key advantages of DeFi is the ability to create new financial instruments and marketplaces. This includes the creation of decentralized exchanges (DEXs), which allow for the trading of digital assets in a peer-to-peer manner. This has created a new paradigm in the settlement process, allowing for the near-instant settlement of trades, reduced costs, and increased accessibility to financial markets.

However, as with many rapidly adopted technologies, this evolution has brought forth a range of new risks and challenges, starting from the prospect of increased security risks due to the decentralization of financial systems (digital systems, smart contracts and oracles, the building blocks of DeFi, are prone to hacking, cyberattacks and loopholes), to apprehensions regarding the absence of regulation and supervision, potentially leading to increased fraud and market manipulation, leading the industry towards new institutional standards able to provide innovation to the settlement process by maintaining a safe and regulated ecosystem.

**To better understand this paradigm shift, this document provides a comprehensive analysis of the trade life-cycle in traditional financial (TradFi) markets, centralized-finance (CeFi), and DeFi. The key elements of clearing and settling securities transactions in each are evaluated, along with their respective advantages and disadvantages. It concludes with an overview of the future of post-trade services and a summary of the key findings.**



# EVOLUTION OF THE CAPITAL MARKETS

Throughout the last five decades, the processes' design of capital markets, as well as the technology infrastructure underneath them have vastly changed. Such change has primarily been driven by the advent of electronic markets, the rise of High Frequency Trading (HFT), the emergence of new sophisticated financial instruments and products, the broadening of access to capital markets by retail investors, and the influence of increasingly stringent regulatory measures.

Furthermore, the rise of Distributed Ledger Technologies (DLT), and more specifically blockchains, blockchain-related assets (i.e. crypto-assets), and decentralized finance (DeFi) presented new challenges for regulators and the financial industry.

The steady growth of the blockchain-based services as well as the crypto-asset market has already had a strong impact on capital markets, both in terms of technological infrastructure and regulatory considerations.

While the extant literature from both academia and practitioners have extensively examined the broader intersection between DLT and financial services (see Bringas et al. (2020), Treleven et al. (2017), and Mazur (2019)), this paper is mainly focused on the impact of these technologies on post-trade processes.

The post-trade process occurs after a trade is executed and encompasses two main activities: the clearing, and the settlement of the trade.

The clearing phase includes all actions taken prior to trade settlement, such as verification of the consistency of trade details, transactions approvals, modification of ownership records, and procedures to facilitate settlement. The clearing phase is mainly referred to the processes of matching and netting items that are rolled out after the trades are executed, typically within one business day of trade execution (T0 and T+1).

The settlement phase identifies the finalization of the trade, at which point the seller receives the payment and the buyer receives the security. The settlement phase commonly occurs two business days after the trade occurs (T+2).

Financial services have already actively analyzed the potential benefits arising from the implementation of blockchain throughout the trade lifecycle, highlighting that post-trade processes can be substantially enhanced by removing inefficiencies such as reconciliation of financial data, manual processing, long custody chains, and other operational frictions. (Priem, (2020)).

To provide a better understanding of the new paradigm fostered by DLT technologies on post-trade processes, it is essential to adopt a holistic perspective on the subject. In this vein, the remainder of this paper proposes a framework with three verticals, where vertical (i) describes the trade life cycle in different paradigm, vertical (ii) highlights the differences between clearing and settlement process, and vertical (iii) evidences advantages and disadvantages of the state of post-trade processes, in 1. Traditional Finance (TradFi), 2. Centralised Finance (CeFi), and 3. Decentralised Finance (DeFi).

For the scope of this report (i) TradFi is considered as the entire system underpinning traditional capital markets, including regulated financial intermediaries and market agents, (ii) CeFi addresses entities commonly referred as Virtual/Crypto Assets Service Providers (VASP or CASP) that provide centralized crypto-related services by interacting with smart contracts or blockchain technology, such as crypto-assets trading, lending, custody, etc..., and (iii) DeFi is referred as the ecosystem of financial services offered by decentralized protocols and smart contracts.



Fig.1: The new financial paradigm

# MARKET AGENTS

To streamline the post-trade process, both TradFi, CeFi, DeFi markets are hosting a heterogeneous set of agents and entities interacting with each other. Table 1 provides a taxonomy of market agents participating in the process.

	TradFi	CeFi	DeFi
Investors	X	X	X
Brokers	X	X	
Market Makers	X	X	X
Exchanges (trading platforms)	X		
Custodian Banks	X		
Depository Banks	X		
Clearing Houses	X		
CEXes		X	
Wallet providers		X	X
Blockchains		X	X
Token Issuers		X	X
DEXes			X

Table 1: Market agents involved in the trade life-cycle for the three systems

- **Investors:**

A market transaction begins with two parties who wish to engage into a trade, one seeking to buy an asset and the other to dispose of it. These parties are referred to as buyers and sellers respectively, and are identified as investors.

- **Brokers:**

A securities broker, also known as a registered representative, is a regulated intermediary that facilitates trades on behalf of investors by matching them with the investment opportunities and executing buy and sell orders.

There are two main types of brokers: i) the broker-principal (also known as single-dealers) and (ii) the broker-agent (also known as aggregators). Broker-principals act as market makers and are the counterparty of the client's trades, whereas broker-agents execute the client's order within the exchange or against other liquidity providers and market makers. Other

classifications include ECNs, OTC desks, prime-brokers, ATS, MTF, and systematic internalizer, those are all different types of brokers which differentiate among each regarding the procedure of execution of the trade and the set of services they provide. In their purest form, brokers are compensated through fees as the trade is executed, their interest is aligned with that of their investor, and they bear no risk as they never represent the counterparty of a trade but only act as intermediaries that facilitates it i.e. broker agent model.

- **Market Makers:**

Market makers are entities that provide liquidity to the market in the form of bid and ask prices at which investors seeking to acquire or dispose of assets can transact. The involvement of market makers in the secondary market usually leads to a rise in liquidity (Eldor et al., (2006)) and a reduction of the bid-ask spread. As the liquidity of the asset increases, market efficiency increases as well, resulting in a substantial



increase in the value of the asset (Sanger and McConnell (1996), Elyasiani et al. (2000)). . Market makers commonly operate within a high-frequency trading (HFT) environment and are frequently regulated entities. HFT competition in crypto-assets is mitigated by the not-latency sensitivity of the exchanges' technological infrastructure, since they have always preferred scalability over latency.

- **Exchanges:**

A stock exchange is a centralized platform that allows investors to buy and sell assets. Exchanges are organized on a call or continuous auction-based system. In a call auction system, offers to trade are aggregated over a designated time frame before being executed, whereas in a continuous auction system trades are processed instantaneously and paired with the available liquidity. The manner in which an exchange clears its orders ultimately affects market efficiency and liquidity (Garbade and Silber (1979)). Exchanges can also be classified as either order-based or dealer-based systems. An order-based system, such as the New York Stock Exchange (NYSE), relies on a limit order book (LOB) in which investors, via their brokers, place orders to sell or buy at a predefined price. A dealer-based system, such as Nasdaq, relies on prices and liquidity provided by market makers to enable trading. The first model does not guarantee execution but offers certainty of price of execution if the order is processed, the second one guarantees execution but at bid or ask prices. Currently, most exchanges function in a hybrid environment where both LOB and dealers are present.

