A Comparative Analysis of the Performance of Centralized and Decentralized Exchanges in the Cryptocurrency Market: A Liquidity, Security, and Knowledge Management Approach

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Abstract: The primary benefit of decentralized exchanges (DEX) and centralized exchanges (CEX) in the cryptocurrency market is their distinct approach to resolving issues related to liquidity, security, and knowledge management. Adjusting strategies in a timely manner based on market conditions and user feedback can lead to resource optimization and improved efficiency. One of the key advantages of DEXs is their reliance on decentralized networks, where knowledge is distributed across users, enhancing transparency and security. On the other hand, CEXs benefit from centralized control, which allows for swift decision-making and high liquidity. In this paper, we aim to analyze and prioritize the factors influencing the performance challenges in both types of exchanges, focusing on liquidity management, security protocols, and the role of knowledge sharing. Through a comprehensive review of the literature, three categories of factors—organizational, technological, and user-based—were identified. These factors are crucial in determining how knowledge is managed and applied to improve decision-making processes and security in both CEXs and DEXs. Expert opinions from professionals in the cryptocurrency and blockchain industry were gathered to validate these factors. Using the DANP method, we explored the causal relationships and prioritized the factors based on their impact on performance. The findings revealed that organizational factors in CEXs have a significant influence on liquidity and security, while user-based factors are more prominent in DEXs due to their decentralized nature. Technological factors, including blockchain innovation, play a critical role in both. The study identified five key challenges related to knowledge management: insufficient knowledge sharing between users and developers, reluctance to adopt new security technologies, lack of communication between market participants, limited training for new users, and the underestimation of knowledge management's impact on overall performance. Recommendations were provided to help exchanges reduce these challenges, ensuring better management and enhanced performance in both centralized and decentralized platforms.

Keywords: Centralized Exchanges (CEX), Decentralized Exchanges (DEX), Cryptocurrency Market, Knowledge Management, Liquidity Management, Security in Exchanges.

1. Introduction

The rise of cryptocurrencies has transformed the global financial landscape by introducing new paradigms of value exchange, trust management, and market operation. At the core of this transformation are cryptocurrency exchanges, which act as the primary infrastructure for enabling trading, liquidity formation, and risk allocation across digital assets. Exchanges exist in two broad categories—centralized exchanges (CEXs) and decentralized exchanges (DEXs). Each of these systems embodies different philosophies and operational logics that shape how liquidity is provisioned, how security is ensured, and how knowledge is managed across networks. Centralized exchanges mirror the design of traditional financial institutions, where authority and control are consolidated under a single organization that facilitates order book trading. Decentralized exchanges, in contrast, rely on blockchain protocols and automated market makers (AMMs) to facilitate peer-to-peer transactions without intermediaries. Understanding the dynamics of CEXs and DEXs has become especially urgent in light of significant recent developments such as the collapse of major platforms, the proliferation of decentralized finance (DeFi), and the integration of new technologies like non-fungible tokens (NFTs), decentralized identity systems, and decentralized autonomous organizations (DAOs). These innovations are reshaping the contours of global finance and pose fundamental questions about efficiency, transparency, and resilience [1-4].

A central dimension of the comparative analysis between CEXs and DEXs is liquidity, which represents the ability to execute trades rapidly at stable prices. Traditional centralized exchanges benefit from deep liquidity pools and structured order books, making them attractive for high-frequency traders and institutional investors [5]. Their centralized infrastructure supports efficient price discovery but is vulnerable to manipulation and systemic risks. DEXs, on the other hand, have introduced automated market maker protocols, most prominently Uniswap, that allow liquidity providers to pool assets and earn transaction fees. The constant product formula underlying AMMs has attracted significant theoretical scrutiny, with research highlighting its strengths and conceptual limitations [6, 7]. Further innovations, such as concentrated liquidity in Uniswap v3, have sought to overcome inefficiencies and enhance market depth [3, 8]. However, liquidity fragmentation and the high cost of gas fees on blockchain networks continue to pose significant barriers to seamless adoption [1, 9]. These challenges underline the need to assess not only the mechanics of liquidity provision but also its interaction with transaction costs and broader market efficiency.

Security remains another key differentiator between centralized and decentralized platforms. Centralized exchanges, while efficient, rely on custodial models in which user assets are held by the exchange operator. This structure has repeatedly exposed CEXs to catastrophic failures, including hacks, insider fraud, and liquidity crises. The recent collapse of FTX vividly illustrated the risks inherent in centralized custody, eroding user trust and sparking regulatory scrutiny [10]. Reports of massive losses underscore how operational and governance failures can destabilize entire markets [11]. By contrast, decentralized exchanges enable users to retain custody of their assets through non-custodial wallets, reducing counterparty risks. Yet DEXs are not immune to security vulnerabilities; smart contract exploits and governance loopholes have enabled hackers to siphon millions from DeFi platforms [12]. Moreover, impermanent loss—a phenomenon unique to AMM-based liquidity provision—exposes liquidity providers to significant risk [13, 14]. Innovative strategies, such as variance swaps and delta hedging, have been proposed to mitigate these risks, but their adoption remains limited [9, 15]. The duality of enhanced user autonomy and heightened technical vulnerabilities positions security as a core area of comparative research between CEXs and DEXs.

Knowledge management constitutes a less frequently examined but equally critical factor in shaping exchange performance. Centralized exchanges benefit from centralized data aggregation, allowing them to deploy advanced analytics, optimize trading algorithms, and tailor services to user profiles [16]. They integrate compliance systems, risk models, and customer relationship management strategies into cohesive infrastructures. In contrast, decentralized exchanges embody a radically different model of knowledge management, where transparency is enforced by blockchain design but data is fragmented across distributed ledgers. This makes it challenging to analyze market activity comprehensively without sophisticated tools [17]. Nevertheless, the open-source and community-driven ethos of DEXs fosters rapid innovation, as collective intelligence and peer review accelerate the development of new protocols and security patches [18]. The intersection of transparency, fragmentation, and collective knowledge dynamics distinguishes DEXs from their centralized counterparts and introduces new research challenges regarding decision-making efficiency and innovation.

