The Actual Cost of Retail Crypto Trading*

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Abstract

We execute several hundred crypto trades to compare costs at major crypto exchanges with costs of simultaneous trades across three benchmarks: trades executed at Robinhood, trades reported by Kaiko, and trades on token-tracking ETFs reported by TAQ data. Effective spreads at major crypto exchanges are substantially higher than these benchmarks, ranging from 253 to 835 basis points. Overall, the results show that retail crypto trading costs are economically large, might be underestimated using common benchmarks, and that substantially cheaper trading alternatives appear to exist. Regulation, such as enforcing best execution, establishing a crypto NBBO, and creating a consolidated tape, could help bring these costs in line with those in other markets and make benchmarks more reliable to accurately reflect retail execution costs.

Keywords: benchmarks, crypto, crypto assets, cryptocurrency, digital assets, effective spreads, payment for order flow (PFOF), retail trading, Bitcoin, Ethereum, Dogecoin, Solana, Coinbase, Kraken, Crypto.com, Robinhood
JEL Codes: C93, D43, D53, G12, G18

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1 Introduction

Retail participation has and continues to be an important part of cryptocurrency markets over the past decade (Cong et al., 2023; Kogan et al., 2024). Platforms such as Coinbase, Kraken, Crypto.com, and Robinhood have made spot crypto trading accessible to millions of individual investors through simplified interfaces and often commission-free marketing. Whereas early crypto markets were dominated by technologically sophisticated participants, today's environment increasingly resembles mainstream retail brokerage markets in scale and accessibility. Despite this rapid growth, few studies have examined retail trading in crypto asset markets (e.g., Kogan et al., 2024; Pursiainen and Toczynski, 2023; Divakaruni and Zimmerman, 2024) and comparatively little is known about the execution quality retail crypto traders receive.

This paper provides a transaction-level analysis of retail crypto execution costs across major retail platforms. Using 456 trades across four widely traded tokens—Bitcoin (BTC), Ethereum (ETH), Solana (SOL), and Dogecoin (DOGE)—we compute effective spreads, realized spreads, and price impact using both displayed and all-in prices, i.e., displayed prices inclusive of any explicit fees. Effective spreads follow the conventional definition of twice the signed distance between the execution price and the midpoint. They therefore express costs on a round-trip-equivalent basis, rather than the cost of an individual purchase or sale. We benchmark execution quality relative to both (local) exchange-level midpoints and a synthetic three-exchange Best Bid and Offer (3BBO) midpoint constructed from the best quotes across our three venues.

Retail trading costs are large and differ substantially across platforms. Using the 3BBO midpoint, average all-in effective spreads across platform–token combinations range from approximately 253 to 835 basis points on Coinbase, Kraken, and Crypto.com. Accounting for explicit fees changes the ranking of platforms. Coinbase's displayed execution prices are close to the midpoint, but its separately charged fees make it the most expensive platform in our sample. Kraken's displayed prices already imply substantial costs, which increase further after adding its separately charged fees. Crypto.com's charges are embedded in its displayed prices. These differences show why comparisons based only on displayed prices or separately itemized fees provide an incomplete account of retail trading costs.

We compare execution quality of our crypto trades with three benchmarks. First, we compare trades executed on crypto exchanges with simultaneous trades executed on Robinhood, a payment for order flow broker. Second, we compare execution quality of our trades to the execution quality as reported by Kaiko at the same time and on the same exchange. Third, we compare execution quality of our trades to the execution quality of the relevant token-tracking ETFs at the same time.

We find that effective spreads from trades executed on Robinhood and estimated from Kaiko data and from ETFs, are much smaller. All-in effective spreads on Robinhood range

from 133 to 158 basis points.

Average local effective spreads calculated from exchange-reported trades (Kaiko) are below three basis points for every platform–token combination. These estimates exclude explicit fees and are far below the all-in costs we incur. For Kraken and Crypto.com, a substantial difference remains when we use displayed execution prices without adding explicit fees. The gap therefore extends beyond fees added to an otherwise comparable order-book execution price.