- **Custodian Bank:**

A custodian bank, also known as a custodian or a securities custodian, is a financial institution that acts as a trustee for its clients' stocks, bonds, or other assets, whether in physical or electronic form, with the primary objective of safekeeping them. The custodian handles the settlement process, manages compliance and tax issues on behalf of the client.

- **Depository Bank:**

A depository bank is a specialized financial institution responsible for safeguarding the assets of custodian banks or investment funds. It ensures the proper execution of settlement and book entry processes for securities. In the United States, the Depository Trust Company (DTC), a subsidiary of the DTCC, serves as the primary central securities depository. Within the

European Union, investment funds must legally appoint a depository bank to protect their assets and guarantee adherence to the laws and regulations of their jurisdiction. Key services provided by depository banks encompass the monitoring of cash flows, maintaining accurate records, and supervising fund operations such as valuations, risk assessment, and investor subscription and redemption activities. By fulfilling these responsibilities, depository banks play a crucial role in enhancing the stability and transparency of financial markets.

- **Clearing House:**

All financial markets have a designated clearing house that acts as an intermediary between buyers and sellers, to handle the function of validating and finalizing transactions, and ensuring that all parties meet their contractual obligations post-trade execution. Clearing houses ensure that each trader does not incur counterparty risk by ensuring that all transactions are cleared and settled in a timely and efficient manner, and by providing a mechanism for the mutual offset of obligations between counterparties.

- **CEXes:**

Centralized Exchanges (CEXes) are trading platforms for crypto-assets, where participants can trade both FIAT and crypto-assets. They use a matching engine, internal accounting and reconciliation systems to keep track of client trades. They also act as custodians, utilizing omnibus accounts for both crypto-assets and FIAT, and work in a similar way to stock exchanges previously introduced. In addition, they might offer leverage to their clients, allowing them to trade with more funds which can lead to increased potential returns but also risk.

- **Wallet providers and custodians**

Wallet providers are services that allow investors to self-store their crypto assets. While self-custody offers control and security, it also comes with user experience limitations. To address these limitations, several custody service providers have emerged to store crypto-assets on behalf of third parties, thereby eliminating user experience friction at the cost of introducing counterparty risk (i.e. trust in the custodian). With self-custody, the investor is the sole holder of the access key to the wallet and is fully responsible for the integrity of their assets.





- **Blockchain:**

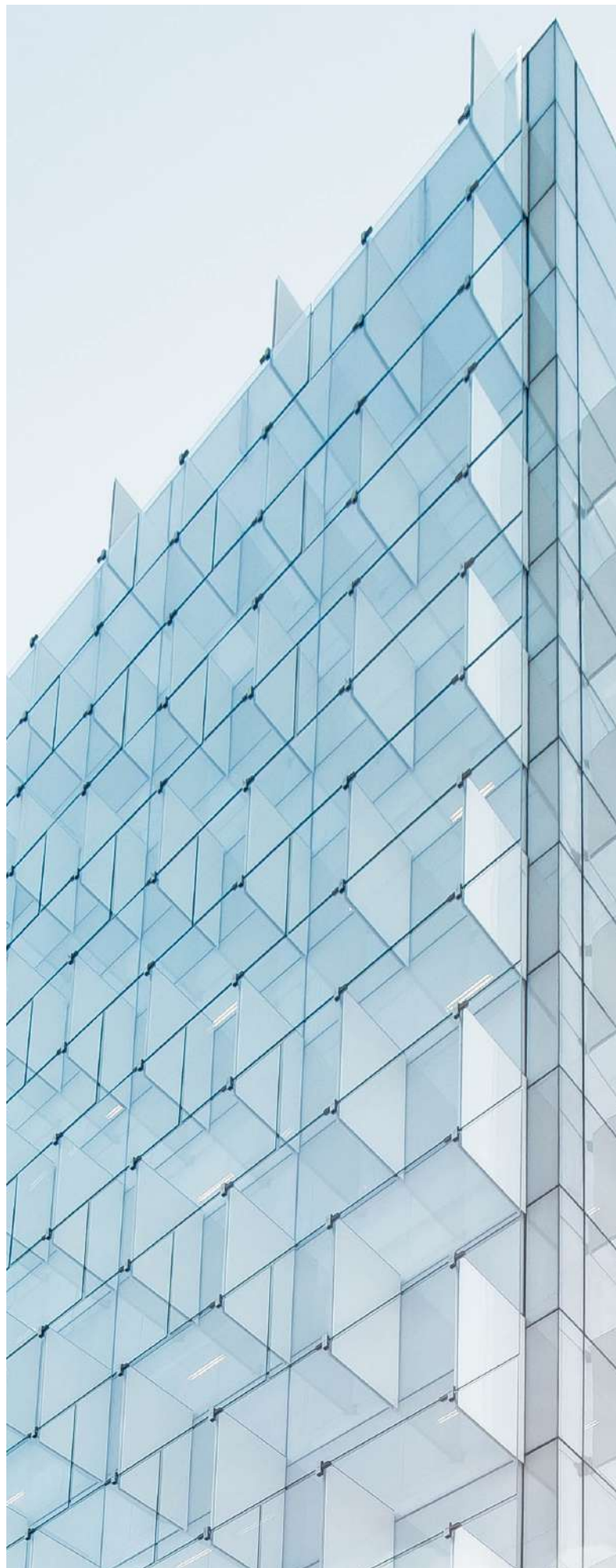
For the scope of this document, blockchain is considered a market participant as it serves as the “settlement layer” of all transactions that take place within the DeFi ecosystem, substituting TradFi market participants such as clearing houses. It’s governance system ensures the proper settlement of these transactions by providing a decentralized, transparent and tamper-proof mechanism to record and verify them.

- **Token issuers:**

Token issuers are the entities that create and launch a specific crypto-assets, commonly known as a token. Tokens are often linked to a particular utility or right within a specific protocol or decentralized application (dApp) and they can be used to access certain features or represent a share in the underlying assets. Token issuers are typically responsible for the token’s issuance, distribution, and management.

- **DEXes:**

Decentralized Exchanges (DEXes) are decentralized applications relying on smart contracts to facilitate crypto-assets trading in a non-custodial manner. In this decentralized system of exchange, investors rely on an order matching algorithm known as an Automated Market Maker (AMM) to perform orders. Unlike centralized exchanges, there is no intermediary dealer or service provider involved in the process. The AMM acts merely as an automatic facilitator of trades and of the price discovery process, and the counterparty in investor’s trades is always another investor. With DEXes, the custodianship of the assets is the responsibility of the investor, as they connect their wallet to the AMM application to enable trading. With AMM, most of the innovation to improve liquidity and market efficiency relates with the order matching algorithm, the democratization of market making activity and the market microstructure of the exchange. Nowadays, the most advanced DEX technology is pushing the boundaries by implementing both conventional Limit Order Books and more sophisticated Automated Market Maker systems to provide liquidity. DEXes also exist for both spot and derivatives trading.