Beyond the triad of liquidity, security, and knowledge management, broader institutional and technological shifts are shaping the debate. The rise of NFTs has blurred the boundaries between financial assets and digital culture, challenging exchanges to integrate novel products [4]. Similarly, the emergence of DAOs raises profound legal and governance questions about the recognition of decentralized collectives as juridical persons [19]. Decentralized identity frameworks and smart contract-based verification systems promise to transform how trust and compliance are managed, with implications for both user experience and regulatory oversight [20, 21]. Legal scholars have also explored blockchain's potential to create decentralized credit scoring models, intestacy distribution systems, and legal record platforms, each of which highlights the convergence between finance, law, and digital governance [22-24]. These developments expand the scope of DEXs beyond mere trading venues into broader infrastructures for decentralized digital economies.

At the same time, the integration of DeFi into traditional financial ecosystems raises both opportunities and tensions. Comparative analyses suggest that decentralized and traditional systems may converge in certain domains, such as supply chain finance and banking services, but may also collide in terms of regulatory frameworks and systemic stability [25-27]. Studies highlight how DeFi's rapid growth has challenged established monetary policies and risk controls, prompting calls for regulatory innovations that balance efficiency with consumer protection [28, 29]. Furthermore, blockchain scaling debates reveal that liquidity concentration and network congestion continue to impede efficiency, reinforcing the necessity of technical solutions such as layer-2 protocols, sharding, and cross-chain bridges [8, 30]. The dynamic interplay between technical innovation, institutional adaptation, and regulatory intervention underscores the multidimensional nature of the DeFi phenomenon.

Theoretical contributions have enriched this discourse by modeling the behavior of liquidity providers, arbitrageurs, and traders across both exchange types. For example, economic models of fee structures show how raising DEX fees paradoxically increases trading volume by incentivizing liquidity provision [31]. Studies on optimal fee design in AMMs provide guidance on balancing efficiency with liquidity incentives [7]. Similarly, analyses of user trust reveal that confidence in decentralized exchanges is shaped not only by technical parameters but also by perceptions of fairness, transparency, and governance [18]. These insights highlight the behavioral dimensions of exchange performance and the importance of aligning technical design with user psychology.

Empirical research has further demonstrated the contextual nature of performance outcomes. For smaller trades, CEXs typically offer lower costs due to minimal transaction fees, while DEXs become more competitive for larger trades because gas fees operate as fixed costs that dilute with trade size [1, 2]. Innovations such as concentrated liquidity pools in Uniswap v3 have improved DEX efficiency, yet centralized platforms still dominate in terms of price efficiency and arbitrage opportunities [32, 33]. Recent shocks like the FTX collapse have shifted user behavior, pushing some investors toward DEXs to mitigate custody risks, while simultaneously highlighting the limitations of unregulated ecosystems [10]. The constant interplay between innovation and crisis suggests that the evolution of exchange systems is far from linear and will likely be shaped by cycles of experimentation, failure, and regulatory response.

Given these dynamics, the present study aims to provide a comparative analysis of centralized and decentralized exchanges, with a particular focus on how liquidity management, security frameworks, and knowledge management practices shape their performance and evolution.

2. Methodology

This study employs a mixed-methods approach combining both quantitative and qualitative analyses to compare the performance of Centralized Exchanges (CEXs) and Decentralized Exchanges (DEXs) in the cryptocurrency market. The focus areas of the analysis are liquidity, security, and knowledge management. The research leverages a dataset that includes transaction data, order books, and smart contract interactions from major exchanges, and integrates these with a theoretical framework based on existing literature.

Data Collection

Since decentralized exchanges (DEXs) operate via blockchain-deployed smart contracts, each interaction is publicly recorded. This comprehensive dataset includes various actions such as creating exchange pairs, liquidity adjustments by liquidity providers (LPs), and token swaps. From these interactions, it is possible to reconstruct information about liquidity levels, quoted prices, transaction prices, and trading volumes at any point in time. We utilized the publicly available data on Uniswap v2 from the Ethereum Mainnet through TheGraph.com, an indexing tool for blockchain data. For Uniswap v3, custom queries on Dune.com were employed to extract transaction records. In contrast, for Centralized Exchanges (CEXs), data were obtained through proprietary sources, including minute-by-minute snapshots of Limit Order Books (LOB) and OHLC (Open, High, Low, Close) price data from Tardis.dev, a specialized cryptocurrency data provider.

To compare the performance of seven major cryptocurrency exchanges, the study examined both decentralized (Uniswap v2 and v3) and centralized platforms (Binance, Kraken, Coinbase, Huobi, OKX) over the period from March 2021 to February 2023. Our dataset includes all trading pairs at the intersection of these exchanges, allowing for a comprehensive evaluation of market quality across both exchange types. The exchanges selected cover over 70% of CEX trading volume and 60% of DEX volume, representing a broad spectrum of cryptocurrency trading activity. Additionally, data from the Iran Securities and Exchange Organization were included to analyze the impact of cryptocurrency on the Iranian market.

Two significant events during this period were selected for further analysis. First, Uniswap v3 was launched on May 5th, 2021, providing a unique opportunity to assess the impact of new decentralized exchange features by comparing it with Uniswap v2, while using CEXs as a control group. This quasi-experimental setup helps explore whether innovations in DEX market designs can lead to measurable improvements in market quality. Second, the collapse of FTX, one of the largest centralized exchanges, occurred on November 10th, 2022. The collapse, triggered by liquidity issues related to FTX's token, FTT, led to significant volatility and financial losses. This event highlights the risks associated with centralized custody, providing a real-world case to study how such risks affect market trust and activity on CEXs.

Trading Volume and Transaction Characteristics

Table I presents summary statistics on the total trading volume and number of transactions for each exchange. The data show that Binance, Uniswap v3, and Huobi generated the highest trading volumes. In terms of the transaction size, DEX trades tend to be larger on average. Specifically, 80% of CEX trades involved amounts below $1,000, compared to just 35% on DEXs. Conversely, 33% of DEX trades were valued at more than $10,000, whereas only 1.7% of CEX trades reached that threshold. Moreover, some DEX transactions exceeded $1 million, a phenomenon virtually absent on CEXs. This difference in trade size distribution is largely attributed to the fixed cost structure of gas fees on DEXs.