ETF trades provide a complementary benchmark for obtaining exposure to cryptocurrency prices. Bitcoin and Ethereum ETF effective spreads are substantially below the all-in spreads on our corresponding crypto trades. The available Solana ETF observations have much wider spreads, underscoring that the comparison varies across tokens. ETFs also differ from direct token ownership in trading hours, transferability, and holding costs. We therefore interpret their secondary-market spreads as a benchmark for alternative price exposure, rather than a complete measure of the cost of owning cryptocurrency.

Overall, these results indicate that common benchmarks (Kaiko data) substantially understate the transaction costs faced by retail customers and that substantially cheaper trading alternatives (Robinhood and ETFs) appear to exist.

We then decompose spreads into realized spreads, a common way to estimate liquidity providers profits. Whether we use effective or realized spreads, results only marginally change, indicating that order processing and platform margins dominate adverse selection as drivers of transaction cost (Huang and Stoll, 1997).

Research on equities and options shows that conventional market data do not always capture the execution costs investors incur. Using simultaneous equity trades, Schwarz et al. (2025) document substantial differences in execution prices across retail brokers, even for otherwise identical orders. In options markets, Muravyev and Pearson (2020) show that traders who strategically time their executions incur lower costs than conventional spread estimates suggest. These findings underscore the importance of matching transaction-cost measures to the investors and trading practices under study.

The institutional setting also matters for interpreting execution costs. U.S. equity and options markets have consolidated quotation systems, and FINRA Rule 5310 requires member firms to exercise reasonable diligence in seeking favorable execution terms for customer orders. Within this setting, O'Hara and Ye (2011) find that fragmentation across trading venues need not impair market quality. Spot crypto trading differs: venues maintain separate order books without a comparable market-wide NBBO, and securities-market execution and disclosure requirements do not apply uniformly across crypto assets and platforms. Retail interfaces may also combine embedded price components with separately charged fees, making their costs difficult to compare using exchange quotes alone. These differences motivate direct measurement of retail execution costs, although our comparisons do not identify the causal effects of regulatory arrangements.

Classical microstructure models explain spreads through adverse selection, inventory risk, and order processing costs (Glosten and Milgrom, 1985; Stoll, 1989, 2000). Applying these explanations to retail crypto transactions requires distinguishing the cost of liquidity in an exchange order book from the additional charges associated with accessing it through a retail interface. Existing crypto research examines related but distinct frictions. Makarov and Schoar (2020) document persistent cross-exchange price differences, particularly across countries, and the role of limits to arbitrage. Easley et al. (2019) study transaction fees on the Bitcoin blockchain. We complement this work by directly measuring execution prices and fees through basic retail interfaces and assessing whether exchange-based benchmarks represent the costs faced by their customers.

This paper makes four primary contributions. First, we extend the "actual retail price" framework developed for equities by Schwarz et al. (2025) to crypto asset markets. By applying consistent effective spread measurement techniques across asset classes, we provide a direct cross-market comparison of retail execution quality. We also provide evidence that payment for order flow-based transactions (i.e. Robinhood), the current standard in equity markets, generally offer better execution quality than fee-based brokers.

Second, we contribute to the broader market microstructure literature by analyzing spread formation in a fragmented and lightly regulated trading environment. Our results suggest that consolidated quoting and best execution obligations play an economically meaningful role in constraining retail spreads. Third, we add to the emerging literature on crypto market design by focusing explicitly on retail transaction prices rather than solely on cross-exchange arbitrage or volatility transmission. In doing so, we provide new evidence on the economic incidence of embedded spread pricing. In particular, execution-cost estimates derived from Kaiko data or token-tracking ETF trades substantially understate the transaction costs we observe through basic retail crypto interfaces.

Finally, our findings contribute to the literature on retail trading more broadly. As retail participation expands across asset classes, understanding the full cost of trading—including embedded spreads—is essential for evaluating welfare, competition, and market design. Crypto markets serve as a natural experiment in how transaction costs evolve when regulatory architecture differs markedly from that of traditional securities markets.

In sum, this paper positions retail crypto execution within the canon of market microstructure research. By measuring effective and realized spreads in an environment without consolidated quoting or formal best execution mandates, we provide new evidence on how institutional design shapes retail trading costs.