# 1. THE TRADE LIFE-CYCLE IN TRADITIONAL FINANCE MARKETS

## 1.1 INTRODUCTION

Over the years, traditional financial markets have organically adapted in order to foster more market efficiency, fairness, accessibility and regulation.

On the technological and regulatory standpoint, with the rise of HFT players and digital retail brokers, subsequent challenges have emerged including the ability to process millions of trades per second, executing them at the best price, ensuring a transparent pricing and a level playing field, providing leverage, maintaining consistent reporting among parties and safeguard assets.

Such challenges are related to heavy operational and market risks that cannot be shouldered by a single entity. Therefore, market participants and regulators have adopted standards, provisions and best-practices to handle the full trade life-cycle that involves multiple specialized entities.

## 1.2 THE TRADE PROCESS

The financial literature distinguishes three main phases throughout the trade life-cycle; pre-trade, execution and post-trade (fig.2).

### 1) Pre-trade phase:

The pre-trade phase mainly refers to all the activities, risk management, and compliance checks that a broker must undertake before executing a client's order. This can include trade marketing to the client, determining the client's eligibility to trade a particular instrument, assessing whether the market has sufficient liquidity to meet the client's needs, and evaluating the client's portfolio risk profile using various risk metrics.

### 2) Execution phase:

The first step an investor undertakes to trade a given security is to submit a buy or sell order to their broker.

Acting as the client's agent, the broker routes the order to the market offering the most favorable price, i.e. best price execution. Once the order is fulfilled, the buyer and the seller enter into a legally binding agreement to transfer the securities from the seller to the buyer, in exchange for monetary remuneration from the buyer to the seller, thus executing the trade on both ends.

### 3) Post trade phase:

Post trade phase refers to all the mechanisms implemented subsequent to the execution of the trade, this can be identified as the sum of two distinct functions: clearing and settlement.

#### Clearing:

Trade clearing is the process that occurs within T+1 (trade date + 1 business day) post trade execution, and involves the recording of the transactions, posting sufficient margin, the netting of brokers' gross



Fig.2: Phases of Trade Life-Cycle



transactions, and their validation. This step is executed on a middle and back-office level through the cooperation of the broker, the custodian bank, the depository bank, and the clearing house (central counterparty).

### Settlement

Trade settlement usually occurs on T+2, and represents the final stage of the transaction where the actual transfer of securities and funds takes place. The securities are titled to the buyer and the funds are transferred to the seller. When both transactions are done almost simultaneously, it is referred to as Delivery versus Payment (DvP). The settlement process is facilitated by the clearing house and the custodians.

Most securities markets have resulted in trading on transaction day + 2 business days, taking into consideration the whole post-trade process that occurs in the back-office until final settlement is confirmed. Evidently, there is a degree of counterparty risk that lies on the foundation of such a system which is spread among various parties such as custodians, depository banks, clearing houses, and brokers, as well as high transaction costs and inefficiencies.

## 1.3 THE KEY ELEMENTS OF CLEARING AND SETTLING SECURITIES TRANSACTION IN TRADFI

The core of post-trade processes involves three main functions that brokers, exchanges, custodians or depository banks and clearing houses must perform, namely: (1) the matching of orders, (2) the netting funds, with matching and netting being both part of the clearing process, and (3) the settlement of assets. These processes foster increased capital efficiency for investors, a level playing field and reduce associated counterparty risks.

### 1. Matching:

Matching refers to the process of comparing and verifying that the transaction shall be settled within the required time frame, as dictated by the instructions and details of the counterparties involved in the trade. In today's electronic markets, when a broker sends an order into an exchange, the information that is dispatched is composed of the name of the stock, the price per share, the number of shares required, as well as other order conditions if provided. This information flow passes through a so-called matching engine that is part of the exchange's electronic trading system, the

engine matches buy and sell orders. If the information flow from the buyer and the seller coincides, the order is completed, and sent from the trading venue to the clearing house (referred as the Central Counterparty -CCP- in the EU and the National Security Clearing Corporation -NSCC- in the US).

The CCP cross-checks the counterparties' account with their corresponding custodians and confirms the receipt of the details of the transaction by sending the communication electronically to the trading firms, making it a legally binding communication and committing the firms to complete the transaction in the following settlement process.

Now the matching is completed with limited costs and risks thanks to the digitalization of the process. Nevertheless, the present matching system is far from being optimal and manifests a degree of inefficiency in terms of superfluous complexity and reconciliation, which can be time-consuming and prone to errors.

### 2. Netting:

Netting (fig.4) is a method of minimizing risks, while improving capital efficiency and liquidity in securities trading, by aggregating multiple financial obligations to arrive at a net obligation amount.

Netting is used to reduce settlement, credit, and other financial risks between two or more parties and increase capital efficiency. **According to a statement made by Gary Gensler in a lecture at MIT, the biggest economic reason for having the central intermediation of a clearing house is to allow and facilitate the process of netting.** Netting seeks to reduce the quantity and cost of transactions that must be made between firms to settle their trades.



Fig.3: Trade flow through market agents

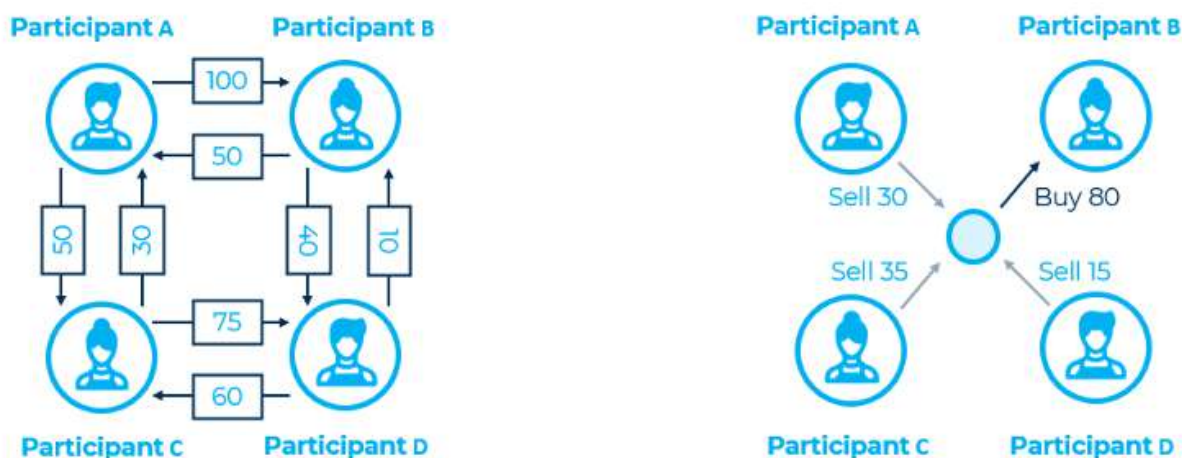


Fig.4: Netting processes

### 3. Settlement & DVP:

Settlement is the process of completing a trade in the financial markets. This involves the transfer of securities or cash from the buyer to the seller, as well as the appropriate recording of the transaction in the respective parties' accounts. The settlement process typically takes place after the trade is executed and can occur on the same day or on a future settlement date (T+2). The settlement process is a relevant part of the post-trade process that ensures a seamless functioning of financial markets. Settlement can occur in two different ways, Delivery versus Payment (DvP) or Free of Payment (FoP).