Gas Fees and Their Role in DEX Transactions

Gas fees refer to the computational effort required to execute transactions on the Ethereum blockchain. These fees, collected by miners, are based on the complexity of the transaction and the gas price, which fluctuates with network congestion. Importantly, gas fees represent a fixed cost regardless of the transaction size, disproportionately affecting smaller trades. Our analysis shows that gas fees, while a minor factor for larger trades, can significantly impact the market quality of DEXs, as traders are incentivized to aggregate larger transactions to dilute the gas costs.

Using data from approximately 330,000 Uniswap v2 transactions and 200,000 Uniswap v3 transactions, we estimated the required gas for each swap and monitored the fluctuations in gas prices, which ranged from under $10 to over $300, depending on network conditions. This variability in gas prices, combined with the fixed gas unit requirement for swaps, creates a friction in the DEX market, affecting liquidity and efficiency, particularly for smaller trades.

In conclusion, the data drawn from both Iranian markets and global cryptocurrency exchanges highlight the critical role of transaction size and gas fees in determining the relative performance of centralized and decentralized exchanges. The study provides a unique comparative analysis, leveraging real-world data and important market events to examine the factors driving market quality across different exchange platforms.

Transaction Costs

With a thorough understanding of how centralized (CEXs) and decentralized exchanges (DEXs) operate, and access to data from Iran's stock market provided by the exchange organization, we are now equipped to examine the first important aspect of market quality—market liquidity. Market liquidity is generally defined as the ease with which assets can be traded at prices that closely reflect their true value (Foucault et al., 2013). A common approach to assess market illiquidity is to calculate the effective transaction cost of a trade, expressed as a percentage of the transaction amount. These costs include both the price impact due to trade size and any commission fees imposed by the exchange or protocol. Since CEXs and DEXs function in fundamentally different ways, their transaction costs are modeled differently. However, both methods are based on a shared conceptual framework, focusing on capturing the actual costs traders incur when executing trades (in US Dollar terms), such as slippage, fees, and settlement expenses.

Empirically, we calculate transaction costs $TC_{XY}(\Delta x)$ for a trade X ↔ Y on an hourly basis, examining different trade sizes for 20 exchange pairs, expressed in USD, separately for CEXs and DEXs.

A. CEX Transaction Costs

For CEXs that utilize order books (LOBs), the transaction cost for a market order is determined by two components: (i) the bid/ask spread based on the depth of the LOB, and (ii) the exchange's platform fees (taker fees). The bid/ask spread is calculated using volume-weighted bid and ask prices based on the full depth of order book quotes available at any given moment. This provides a direct measure of the transaction cost for a trade of a specified size. We then add the exchange fee to this spread to obtain the total transaction cost.

$$B_{XY}(\Delta x) = \frac{\sum_i v_i b_i}{\Delta x}$$

such that ${}^{X}v_i = \Delta x\ ,i$

where v_i and b_i represent the volume and the price of each filled bid limit order i, respectively. The volume-weighted ask price A_{XY} for a buy order of size Δx is defined symmetrically as

$$A_{XY}(\Delta x) = \frac{\sum_j v_j a_j}{\Delta x}$$

such that $^X v_j = \Delta x$,j

where v_j and a_j represent the volume and the price of each filled ask limit order j, respectively. We then define the Bid/Ask spread[1] as

$$S_{XY}(\Delta x) = \frac{A_{XY}(\Delta x) - B_{XY}(\Delta x)}{A_{XY}(\Delta x) + B_{XY}(\Delta x)}.$$

Finally, we add the fees f charged by the exchange, thus getting

$$TC_{XY}(\Delta x) = S_{XY}(\Delta x) + f.$$

Notice that the first term in the above expression is time-varying and depends on the trade size, while exchange fees are constant at the exchange level.[2]

B. DEX Transaction Costs

For DEXs using automated market maker (AMM) systems, we calculate transaction costs by including three factors: (i) the bid/ask spread based on the liquidity pools' depth, (ii) the exchange fees, and (iii) the gas fees for executing blockchain transactions. The gas fees, which vary depending on the computational complexity of the smart contract, are averaged over the trade sizes. In Uniswap v2, for instance, the gas costs are calculated by multiplying the gas units required for the trade by the median gas price during the relevant hour.

To summarize, DEX transaction costs for a trade of size Δx are defined as

$$TC_{XY}(\Delta x) = S_{XY}(\Delta x) + f + \frac{g}{\Delta x}, \qquad (3)$$

where S_{XY} is the spread, f the exchange fees, and g the gas fees associated to the trade. The expression for S_{XY} is described by equation (7) for Uniswap v2 and equations (11) and (13) for Uniswap v3. The first and last terms in the above expression are time-varying for both DEXs. The exchange fees f are constant for Uniswap v2, while in Uniswap v3 they depend on the optimal pool selected, as discussed above.

C. Main Results on Transaction Costs

Our analysis highlights two key findings. First, DEXs generally offer lower transaction costs for smaller trades, while for larger trades, Uniswap v3 shows more competitive rates compared to CEXs. Second, Uniswap v3 dominates in transaction cost reduction for stablecoin pairs like USDC-USDT, offering significantly lower costs than even the best-performing CEXs such as Binance. This is particularly notable for large transactions, where Uniswap v3's advanced systems result in spreads and fees comparable to those found in highly liquid financial markets.

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1 Note that our definition agrees with the standard "volume-weighted quoted half-spread".

2 CEXs may periodically revise their withdrawal fees. Using the WayBackMachine, we reconstruct the fee time series for Binance and Kraken based on the available snapshots. Although this approach isn't flawless, given the infrequent updates to these fees, we contend that our methodology is sufficiently accurate. A similar examination of exchange fees reveals that they remained constant throughout our sample period on the CEXs covered by our sample.

3. Findings and Results

To strengthen the reliability of our results, we conclude our analysis with four supplementary investigations. First, one might contend that comparing transaction costs (TCs) between centralized exchanges (CEXs) and decentralized exchanges (DEXs) is not entirely fair, particularly because DEXs also incur settlement costs. To address this concern, we conducted a new analysis that excludes gas fees from DEXs, with the results presented in Figure 1 of the Internet Appendix. The findings indicate that when gas fees are omitted, Uniswap v3 consistently shows lower TCs across various trading pairs and sizes. This observation reinforces our claim that the primary challenge to liquidity in DEXs stems from the inherent characteristics of the underlying blockchain technology rather than from economic frictions.