2 Data

We use data from three different sources throughout our analysis, "Actual Trade Data", "Kaiko", and "TAQ". We conduct trades ourselves on three crypto exchanges and benchmark

these to trades that we conduct on Robinhood. We call this data the "Actual Trade Data". We further benchmark our trades against trades as reported by "Kaiko" and against trades of token-tracking ETFs as reported by "TAQ".

2.1 Actual Trade Data

We conduct actual trades across four U.S.-based retail brokers: Robinhood, Coinbase, Kraken, and Crypto.com. Details for each broker are available in the Appendix Table A.1. Robinhood and Coinbase are publicly traded companies while Kraken and Crypto.com are privately owned.

We selected these brokers because they allowed account sign-ups in Michigan, from where we accessed the trading platforms and because they are some of the largest brokers in the United States offering retail trading in US dollar terms. According to CoinMarketCap, as of March 2026, Coinbase was the largest exchange or broker offering U.S.-dollar crypto trading services; Crypto.com ranked third and Kraken fifth.[1] Robinhood is not included in the CoinMarketCap ranking. However, public records indicate that Robinhood executes $635.6 million in crypto volume per day, which would make it one of the largest crypto trading platforms in the United States.[2]

Robinhood is the only broker that uses payment for order flow (PFOF), while the other three brokers are fee-based. Robinhood also offers a smart router trading option that does not use PFOF. While our primary empirical results focus on standard Robinhood transactions, we also conduct robustness tests using trades executed through Robinhood's Smart Order Router. Across benchmarks, our conclusions are unchanged: we find no significant differences when comparing our trades with standard Robinhood executions versus Smart Order Router executions.

To emulate the simplest possible retail trading operations, we use the most basic broker functionality offered (e.g., standard Coinbase, Kraken, etc. as opposed to Coinbase Advanced or Kraken Pro, both of which require minimum volumes for reducing transaction fees).

We execute retail trades in synchronized pairs between Robinhood (PFOF) and the other three exchanges. Trades began in April 17, 2025, ending in September 3, 2025, and ranged randomly from $100 to $400 in dollar value. Table 1 provides the distribution (of trades in Panel A and dollar volume in Panel B) of the 456 total trades that we executed.

[Place Table 1 about here]

Our sample is designed to provide broad and balanced coverage across brokers, tokens,

[1] See `https://coinmarketcap.com/rankings/exchanges/`.

[2] See `https://robinhood.com/us/en/newsroom/this-year-in-crypto-2025/` for details on Robinhood's crypto trading volume in 2025.

and trade directions. We execute both buy and sell orders for each token on each broker, yielding 456 trades in total, with similar numbers of buys and sells, 236 and 220, respectively. Our trades are executed contemporaneously and paired directly against Robinhood: every buy or sell order on Coinbase, Kraken, or Crypto.com (e.g., a BTC purchase on Coinbase or an ETH sale on Kraken) is matched with a simultaneous order of the identical dollar amount on Robinhood. Trading activity is also comparable across tokens, ranging from 108 trades in DOGE to 124 trades in BTC (Section 2.2 explains how we chose which tokens we trade). Dollar volume is likewise distributed across assets and brokers, with somewhat larger volume for BTC and Robinhood, but no single token or trade direction dominating the sample. In total, our sample represents more than $73,000 of notional executed trade value.

Data collection for each trade includes the dollar trade size, the number of tokens traded, the displayed trade price, and explicit fees. Note that we do not observe prevailing bid and ask prices. Crypto exchanges often do not provide bid and ask prices, as indicated by their trading interface, see Appendix Figure A.2.

Displayed prices are the prices provided by the broker at the time of execution. For some brokers, such as Coinbase and Kraken, the displayed price excludes the explicit fee, while for Crypto.com, the displayed price already incorporates the explicit fee. To ensure comparability across brokers, we calculate an all-in price as the dollar trade size divided by the number of tokens traded, as shown in Equation 1:

$$\text{All-in Price} = \frac{\text{Dollar Trade Size}}{\text{Number of Tokens Traded}} \tag{1}$$