On the one hand, Delivery versus Payment (DVP) is a type of settlement process in which the delivery of securities to the buyer occurs only after the buyer made the payment. This type of settlement process reduces the risk of one party defaulting on the trade. In a DVP settlement, the securities are transferred to a third-party custodian, who holds them until payment is received from the buyer. Once payment is received, the custodian releases the securities to the buyer. This type of settlement process is commonly employed in the financial markets to ensure that both parties fulfill their obligations under the trade, being the custodian in the possess of the asset at the time of the payment, any default incurred by the seller between the time of the trade and the delivery of the asset will not affect the buyer and the ordinary settlement of the trade.

On the other hand, Free of Payment (FoP) settlement is a type of settlement process in which securities are transferred from the seller to the buyer without any payment being made at the time of the transfer. In FoP settlement, compensation is made at a later date, after the transfer of the securities takes place. This type of settlement is typically used in instances where buyer and seller agreed to a deferred payment arrangement, or where the buyer is borrowing the securities from the seller. FoP settlements can be used in both the cash and derivatives markets.







#### 1.4 ADVANTAGES & DISADVANTAGES OF POST-TRADE PROCESS IN TRADFI

	PROS	CONS
<b>Matching</b>	<ul style="list-style-type: none"> <li>- Accuracy of the process and error detecting;</li> <li>- errors managing process;</li> <li>- scalability (handling millions of trades per seconds among several counterparties);</li> <li>- predetermined matching rules.</li> </ul>	<ul style="list-style-type: none"> <li>- Several parties involved (i.e. exchange, brokers, custodians, clearing houses);</li> <li>- inefficiency in communications;</li> <li>- manual error managing process;</li> <li>- risk of human error.</li> </ul>
<b>Netting</b>	<ul style="list-style-type: none"> <li>- Scalability;</li> <li>- cost optimization;</li> <li>- capital efficiency and easier collateral management;</li> <li>- lower settlement cost.</li> </ul>	<ul style="list-style-type: none"> <li>- Counterparty risk (on the clearing house);</li> <li>- lack of DVP.</li> </ul>
<b>Settlement</b>	<ul style="list-style-type: none"> <li>- Isolation of risks on specialized entities.</li> </ul>	<ul style="list-style-type: none"> <li>- Human error;</li> <li>- Delayed settlement.</li> </ul>
<b>Whole post-trade process</b>	<ul style="list-style-type: none"> <li>- Investors are protected from failure of the brokers thanks to horizontal segregation of the bank and securities accounts;</li> <li>- advantages highlighted above.</li> </ul>	<ul style="list-style-type: none"> <li>- Inefficient process that involves several parties;</li> <li>- often requires human intervention that implies additional risk factors.</li> </ul>

*Table 2: Advantages & disadvantage of post-trade process in TradFi*



## 2. THE TRADE LIFE-CYCLE IN CENTRALIZED FINANCE

### 2.1 INTRODUCTION

**Centralized Finance (CeFi) is the term used to describe centralized crypto-assets capital markets where there are centralized players acting in the crypto-assets market ecosystem. These players include, but are not limited to exchanges, custodians, lenders, and OTC desks.**

The design of the processes and infrastructure of crypto-capital markets has been significantly influenced by the bottom-up, rapid growth of the market.

From the inception of the crypto markets, when entities such as M.T. Gox, BitInstant or Bitstamp held a dominant position, centralized exchanges (CEXes) sought to provide an end-to-end experience to crypto-traders and foster the scalability of their systems, favoring user experience over risk management. In fact, CEXes centralized all the risks that in TradFi are scattered among the market agents analyzed in section 1.3, as they serve as crypto-asset custodian, fiat custodian (without horizontal segregations among clients), broker, exchange and they perform the settlement. CEXes are handling all the risks across the entire trade life-cycle.

**This approach facilitated a fast growth environment but ultimately resulted in the failure of several exchanges, at the expenses of the investors.**

### 2.2 TRADE LIFE-CYCLE IN CeFi

As previously mentioned, in CeFi, all crypto trading activity is handled through a single institution, the service provider, which operates a privately-owned platform, the CEX, that facilitate the trading of crypto assets and allows the exchange of fiat currencies for cryptocurrencies. Investors are required to deposit fiat currencies or crypto-assets into their account within the purview of the service provider.

In the scenario of fiat currencies, the funds deposited by the investor will flow towards an omnibus account in the name of the service provider, whereas for crypto-assets deposits the assets will be directed to the omnibus wallet and custody solution used by the service provider.

When the deposit is made, investors submit their orders to the CEX, which possesses its own matching-engine capable of pairing buy and sell orders and executing the trade.

Once the order is executed, only the internal ownership records of the CEX is updated and investors are allowed to withdraw the funds to their own bank account or wallet.

#### 1. Pre-trade phase:

The CeFi pre-trade phase involves the onboarding on the CEX and deposit of funds ex ante the trade. There are no specific risk evaluations since the regulation does not require them. Nevertheless, the recent regulatory efforts are likely to result in the requirement to conduct pre-trade phase TradFi best-practices also for crypto-asset intermediaries.

#### 2. Execution phase:

Investors submit the order, and the centralized matching engine pairs buy and sell orders and execute the trade. In contrast to TradFi, CeFi matching engines do not have standard execution rules across the industry and may present a higher variance of latency in the execution. However, this higher latency is primarily attributed to the nascent state of the industry and the bottom up nature of the market that has pushed the industry towards a web-based infrastructure, which favors the maintenance of a broader, more equal, and concurrent access, in exchange for poorer performances and less liquidity. Furthermore, several exchanges have experienced downtimes during high volatile market conditions, as the entire crypto-world still resent from negative events related to specific market participants.



**3. Post-trade phase:**

in CeFi, post-trade processes are handled by the exchange’s internal systems that reconcile the accounting ledger, sacrificing transparency for investors. Additionally, settlement occurs immediately upon trade execution, and the matching is processed as deposits are made ex ante. This practice drastically increases the counterparty and operational risks. Furthermore, it can be argued that settlement can only be considered executed when the investor withdraws funds from the CEX to its own bank accounts. Furthermore, it is important to note that fiat settlement within, between, or from centralized exchanges is not as seamless as one might expect. This is primarily due to the limited number of banks willing to collaborate with Virtual Asset Service Providers (VASPs), as they face potential anti-money laundering (AML) and reputational risks.