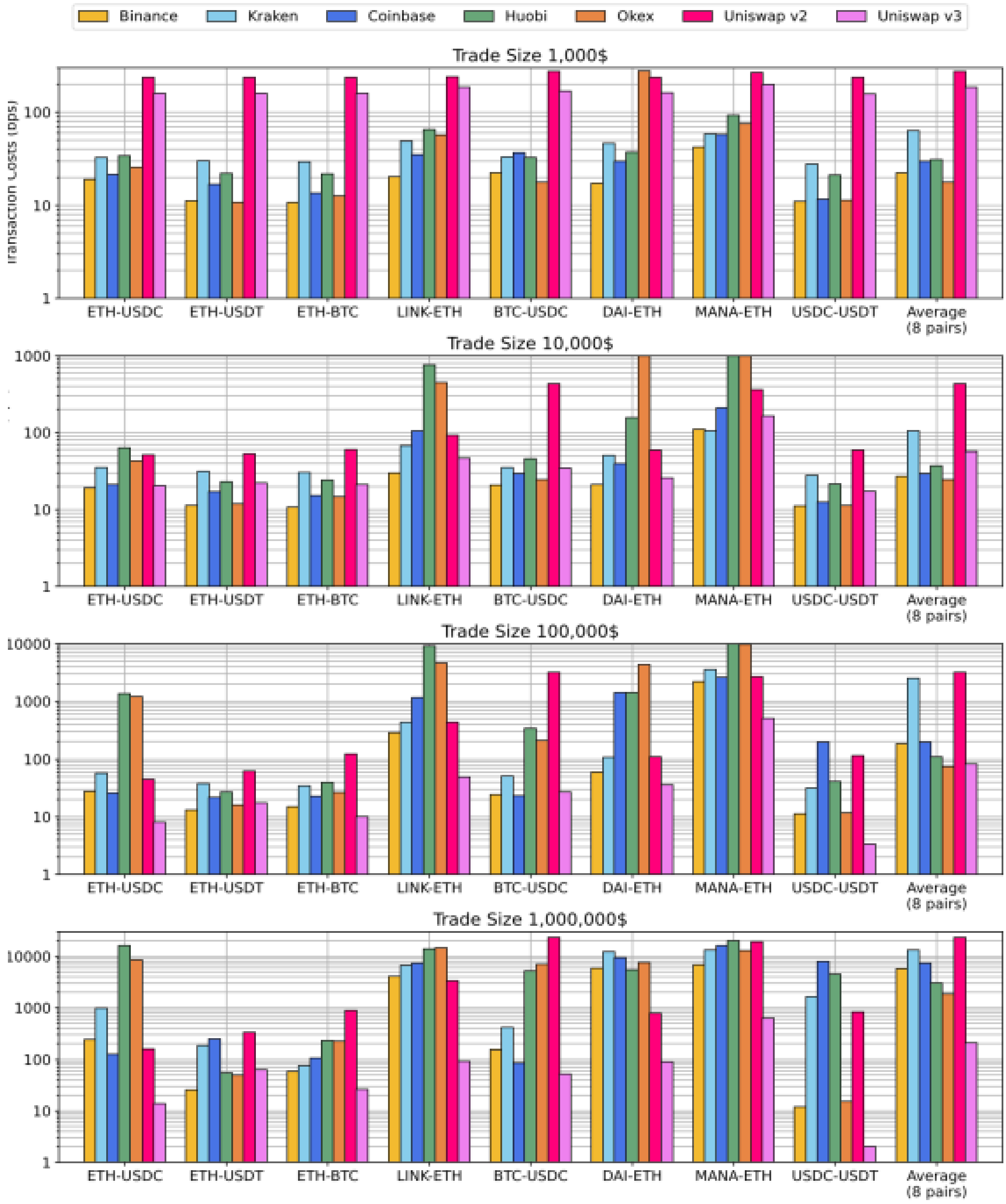

Figure 1. Transaction Costs (Excluding Gas Fees)

Second, we confirmed the robustness of our findings by including additional CEXs such as Coinbase, Huobi, and OKX, while limiting our analysis to the eight pairs common across all seven exchanges, as illustrated in Figure 2. Third, since Uniswap v3 was launched in May 2021, its TCs may be based on a smaller dataset than those of other exchanges, potentially skewing comparisons. To mitigate this issue, we re-evaluated our analysis using only data from the v3 subset starting in May 2021.