For example, consider a BTC purchase on Coinbase where the displayed price is $84,737.775, the dollar trade size is $100.17, and the number of BTC purchased is 0.0011266. The all-in price is calculated as $100.17 divided by 0.0011266, which equals $88,913.545. For this transaction, Coinbase reports an explicit fee of $4.704422685. The total dollar amount paid by the investor (Dollar Trade Size) is equal to the value of the Bitcoin purchased at the displayed price plus the explicit fee, calculated as $84,737.775 multiplied by 0.0011266 plus $4.704422685, which totals $100.17. Thus, the all-in per token price captures the total cost paid by the investor, including both the displayed execution price and any per token explicit fees ($\frac{\text{Dollar Explicit Fee}}{\text{Number of Tokens Traded}}$), as defined in Equation 2:

$$\text{All-in Price} = \text{Displayed Price} + \text{Trade Direction} \times \text{Explicit Fee} \tag{2}$$

Note that Equation 2 does not apply to Crypto.com, where the displayed price already incorporates the explicit fee.

2.2 Kaiko Data

We use tick-by-tick data from Kaiko, a private firm that provides trade and top-of-book quotes timestamped to the millisecond and recorded in UTC. This data source is commonly used in other studies (Makarov and Schoar, 2020; Li et al., 2021; Dyhrberg et al., 2023; Foley et al., 2023; Divakaruni and Zimmerman, 2024). We obtain data from the three crypto exchanges we used for our "actual" trades (Coinbase, Kraken, and Crypto.com). The data includes the buy/sell indicator, the transaction price in USD, and the number of tokens traded. The dollar trade size for each trade is calculated as the product of the transaction price and the number of tokens traded. The best bid and ask data per exchange are an event-driven record of top-of-book quotes where a new observation is recorded for every update.[3] From these, we construct a "3BBO" using the best bid and ask across the three exchanges. While this follows the logic of the NBBO in equity markets, we term it the 3BBO because it is constructed from only the three exchanges in the Kaiko data.

We focus on four crypto tokens for our experiment. The first are BTC and ETH, the two largest crypto asset tokens by market capitalization as of March 2026.[4] We also include SOL and DOGE, both of which are in the top ten crypto assets by market capitalization and are relatively popular amongst retail investors due in part to their low single unit prices. We provide the daily total trading volume (in USD) over our sample period for each crypto asset in Figure 1.

[Place Figure 1 about here]

Trading volume is highly skewed across both assets and exchanges. Coinbase and Crypto.com generally dominate trading volume across all tokens, except Dogecoin. BTC and ETH account for the largest dollar volumes, with frequent days above $1 billion (on both Coinbase and Crypto.com), while SOL and DOGE trade at lower levels, at, respectively, around $200 and $50 million per day on Coinbase. While crypto trading volume is difficult to measure because of concerns about wash trading (see Cong et al., 2023), we restrict our sample to regulated exchanges, where such concerns should be less pronounced.

To compare our transactions with Kaiko's trade records, we examine a one-minute window of Kaiko data immediately preceding and following each of our trades.

[3] Kraken does not have best bid and ask for Dogecoin available from Kaiko.

[4] See `https://coinmarketcap.com`.

2.3 TAQ (ETF) Data

We obtain tick-by-tick transaction and quote records from the Trade and Quote (TAQ) database, accessed through Wharton Research Data Services (WRDS). Our sample consists of Exchange-Traded Funds (ETFs) tracking BTC, ETH, and SOL.[5] The underlying crypto ETF tickers in our sample are as follows: (i) ETFs tracking BTC: IBIT, FBTC, GBTC, BITB, HODL, BTC, ARKB, BRRR, BTCO, BTCW, and EZBC; (ii) ETFs tracking ETH: ETHA, ETHE, ETH, FETH, ETHW, ETHV, QETH, and EZET; and (iii) ETFs tracking SOL : SSK.[6] Transaction prices are extracted from the TAQ trades files, while prevailing bid and ask quotes are obtained from the TAQ complete NBBO files.

To compare our transactions with the ETF trade records, we examine a one-minute window of TAQ data immediately preceding and following each of our trades.

2.4 Variable construction and summary statistics

For both our actual trades and the benchmark transactions reported by Kaiko and TAQ, we estimate the quoted spread (QSP), effective spread (ESP), realized spread (RSP), price improvement, and price impact as given below.