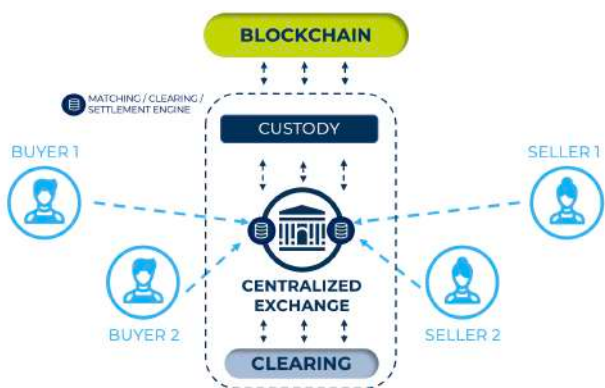


Fig. 5: Trade process in CeFi

**2.3 THE KEY ELEMENTS OF CLEARING AND SETTLING SECURITIES TRANSACTIONS IN CeFi**

CeFi trading can occur on both CEXes or through OTC desks; for the purpose of this report the emphasis will be on CEXes. Even in CeFi trading, it’s possible to identify matching and settlement phases, however, the netting process is unnecessary as the reconciliation is conducted internally and not among several parties, and the funds are deposited upfront by the investors.

**1. Matching phase:**

Centralized exchanges have order books: buy and sell

liquidity providers (often referred as Makers) and liquidity consumers orders (often referred as Takers) are listed and sorted by the intended buy or sell price, time in which the order is placed, and every trade from every user is recorded. The exchange’s matching engine pairs buyers and sellers according to the best executable price given the desired lot size. Investors can buy and sell crypto-assets at the prevailing price (i.e. “spot” price) or leave orders that are executed when the asset reaches the investor’s desired price target (i.e. limit orders). Upon trade execution, the exchange’s internal accounting and reconciling system matches the size, timestamps, and other details of the trade. The system retains fees to compensate for the exchange and the reconciliation of the orders. This concludes the matching phase<sup>1</sup>.

**2. Settlement phase:**

The trade settlement then occurs internally on the CEX’s ledger, be it a fiat-crypto trade or crypto-crypto trade, as the assets are held by the centralized exchange and the balances of each client account simply need to be adjusted post-transaction. When a client desires to deposit or withdraw a crypto asset, the settlement between the client’s wallet address and the exchange’s wallet address occurs on the blockchain. In the case of fiat, it is facilitated through centralized networks between the corresponding banks. Moreover, the settlement time differs depending on the type of withdrawal: crypto assets have a 24/7 operating time while fiat currency has a processing time of two to five business days (could also be instantaneous if available by the corresponding banks).

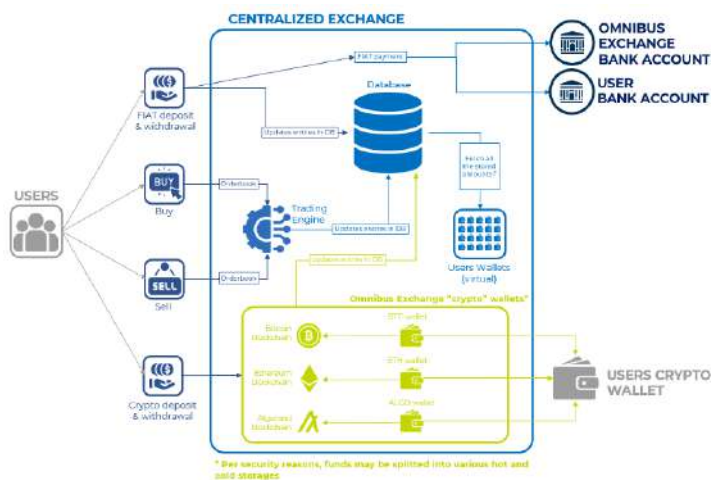


Fig.6: Trade process in custodial CEXes

<sup>1</sup> For the scope of this document OTC, which is increasing steadily in crypto, is not considered





As previously stated, the current settlement design in CeFi poses significant counterparty risks to investors, as they are required to settle the payment before the exchange dispatches the funds. Moreover, funds are stored in an omnibus wallet or an omnibus fiat account, resulting in mixing among the client's assets. Lastly, since client's funds are not segregated, clients do not have a preferential protection in the event of the exchange's failure or financial distress, and are treated equally to other creditors. Consequently, investors bear a significant counterparty risk related to any wrongdoing by the service provider that manages the centralized exchange.

## 2.4 ADVANTAGES & DISADVANTAGES OF TRADE FACILITATION THROUGH CENTRALIZED EXCHANGES

	PROS	CONS
Matching	<ul style="list-style-type: none"> <li>- Trade prioritization rules in place;</li> <li>- trade counterparty account details are all in the internal database of exchanges;</li> <li>- no human error in matching;</li> <li>- scalability (capacity to handle millions of trades per seconds);</li> <li>- collateral management and liquidation mechanisms.</li> </ul>	<ul style="list-style-type: none"> <li>- Use of individual internal database and matching engine for trade matching increases the risk of manipulation by the CEX due to the lack of transparency and point of control;</li> <li>- over dependence on a single matching engine and system to avoid trading halting, wrong liquidations, etc.;</li> <li>- wash trading;</li> <li>- not robust infrastructure, scalability is preferred over performances.</li> </ul>
Netting	N/A	N/A
Settlement	<ul style="list-style-type: none"> <li>- Internal settlement within the DEX accounting system;</li> <li>- almost instantaneous (depending on the blockchain infrastructure);</li> <li>- assets can be withdrawn to an address for which client holds the private keys with full ownership and direct control;</li> <li>- transactions settled on-chain resulting in transparency improvement without central communication.</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of transparency and risk of manipulation e.g. FTX;</li> <li>- withdrawal settlement relies on client-initiated transactions, but issues with the CEX's non-transparent trade processes may cause the settlement to fail;</li> <li>- risk of assets being unilaterally frozen on the side of the CEX upon the withdrawal settlement.</li> </ul>
Whole post-trade process	<ul style="list-style-type: none"> <li>- Good user experience in terms of funds management on the CEX account as well as trading;</li> <li>- faster transactions at lower costs;</li> <li>- cryptographically provable transactions;</li> <li>- self custody available if requested by customer.</li> </ul>	<ul style="list-style-type: none"> <li>- Client does not have full control of assets in custody in the exchanges' platform;</li> <li>- risk of manipulation of trade matching details and account balances due to the accounting information of the CEX being held on an internal and non-transparent database;</li> <li>- high cybersecurity risk;</li> <li>- not forecastable settlement cost due to variable blockchain fees.</li> </ul>

Table 3: Advantages & disadvantage of post-trade process in CeFi



## 3. THE TRADE LIFE-CYCLE WITHIN DECENTRALIZED FINANCE

### 3.1 INTRODUCTION

The term **Decentralized Finance (DeFi)** refers to a new capital markets' paradigm, which aims to replicate and innovate upon traditional financial system dynamics and agreements through the utilization of decentralized protocols built on blockchain technology and the implementation of smart contracts that favor the deterministic automation of transaction executions.