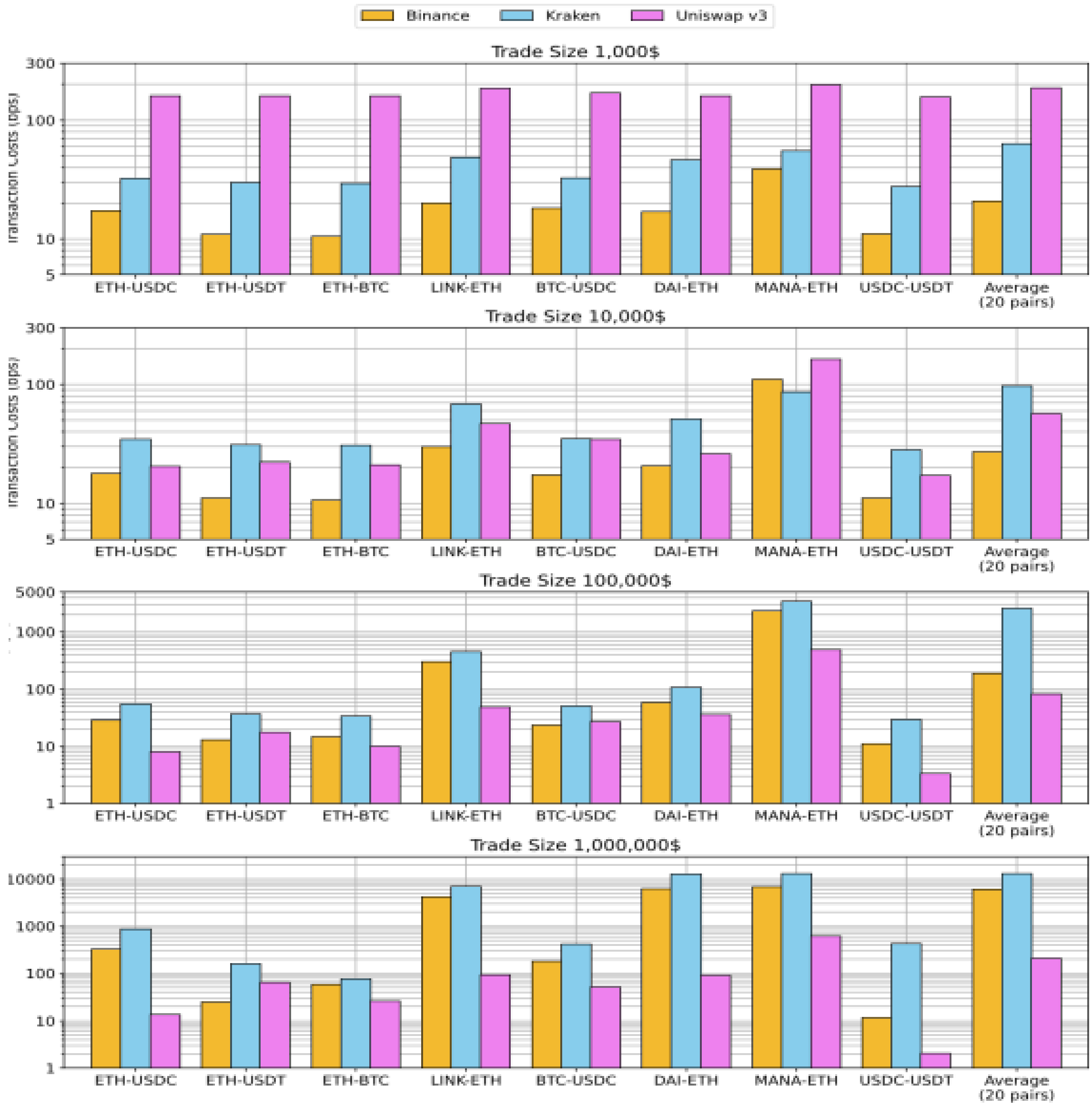

Figure 2. Transaction Costs (All Exchanges).

Lastly, it is worth noting that the high liquidity levels of DEXs may be linked to asset custody concerns. Investors might opt for these alternative platforms to minimize exposure to custody risks. This motivation could incentivize liquidity providers (LPs) to supply liquidity to DEXs. Additionally, as Figure 2 indicates, traders may still engage in smaller transactions on DEXs, even if it entails higher transaction costs. Should this custody concern be a driving factor behind the success of DEXs, one might predict a decrease in their attractiveness if tighter regulations on CEXs mitigate custody risks.

The collapse of the FTX exchange provides an insightful case study to examine the implications of risks associated with CEX custody. As one of the largest cryptocurrency exchanges globally, FTX declared bankruptcy on November 11, 2022, putting at risk approximately $740 million in crypto assets held on its platform (Huang, 2022). We hypothesize that this incident has heightened awareness of deposit risks and raised concerns about the management of user assets by CEX operators, potentially eroding trust. Furthermore, a notable increase in trading volumes on DEXs following this event could indicate a shift from CEXs to DEXs, emphasizing the role of custody risk in driving DEX adoption.

To evaluate the significance of custody risk, we conducted difference-in-differences regression analyses on trading activities across CEXs and DEXs surrounding the FTX bankruptcy. Our sample covered a two-month period before (September 9, 2022) and after (January 9, 2023) the collapse. We used daily trading volume on CEXs and DEXs as the dependent variable, regressed against a treatment dummy for DEXs, a time dummy for the period following the FTX collapse, and their interaction. The validity of the parallel trend assumption was confirmed.

In this section, we turn our attention to our second testable hypothesis, which posits that centralized exchanges (CEXs) exhibit greater price efficiency than decentralized exchanges (DEXs). This hypothesis is supported by findings from the preceding section, which indicate that DEXs are less suitable for smaller transactions due to the associated gas fees. We believe that these costs hinder arbitrage activities, allowing for persistent price discrepancies that undermine the informativeness of transaction prices. The rationale is that arbitrage opportunities requiring smaller amounts of capital become unprofitable when accounting for transaction costs, thus diminishing the motivation for arbitrageurs to correct price inefficiencies.

To empirically assess deviations from the law of one price, we will focus on triangular arbitrage, which is typically executed within a specific market and is nearly risk-free. This no-arbitrage condition serves as an optimal framework for identifying market-specific frictions and comparing the price efficiency across various trading venues. A triangular arbitrage opportunity arises when there is a violation of the law of one price across a closed triplet of currency pairs, specifically X ↔ Y, Y ↔ Z, and Z ↔ X. The deviation from the law of one price can be quantitatively expressed as:

$$\theta = PXY\ PY\ Z\ PZX - 1, \qquad (4)$$

where PABP_{AB}PAB refers to the quoted price of asset A in terms of asset B. A triangular trade is considered profitable if the value of θ\thetaθ exceeds a certain threshold, meaning the gross profits from the trade surpass the costs incurred in executing the three transactions.

To estimate the extent of price deviations, we collect data on |θ||\theta||θ| at an hourly interval for each exchange triplet in our sample, employing various price proxies according to the type of exchange. For CEXs, we utilize the mid-price, which is the average of the best bid and ask prices. In the case of Uniswap v2, we measure the price as the ratio of the reserves of the two tokens involved, as illustrated in equation (5). For Uniswap v3, historical quoted prices are sourced from Dune.com. The resulting hourly deviations are averaged for each exchange triplet over the observation period from March 2021 to February 2023.

Main Results on Price Efficiency

Figure 3 illustrates the average price deviations across our sample, presented on a logarithmic scale. The primary observation is that DEXs show considerably lower price efficiency compared to CEXs. For the majority of triplets, price deviations for Uniswap v2 range from 10 to 30 basis points, while for the less liquid BTC-ETHDAI, deviations exceed 600 basis points. Uniswap v3 demonstrates improved performance relative to its predecessor, with average deviations between 5 and 50 basis points. In contrast, CEXs maintain average deviations below 5 basis points across all triplets, with Binance leading in price efficiency at under 3 basis points on average.