We calculate the quoted spread (QSP) for trade t on exchange i as shown in Equation 3:

$$\text{QSP}_{i,t} = \frac{\text{Ask}_{i,t} - \text{Bid}_{i,t}}{\text{Mid}_{i,t}} \tag{3}$$

where $Ask_{i,t}$ and $Bid_{i,t}$ are the best ask and bid prevailing trade t on exchange i, and $Mid_{i,t}$ is the midpoint between the best bid and ask quote at the time of trade t for exchange i. We do not construct quoted spreads directly for our actual trades because we do not observe the prevailing bid and ask prices, as discussed in Section 2.1. However, for each actual trade, we match the trade to the prevailing bid and ask prices reported by Kaiko for the same exchange and use these quotes to calculate $\text{Mid}_{i,t}$.

We measure the effective spread for trade t on exchange i as shown in Equation 4:

$$\text{ESP}_{i,t} = 2 \times \text{BuySell}_{i,t} \times \frac{\text{Price}_{i,t} - \text{Mid}_{i,t}}{\text{Mid}_{i,t}} \tag{4}$$

where $Mid_{i,t}$ is defined as before, $BuySell_{i,t}$ is the buy/sell indicator, taking +1 (-1) for a buyer (seller) initiated order at the time of trade t for exchange i. For our actual trade data and for trades from Kaiko we know the true trade initiator, but for trades from TAQ we follow Lee and Ready (1991) to determine whether a trade is buyer or seller initiated. $Price_{i,t}$ is the trade price.

[5]The first DOGE ETF is introduced after the end of our sample period, so no data are available.

[6]Crypto.com ETH does not have corresponding ETF transactions because these trades occur between 8:00 PM and 4:00 AM the following day, when no TAQ data are available. We obtain only 13 observations for SOL ETFs because the product was only recently introduced and remains relatively illiquid.

For our actual trade data, we compute two effective spread measures: one based on the displayed transaction price and another based on the all-in price. Because the all-in price incorporates both the displayed price and explicit fees, the effective spread calculated using the all-in price is given in Equation 5:

$$\text{ESP}_{i,t}^{\text{All-in}} = \text{ESP}_{i,t}^{\text{Displayed}} + 2 \times \frac{\text{Explicit Fee}_{i,t}}{\text{Mid}_{i,t}} \tag{5}$$

Note that Equation 5 does not apply to Crypto.com, where the displayed price already incorporates the explicit fee. In this case,

$$\text{ESP}_{i,t}^{\text{All-in}} = \text{ESP}_{i,t}^{\text{Displayed}} \tag{6}$$

We measure the realized spread for trade t on exchange i as defined in Equation 7:

$$\text{RSP}_{i,t} = 2 \times \text{BuySell}_{i,t} \times \frac{\text{Price}_{i,t} - \text{Mid}_{i,t+1\,\text{minute}}}{\text{Mid}_{i,t}} \tag{7}$$

We measure the round-trip price improvement for trade t on exchange i as defined in Equation 8:

$$\text{PriceImprovement}_{i,t} = \text{QSP}_{i,t} - \text{ESP}_{i,t} \tag{8}$$

We measure the price impact for trade t on exchange i as defined in Equation 9:

$$\text{PriceImpact}_{i,t} = 2 \times \text{BuySell}_{i,t} \times \frac{\text{Mid}_{i,t+1\,\text{minute}} - \text{Mid}_{i,t}}{\text{Mid}_{i,t}} \tag{9}$$

Panels A and B of Table 2 provides summary statistics for our Kaiko and TAQ data: the number of trades, the average dollar trade size, the total dollar trading volume, and the average quoted and effective spreads over all trades during the one-minute before and after each of our actual trades. Average values are calculated as follows: we first compute the equally weighted average within the one-minute window surrounding each of our actual trades. We then take the equally weighted mean within each subset (e.g., Coinbase BTC). Trade counts and dollar trading volume are reported as totals across the corresponding windows.

[Place Table 2 about here]

Most trading, as reported by Kaiko, occurs on Coinbase and Crypto.com and on BTC and ETH, consistent with Figure 1. For example, during the one minute before and after each of our 18 BTC trades on Coinbase, we find in total 16,913 BTC trades on Coinbase with a total trading volume of almost $30 million.