The rise of DeFi applications is rooted in the fundamental principles that underpin Bitcoin and blockchain technology, such as the censorship resistance of transactions, the scalability of protocols enabling widespread access to financial services and financial roles, and the disintermediation of centralized third parties.

The combination of blockchain's capabilities and smart contract's programmability promoted the emergence of several decentralized financial applications. In DeFi, investors can participate in a plethora of financial contracts (e.g. asset exchange, lending-borrowing, derivatives, etc...) without any type of legal or physical constraints, aside from DeFi user experience complexity. DeFi enables investors to assume the role of liquidity provider, a function that is traditionally exclusive to established and relevant institutions in CEXes and TradFi.

In the following sections, the various agents within the DeFi ecosystem will be examined and subsequently, the DEX trading life-cycle is presented together with a focus on the post-trade phase.

### 3.2 DEFI TRADE LIFE-CYCLE

The process, opportunities and challenges of DEX trading are intrinsically related to two elements: the design of the DEX smart contract, that embeds the logic of the trade cycle, and the underlying blockchain on which the smart contract is built on.

Since the nature of DeFi is peer-to-peer networking and on-chain validation of orders, early DEXes faced significant challenges such as the additional cost of on-chain transactions (blockchain fees) with respect to traditional stock exchanges, the ability to automatically provide liquidity under diverse circumstances, and the provision of a reliable price discover process.

The cost of on-chain transactions implies that DEXes could not rely on a system as efficient as stock exchanges, as market makers and investors would have to incur a blockchain fee to simply submit the order, thus affecting liquidity and the pricing mechanics. Uniswap mitigated the issue by introducing the concept of an Automated Market Maker (AMM).

AMM allows digital assets to be traded leveraging the concept of liquidity pools. In the first versions of Uniswap (V1.0 and V2.0), investors allocated their liquidity equally in the quote and base currency.

Investors acting as a liquidity provider are remunerated with a pro-quota reward based on the size of their provision relative to the entire pool. Every transaction made in a DEX by buyers and sellers consumes liquidity provided by the liquidity pool, for which liquidity providers earn a reward. Liquidity pools serve a critical function in facilitating the price discovery process by employing bonding curves or constant product logic to ascertain the price of assets. In the context of a constant product liquidity pool, the product of the quantities of the base and quote currencies remains unchanged. As the demand for the quote currency escalates, investors exchange an increased amount of base currency for it, subsequently altering the composition of the pool. As a result, the pool contains a larger proportion of base currency and a reduced proportion of quote currency. In accordance with the constant product formula, this shift engenders an augmentation in the price of the quote currency, as the pool endeavors to maintain the invariant product value. This mechanism ensures the perpetual updating of prices, reflecting market forces and fostering efficient price discovery.

The key features of DeFi and DEXes trading is that investors can engage in non-custodial and permissionless trading and that smart contracts ensure



an almost instantaneous DvP settlement. To interact with a DEX, investors must connect their wallet with the DEX, transfer the asset they want to trade to the smart contract, and receive the desired asset back from the smart contract.

Some DEXes furtherly innovate the trade cycle by issuing a specific token, known as LP token, to liquidity providers who contribute both token to the pool. This LP token represents the share the investor has in the liquidity pool, and the claim on the reward from providing liquidity to the market. LP tokens are exchangeable as any other token and investors can use them as collateral to borrow additional funds or trade them as they carry the right to perceive future cash flow of the pool.

### 3.3 THE KEY ELEMENT OF POST-TRADE SERVICES IN DEFI

In a DeFi context, the smart contract fulfills the role of both TradFi and CeFi matching engine, as well as that of a clearing house. The smart contract executes initial pairings of investors with liquidity providers, subsequently transmitting the corresponding assets and settling the trade.

In fact, the matching and clearing function is carried by the smart contract in a deterministic and atomic way. Furthermore, the smart contract is in charge of the actual settlement via the blockchain infrastructure.

The concentration of different roles within a single, automated contract already testifies one of the main improvements that DeFi might provide to settlement: a hedge against human error and wrongdoing. On top of that, on-chain settlement brings transparency and instantaneity as additional benefits. On the transparency side, any individual can verify that the settlement transaction occurred, along with the details of the trade, the amount, the kind of trade, and the parties involved. This is what the investor receives in exchange for paying the blockchain fee. However, the parties are identified by pseudonyms in the form of alphanumeric strings, mitigating the lack of privacy of the parties.

Regarding instantaneity of the settlement, the smart contract by executing the transaction ensures a DvP settlement where the parties do not bear any counterparty risk, neither from the other party involved in the trade nor of any service provider as happens in

CEXes. The only relevant risk that parties are undertaking is the smart contract's cybersecurity risk. However, the most adopted DEXes have battle-tested, audited and open-source smart contracts, with a strongly mitigated and decreasing in time cybersecurity risk.