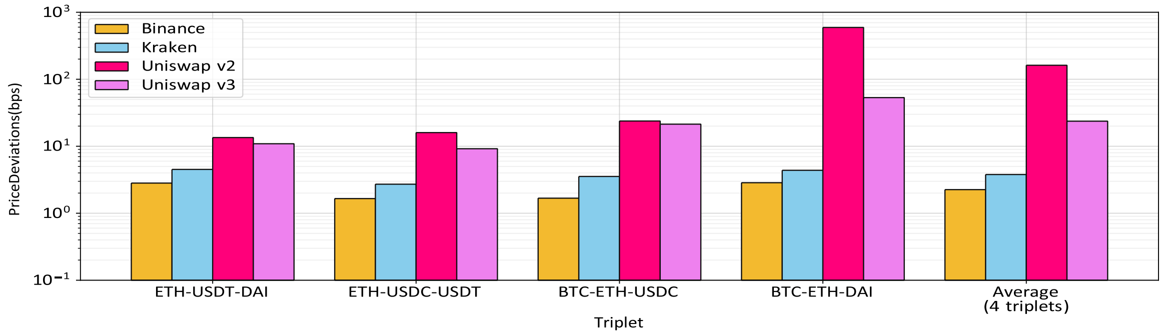

Figure 3. Average Price Deviations.

Figure 3 depicts the time-series trends of hourly price deviations for the ETHUSDC-USDT triplet, with each data point representing an observation. The upper panel details the CEXs, identified by the price deviation with the smallest absolute value, recorded each hour among Binance, Kraken, Coinbase, Huobi, and OKX. The lower panel reflects the same measure for Uniswap v2 and Uniswap v3. The introduction of Uniswap v3 in May 2021 is visually represented by coloring dots in pink when the minimum is achieved in v2 and in violet when it occurs in v3. The solid lines on both panels denote the top decile of the distribution of absolute deviations, calculated using a 7-day rolling window. A key takeaway is the consistent superiority of CEXs in terms of price efficiency throughout the sample period, with observed deviations an order of magnitude smaller than those in DEXs. Additionally, the launch of Uniswap v3 is correlated with a marked enhancement in DEX price efficiency, which declines by more than 50% from the beginning of the observation period.

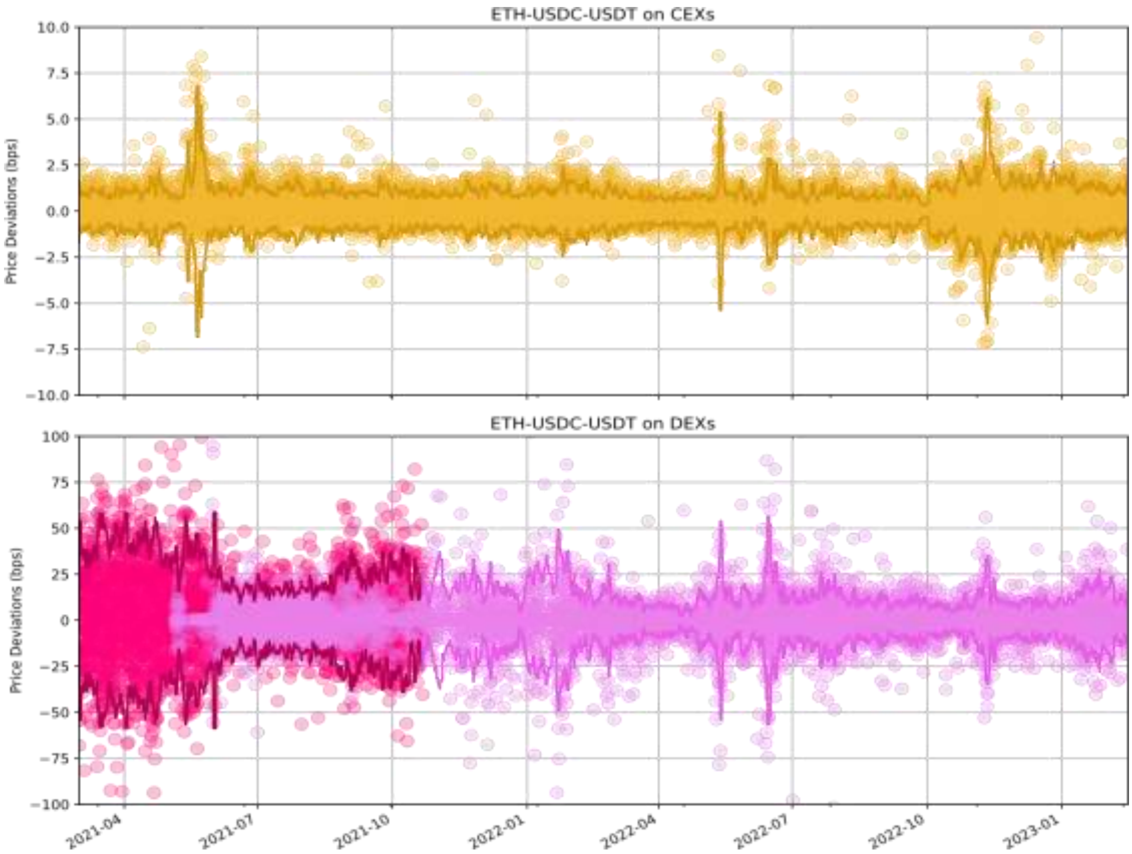

Figure 4. Price Deviations

These findings provide robust evidence supporting our second hypothesis, confirming that CEXs deliver enhanced price efficiency. The following sections will explore the causal influence of gas fees on this observed outcome.

Gas Fees and Price Efficiency

We contend that the lower price efficiency of DEXs is primarily due to two key factors: the lack of custodial delegation and the significant influence of gas fees.

To illustrate, arbitrageurs on CEXs generally have their capital readily available within the exchange, as transferring funds from a non-custodial wallet incurs costs and takes time. Consequently, in a competitive market, arbitrageurs are encouraged to delegate custody of their arbitrage capital to the exchange, which exposes them to increased counterparty risk but eliminates the gas costs tied to depositing and withdrawing funds. Given that gas fees remain constant regardless of trade size, this avoidance allows CEX arbitrageurs to execute transactions involving any amount of capital—even small ones—whenever a triangular arbitrage opportunity appears.