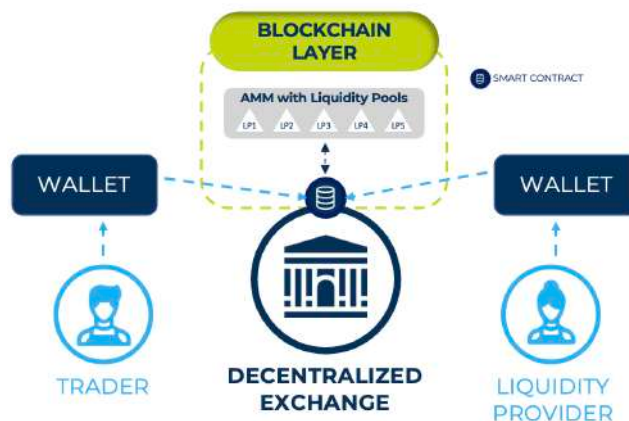


Fig.7: Trade process in DeFi







### 3.4 ADVANTAGES & DISADVANTAGES OF TRADE FACILITATION IN DECENTRALIZED FINANCE

	PROS	CONS
<b>Matching</b>	<ul style="list-style-type: none"> <li>- Trade prioritization rules in place;</li> <li>- no human error in matching;</li> <li>- scalability (depending on the blockchain infrastructure);</li> <li>- transparency in code composing the smart contract that dictates the trade matching;</li> <li>- transparency regarding market players.</li> </ul>	<ul style="list-style-type: none"> <li>- Cybersecurity risk;</li> <li>- front-running risk i.e. MEV;</li> <li>- high trading costs due to slippage and lack of liquidity;</li> <li>- no KYC/AML;</li> <li>- no privacy regarding market trades.</li> </ul>
<b>Netting</b>	N/A	N/A
<b>Settlement</b>	<ul style="list-style-type: none"> <li>- Almost instantaneous (depending on block speed);</li> <li>- delivery versus Payment;</li> <li>- transactions settled on-chain, cryptographically provable;</li> <li>- transparency of settlement regarding the instruments and the market agents.</li> </ul>	<ul style="list-style-type: none"> <li>- Security and guarantee of settlement is dependent on underlying blockchain used;</li> <li>- variable cost of settlement due to blockchain fee volatility;</li> <li>- no standardized integrations and interactions with FIAT legacy systems.</li> </ul>
<b>Whole post-trade process</b>	<ul style="list-style-type: none"> <li>- Seamless access to anyone with a wallet i.e. social scalability;</li> <li>- trading facilitated in non-custodial manner;</li> <li>- no need for trust in a central counterparty;</li> <li>- instant execution with AMM;</li> <li>- cryptographically provable transactions;</li> <li>- transparency of code composing smart contract resulting in self-auditability.</li> </ul>	<ul style="list-style-type: none"> <li>- No KYC or AML enforcement;</li> <li>- systemic risk in terms of underlying technology and exposure to hacks;</li> <li>- not fully integrated with the FIAT systems yet;</li> <li>- not fully integrated with traditional instruments, i.e. Real-World Assets (RWA) yet;</li> <li>- high cybersecurity risk;</li> <li>- lack of privacy;</li> <li>- MEV exploitations;</li> <li>- regulatory risks varying upon different jurisdictions;</li> <li>- not efficient price discovery accompanied with high transaction costs.</li> </ul>

Table 4: Advantages & disadvantage of post-trade process in DeFi

# THE FUTURE OF POST-TRADE SERVICES

As previously demonstrated, post-trade services are critical to understand the net position of traders, reconciling positions among buyers and sellers, and mitigating counterparty risks.

**In TradFi**, all these functions are carried by the several agents involved, thus resulting in high operational costs but in relative risks for the investors.

On the other hand, **in CeFi** these responsibilities are solely carried out by the service provider that manages the exchange. This structure implies a massive concentration of risks on an unregulated entity (the exchange) and a low safeguard for investors. Furthermore, the lack of segregation between the equity capital of the exchange and clients' funds serves as an additional risk factor, frequently resulting in substantial losses for investors<sup>2</sup>.

**DeFi**, instead, brings several innovations for the post-trade settlement process. Thanks to the deterministic nature of the smart contracts, matching and clearing activities happen instantaneously and without human intervention, this ensures a DvP settlement with drastically reduced counterparty risks as well as inefficiencies of TradFi settlement model, while significantly improving the transparency of the trade. However, it is important to highlight that not all blockchain systems have the same security model, finality, and decentralized nature, in fact every blockchain comes with its own tradeoffs and it is critical to choose the right one to pursue the aforementioned objectives.<sup>3</sup>

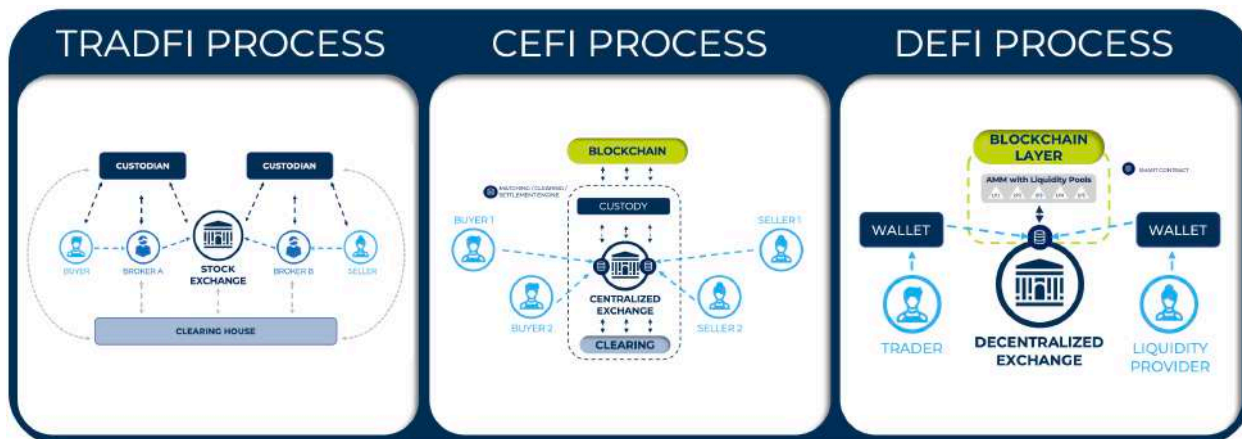


Fig.8: Comparison of the trade processes

<sup>2</sup> <https://www.investopedia.com/what-went-wrong-with-ftx-6828447>

<sup>3</sup> [https://scholar.princeton.edu/sites/default/files/markus/files/blockchain\\_paper\\_v3g.pdf](https://scholar.princeton.edu/sites/default/files/markus/files/blockchain_paper_v3g.pdf)



## CONCLUSION

It is clear that by leveraging DeFi design and blockchain integration, capital markets will witness substantial improvement in efficiency. We believe that thanks to the development of applications aiming to tokenize assets with different degrees of liquidity and bring them on-chain, institutional investors and market agents will start trading traditional equity or debt instruments on-chain, leveraging DeFi solutions. However, to achieve that stage, many improvements need to be implemented. DeFi still lacks the ability to enforce KYC and AML procedures and other compliance practices that must be introduced to give institutions the right comfort level. In addition, the DeFi space needs to grow and mature to become appealing to institutional players. As of January 2023, the liquidity, i.e. total value locked (TVL) and volumes in DeFi are not enough to ensure an efficient and seamless trading experience for institutions and sophisticated investors.

Finally, from the CeFi standpoint, we believe that the upcoming MiCA regulation and the growing maturity of the industry is pushing for a design similar to that of TradFi ones, where investor funds are segregated, conflict of interest is mitigated, custodians will be insured and isolated from exchanges, Chinese walls will be in place among market makers and exchanges. In this way, all the risks involved in the whole trade life cycle shall be split among specialized entities. Some actors like Hercle are already pushing for the aforementioned process' design.

Some actors are already trying to tackle those challenges by providing safe and secure solutions to enable institutional-grade trading for digital assets, contributing to the emergence of a new paradigm defined by Institutional DeFi.

**From Singapore (with Project Guardian) to Italy (with Cetif Advisory's ecosystemic project "Institutional DeFi for Security Token"), those services provide institutions with the necessary infrastructure to take advantage of the DeFi space safely and securely, allowing the authority to promote a regulated ecosystem of new financial services. By leveraging institutional DeFi services, institutions can gain access to a new and rapidly growing asset class while managing the risks associated with the nascent DeFi space.**



# GLOSSARY

<p><b>Alternative Trading System (ATS)</b></p>	<p>Electronic system that enables trading of financial products outside traditional stock exchanges. It provides an efficient and transparent marketplace, offering investors access to multiple sources of liquidity and pricing, as well as to increase trading volume and reduce execution costs.</p>
<p><b>Automated Market Maker (AMM)</b></p>	<p>Automated trading protocol that uses algorithms to enable the creation of a digital asset's secondary market. The majority of AMM is based on liquidity pools.</p>
<p><b>Central Counterparty (CCP)</b></p>	<p>Financial institution that provides clearing and settlement services for financial transactions between buyers and sellers. It acts as the intermediary between the two parties, taking on the counterparty risk of both parties and ensuring that the transaction is settled in a timely manner.</p>
<p><b>Decentralized Application (dApp)</b></p>	<p>Decentralized platform that does not rely on a third-party service to hold client funds and allows for exchanges to be made directly between users (peer-to-peer) through an automated process.</p>
<p><b>Decentralized protocol</b></p>	<p>Decentralized protocols are distributed systems that run on multiple computers connected via a network. They do not have a single point of control or failure, meaning that the system is resilient and continues to function even when individual components fail.</p>
<p><b>Delivery versus Payment (DvP)</b></p>	<p>System that delivers an asset in exchange for payment at the same time. This ensures that payment is made before the asset is delivered, eliminating the risk of default.</p>
<p><b>Digital retail brokers</b></p>	<p>Online stockbrokers who provide customers with access to a wide range of financial products. They offer a range of services, including asset allocation advice, portfolio management, research and analysis, and even automated trading.</p>
<p><b>Electronic Communication Network (ECN)</b></p>	<p>Electronic system that facilitates the trading of financial products outside traditional stock exchanges. It enables the electronically matching of purchase and sale orders in order to execute them.</p>
<p><b>High Frequency Trading (HFT)</b></p>	<p>Algorithmic trading type that uses powerful computers to transact a large number of orders at extremely high speeds. HFT uses complex algorithms to analyze multiple markets and execute orders based on market conditions to gain small profits from short-term price movements in stocks, options, futures, and other securities.</p>

# GLOSSARY

<b>Multilateral Trading Facility (MTF)</b>	Self-regulated financial trading venue that facilitates the exchange of financial instruments between multiple parties. It is a trading system in which multiple buyers and sellers can execute orders anonymously.
<b>National Security Clearing Corporation (NSCC)</b>	Clearinghouse that provides centralized risk management and post-trade clearance and settlement services for the U.S. securities markets. It is owned by the Depository Trust & Clearing Corporation (DTCC).
<b>Omnibus account</b>	Account in which a single account holder holds securities for multiple participants, such as brokers, traders, and investors. The account holder is responsible for the settlement of all transactions that involve securities held in the account.
<b>OTC desk</b>	Over-the-counter trading desks are investment companies that specialize in trading securities outside of exchanges. The company typically acts as an intermediary between buyers and sellers, facilitating transactions and providing liquidity to the market.
<b>Prime-broker</b>	Financial services firm that provides integrated services to hedge funds, including financing, securities lending, clearing, and settlement of trades, as well as custody of assets
<b>Real World Asset (RWA)</b>	Tangible asset that is held by an individual or business. Examples include real estate, precious metals, artwork, and other physical assets. These assets can be used as collateral, stored for investment or used as a hedge against inflation.
<b>Systematic internalizer</b>	Financial services firm that carries out transactions on its own account and acts as a market maker in financial instruments, rather than relying on a third-party broker. The firm is an intermediary between a buyer and a seller in a financial transaction.
<b>Smart contract</b>	Self-executable digital agreement notarized on a blockchain and enforced by the network.
<b>Virtual/Crypto Assets Service Providers (VASP or CASP)</b>	Companies that provide services to customers related to virtual/cryptocurrency and other digital assets, including buying and selling, storage and exchange services. They may also provide services such as merchant payment processing, consulting, and financial advice.
<b>MEV</b>	Maximal Extractable Value (MEV) is a term used in the context of cryptocurrency to refer to the maximum value that can be extracted by a miner or validator through frontrunning or transaction reordering.

# REFERENCES

- ▶ Amihud, Y., and H. Mendelson (1986). *Asset pricing and the bid–ask spread*. *Journal of Financial Economics*, 17, 223–249.
- ▶ Eldor R., Hauser S., Pilo B., and I. Shurki (2006). *The contribution of market makers to liquidity and efficiency of options trading in electronic markets*. *Journal of Banking and Finance*, 30, 2025–2040.
- ▶ Elyasiani, E., Hauser, S., and B. Lauterbach (2000). *Market response to liquidity improvements: Evidence from exchange listings*. *Financial Review*, 35 (1), 1–14.
- ▶ Garbade, K.D., and W.L. Silber (1979). *Structural organization of secondary markets: Clearing frequency, dealer activity and liquidity risk*. *Journal of Finance*, 34, 577–593.
- ▶ Sanger, G., and J. McConnell (1996). *Stock exchange listings, firm value, and security market efficiency: The impact of NASDAQ*. *Journal of Financial and Quantitative Analysis*, 31, 1–25.
- ▶ *Blockchain Platforms in Financial Services: Current Perspective* (Pablo Garcia Bringas; Iker Pastor-López; Giuseppe Psaila; 2020)
- ▶ *Blockchain Technology in Finance* (Philip Treleaven; Richard Gendal Brown; Danny Yang; 2017)
- ▶ *Brawl at the Gates: How Distributed Ledger Technology Is Transforming the Financial Services Sector* (Mieszko Mazur, 2019).
- ▶ <https://www.bancaditalia.it/pubblicazioni/altri-atti-seminari/2011/paper-Degryse.pdf>
- ▶ Priem, R. (2020, February 6). *Distributed Ledger Technology for Securities Clearing and settlement: Benefits, risks, and regulatory implications - financial innovation*. SpringerOpen. Retrieved December 10, 2022, from <https://jfn-swufe.springeropen.com/articles/10.1186/s40854-019-0169-6>
- ▶ <https://www.fatf-gafi.org/glossary/u-z/#:~:text=Virtual%20asset%20service%20provider%20means,ii>.
- ▶ <https://www.federalreserve.gov/econres/feds/files/2022057pap.pdf>
- ▶ [https://www.deutsche-boerse.com/resource/blob/69642/6bbb6205e6651101288c2a0bfc668c45/data/high-frequency-trading\\_en.pdf](https://www.deutsche-boerse.com/resource/blob/69642/6bbb6205e6651101288c2a0bfc668c45/data/high-frequency-trading_en.pdf)
- ▶ <https://www.jbs.cam.ac.uk/wp-content/uploads/2022/06/2022-ccaf-conference-version-paper-bryzgalova-pavlova-sikorskaya-final.pdf>
- ▶ <https://support.sas.com/resources/papers/proceedings16/11201-2016.pdf>
- ▶ Hargrave, Marshall. “Netting: Definition, How It Works, Types, Benefits, and Example.” Investopedia, Investopedia, 30 Nov. 2022, <https://www.investopedia.com/terms/n/netting.asp>.
- ▶ <https://www.coindesk.com/markets/2014/04/16/mt-gox-officially-files-for-liquidation/>
- ▶ <https://cointelegraph.com/news/charlie-shrem-bitinstant-was-the-netscape-of-crypto>
- ▶ <https://arxiv.org/pdf/2102.11350.pdf>



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