In contrast, DEX arbitrageurs lack the option to deposit their capital into the exchange to evade gas fees. This results in a first-order consequence where they must absorb the gas costs of each transaction, leading to increased overall trading expenses. Moreover, a second-order effect arises: akin to models incorporating entry costs, DEX arbitrageurs confront a trade-off between diluting gas costs and minimizing price impact. Consequently, they only engage in arbitrage when liquidity permits larger transactions, as gas fees inhibit their ability to restore the law of one price.

To substantiate our claim regarding the impact of gas fees, we conduct a series of econometric analyses. Initially, we investigate the correlation between price deviations and gas fees through a panel regression. To mitigate concerns of endogeneity, we then employ a VAR model for a similar analysis. Finally, we assess the causal effect of gas fees on price efficiency via an instrumental variable regression, using external shocks to gas prices driven by fluctuations in NFT market activity.

Panel Regression and VAR

The panel regression is executed at the triplet-hour level, with DEX price deviations as the dependent variable and the Ethereum gas price as the primary independent variable. We incorporate controls for additional factors that might influence DEX price deviations, including: (i) contemporaneous price deviations on CEXs to account for possible simultaneous price variations due to common influences; (ii) total percentage spreads between CEX and DEX prices for the relevant currency pairs in each triplet to address cross-exchange pricing discrepancies; (iii) average return volatility over the prior 24 hours for the pairs in each triplet, serving as a risk metric potentially linked to information asymmetries; (iv) the absolute return of the USD-denominated ETH price to capture market regime variations; and (v) hourly DEX transaction costs averaged across the pairs in each triplet, testing whether gas prices provide additional explanatory power beyond spreads and exchange fees.

The estimation outcomes, presented in Table IV, reveal positive and statistically significant coefficients for gas prices across all model specifications, signifying a positive association between gas costs and the extent of DEX price deviations. The coefficients suggest that a one-standard-deviation increase in gas prices correlates with a 4.2 basis point increase in DEX price deviations, representing an 18% rise relative to the unconditional average.

To address potential endogenous dynamics, we estimate a VAR model incorporating DEX price deviations, gas prices, and other controls as endogenous variables. The VAR analysis, detailed in Figure 5, corroborates our initial findings.

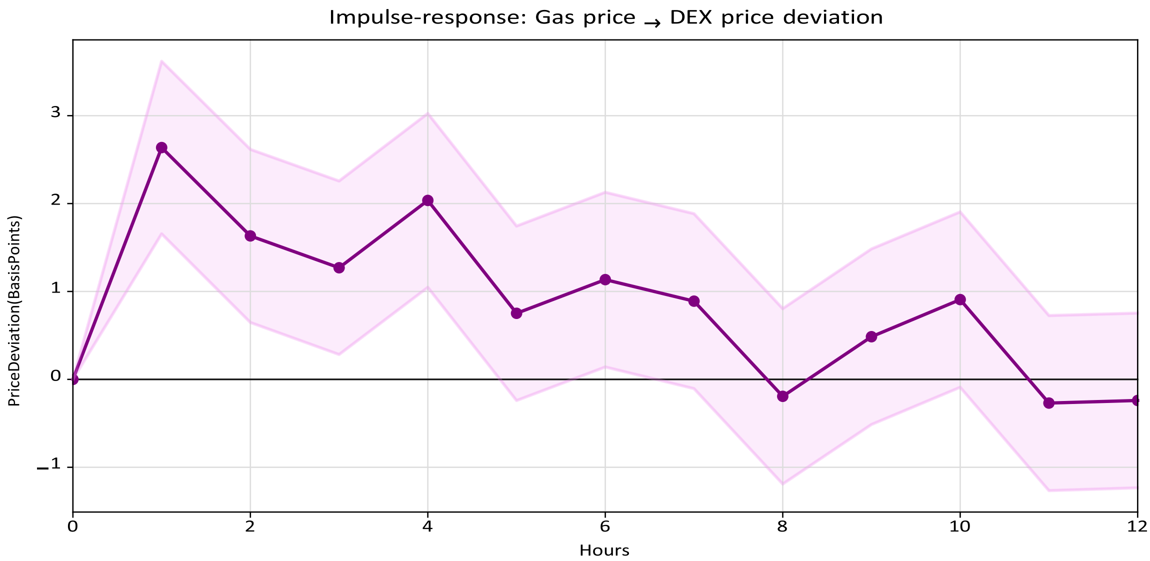

Figure 5. The Impact of Gas Prices on DEX Price Deviations.go o

4. Discussion and Conclusion

The results of this study reveal important insights into the comparative performance of centralized exchanges (CEXs) and decentralized exchanges (DEXs) across three major domains: liquidity, security, and knowledge management. In terms of liquidity, the findings showed that CEXs retain a significant advantage for small to medium trades due to their structured order book models and lower relative costs. However, for larger transactions, DEXs—particularly those utilizing concentrated liquidity pools such as Uniswap v3—were shown to be more cost-efficient. This result aligns with prior research emphasizing that centralized platforms provide strong liquidity depth, which enables tight bid–ask spreads and high levels of trading efficiency [5]. Yet, as documented in studies on liquidity fragmentation, decentralized models are increasingly closing the gap by innovating in market design [1, 8]. The observed trend in this study, where large transactions benefit more from the fixed-cost structure of gas fees, directly supports the argument that decentralized liquidity provision is more competitive in certain contexts [2].

A further dimension of liquidity concerns the efficiency of pricing and arbitrage opportunities. The study found that while DEXs demonstrated improved price efficiency with the introduction of Uniswap v3, they continue to lag behind CEXs due to persistent gas fee frictions. This is consistent with theoretical models which predict that transaction costs create barriers to arbitrage, thereby reducing the ability of markets to converge to efficient pricing [6, 7]. Prior findings that gas fees hinder effective asset repositioning among liquidity providers also resonate with the results [9]. Moreover, economic models of fee dynamics support the conclusion that changes in fee structures on DEXs can paradoxically boost trading activity by incentivizing deeper liquidity [3, 31]. These results highlight the complex interplay between market design, trading costs, and liquidity provision across exchange models.

The results also underscored the distinct security challenges and advantages of both exchange types. CEXs continue to be vulnerable due to centralized custody, as dramatically illustrated by the collapse of FTX, which eroded user trust and highlighted systemic risks [10]. Consistent with prior analyses of operational risk events in financial markets [11], the FTX case reinforces how governance failures in centralized systems can have devastating consequences for investors. By contrast, DEXs enable users to retain custody of their assets, minimizing the risk of exchange-level mismanagement. This advantage was reflected in the observed user migration to DEXs following the FTX crisis. However, the findings also revealed that DEXs carry their own risks, particularly in relation to smart contract vulnerabilities and impermanent loss. Prior studies have emphasized that liquidity providers face exposure to losses due to asset price fluctuations within pools, with mitigation strategies such as variance swaps and delta hedging offering partial solutions [9, 13, 15]. The current findings support these analyses, showing that impermanent loss remains a major deterrent for liquidity providers despite design innovations like concentrated liquidity [14].

Another contribution of this study lies in its emphasis on knowledge management as a factor influencing performance. The results revealed that centralized exchanges leverage centralized data systems to optimize decision-making, enhance customer experience, and comply with regulatory requirements. This is consistent with previous literature documenting how order book data and integrated systems strengthen trading strategies and risk management [16]. In contrast, the study found that decentralized exchanges, while transparent due to blockchain design, face significant challenges in managing fragmented and distributed data. This finding supports research highlighting that while blockchain creates a fully transparent ledger, extracting actionable insights requires advanced analytical tools [17]. However, the study also documented evidence that DEXs foster innovation more rapidly than CEXs due to their open-source and community-driven ethos, a result that aligns with studies on trust and transparency in decentralized ecosystems [18]. The observed role of knowledge fragmentation on DEXs resonates with broader debates about whether decentralized systems can match the analytical power of centralized infrastructures while retaining their collaborative strengths [33, 34].

The broader context of these findings connects to ongoing debates about the future of financial ecosystems. The integration of new digital assets such as NFTs highlights the ability of exchanges to expand beyond trading into cultural and creative markets [4]. The study's observation that innovations in exchange design often coincide with experimentation in NFTs and DAOs echoes the literature on the convergence of financial and governance technologies [19]. Similarly, the findings resonate with research into decentralized identity systems, which highlight the importance of smart contract-based trust mechanisms in scaling user adoption [20, 21]. The empirical evidence from this study, showing that user trust and transparency drive adoption decisions, supports these perspectives. At the same time, the development of decentralized credit scoring and legal infrastructure points to an expanding ecosystem in which exchanges will play an increasingly critical role [22-24].

From an institutional perspective, the study's findings support the view that DeFi is not evolving in isolation but is increasingly integrated with traditional systems. Evidence of overlapping user bases and complementary services aligns with research on the convergence of DeFi and banking, particularly in supply chain finance and lending [25-27]. At the same time, the study identified tensions between decentralized models and established regulatory systems, consistent with prior analyses emphasizing that DeFi challenges traditional governance, consumer protection, and monetary policy [28, 29]. The observed difficulties surrounding scaling and liquidity concentration are also consistent with the literature on blockchain scaling debates [8, 30]. Together, these findings highlight that exchanges are at the forefront of an evolving hybrid financial ecosystem in which technological, regulatory, and user-centered factors interact dynamically.

The results also provide insights into behavioral and psychological dimensions of market participation. The observed migration to DEXs in response to custodial risks at CEXs is consistent with trust-based models of user decision-making [18]. Studies emphasize that perceptions of fairness, transparency, and autonomy play a significant role in shaping user choices in decentralized systems, and the findings of this study reinforce that dynamic. Similarly, the results showed that changes in transaction costs significantly influenced arbitrage activity, resonating with earlier economic models which highlight how frictions reduce the profitability of small-scale arbitrage [6, 7]. This underscores the importance of considering user behavior and incentives when assessing the relative performance of exchange models.

Overall, the results confirm that CEXs continue to excel in liquidity provision and price efficiency, while DEXs offer stronger security through user custody and foster rapid innovation through community-driven development. However, both models face distinct challenges: CEXs with centralized governance and custody risk, and DEXs with gas fee frictions and fragmented knowledge management. By highlighting these trade-offs, the study provides an integrative perspective on the performance of cryptocurrency exchanges, building on and extending the existing literature.

Despite its contributions, this study has several limitations. First, the dataset was confined to a specific set of exchanges and a defined period, which may not capture the full diversity of global market conditions. Second, while the study examined liquidity, security, and knowledge management, other important factors such as regulatory compliance, user demographics, and cross-chain interoperability were not explored in detail. Third, the reliance on secondary data sources for certain aspects may have limited the depth of analysis, particularly in capturing qualitative dimensions of user experience. Finally, the rapidly evolving nature of the cryptocurrency market means that findings may quickly become outdated as new technologies and market dynamics emerge.

Future studies should expand the scope of analysis to include a broader range of exchanges, particularly emerging platforms operating across different blockchains. Longitudinal studies could provide deeper insights into how exchange performance evolves over time, especially in response to major technological or regulatory shifts. Comparative studies across jurisdictions would also be valuable in understanding how regulatory environments shape the performance of CEXs and DEXs. Furthermore, integrating behavioral experiments and surveys could provide richer insights into user decision-making, complementing the quantitative analysis of market data. Future research should also explore the role of interoperability protocols, layer-2 solutions, and cross-chain liquidity in shaping the evolution of decentralized exchanges.

For practitioners, the results underscore the need to balance efficiency with trust. Centralized exchanges must strengthen governance, transparency, and custodial safeguards to prevent failures like those observed in FTX. Decentralized exchanges, meanwhile, should prioritize improving user education on risks such as impermanent loss and continue to innovate in reducing gas fee frictions. Both exchange types could benefit from integrating more advanced knowledge management systems to harness data for better decision-making while ensuring transparency and user protection. Ultimately, hybrid models that combine the liquidity depth of CEXs with the transparency and autonomy of DEXs may represent the most promising path forward for practitioners seeking to build resilient and user-centric trading infrastructures.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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