The average dollar trade size for ETH, SOL, and DOGE on Coinbase ranges from $254 to $311, which is reasonably comparable to the size of our own trades. In contrast to the average trade size on Coinbase, the average dollar trade size is generally larger on Kraken and Crypto.com, reaching up to $2,755 and $3,204 for BTC, respectively.

We calculate quoted and effective spreads using both local and 3BBO midquotes. For example, the local effective spread for Coinbase is calculated as shown in Equation 10:

$$\text{Local ESP}_{\text{Coinbase},t} = 2 \times \text{BuySell}_{\text{Coinbase},t} \times \frac{\text{Price}_{\text{Coinbase},t} - \text{Mid}_{\text{Coinbase},t}}{\text{Mid}_{\text{Coinbase},t}} \tag{10}$$

The 3BBO effective spread for Coinbase is calculated as shown in Equation 11:

$$\text{3BBO ESP}_{\text{Coinbase},t} = 2 \times \text{BuySell}_{\text{Coinbase},t} \times \frac{\text{Price}_{\text{Coinbase},t} - \text{Mid}_{\text{3BBO},t}}{\text{Mid}_{\text{3BBO},t}} \tag{11}$$

We estimate very small average quoted and effective spreads. The average local quoted (effective) spread of the 16,913 BTC trades on Coinbase is less than 0.1 (0.5) bps. Across all exchanges and tokens, local quoted and effective spreads consistently remain below 3 bps. In fact, local quoted spreads are below one basis point in all but two cases (Coinbase DOGE at 1.05 bps and Kraken SOL at 1.49 bps). Furthermore, the 3BBO quoted spreads are frequently negative, reflecting potential arbitrage opportunities across these three exchanges. The 3BBO effective spreads on Coinbase are positive, while most of the 3BBO effective spreads for Kraken and Crypto.com are negative.

Negative effective spreads arise if the trade price is above (below) the midpoint for a seller (buyer) and may indicate extreme price improvements, potentially because of hidden liquidity. For example, if there is an iceberg hidden buy order that is not fully visible in the order book, a market sell order may execute at a price above the quoted midpoint, resulting in a negative effective spread.

In equity markets, buy and sell indicators are often inferred using the Lee and Ready algorithm, under which negative effective spreads are mechanically impossible. A trade price above (below) the midpoint price is automatically considered a buyer (seller) initiated trade. In contrast, our dataset provides the actual trade direction, allowing negative effective spreads to arise.

Negative spreads could also indicate stale quoted prices. While the average and the median time between trades and quotes in our data is below one second for both Coinbase and Crypto.com, the average delay is approximately ten seconds for Kraken.

Panel B reports the same summary statistics for token-tracking ETFs using TAQ data. We separate the results by crypto exchange because the ETF data are sampled only around our actual trade times, which differ across exchanges. Thus, in Panel B, the exchange distinction reflects differences in sample timing. Local midquotes are therefore undefined and QSP and ESP values are reported only using the NBBO midquote.

Continuing the previous example, we find 12,128 trades on BTC tracking ETFs around our 18 BTC trades on Coinbase. We find that average quoted and effective spreads are much larger than in Panel A. The average quoted (effective) spread of the 12,128 trades on BTC tracking ETFs is around 4.8 (3.5) bps. Panel B also shows much larger variations in spreads across ETFs. Spreads for ETFs tracking BTC are in generally small, below 7 bps. Spreads for ETFs tracking ETH and especially SOL are, in general, larger, ranging from around 3 to 34 bps for ETH and 300 to 400 bps for SOL.

3 Results

We now provide several results indicating that transaction costs on crypto exchanges are large, might be underestimated when relying on publicly available data (Kaiko), and that cheaper alternatives seem to exist (token-tracking ETFs).

3.1 Univariate Results

We calculate effective spreads for our actual trades, using displayed prices as reported by our brokers and matched with quotes as reported from Kaiko prevailing our trades. This allows us to determine the prevailing best bid and ask on each exchange at the exact moment of trade, providing a benchmark to evaluate execution quality. As in Table 2, we calculate local and 3BBO effective spreads.

[Place Table 3 about here]

Table 3 summarizes the transaction cost estimates for our actual trades across trading platforms. The first column shows the explicit fee ratio ($\frac{\text{Explicit Fee}}{\text{All in price}}$), expressed in basis points. Coinbase, Kraken, and Crypto.com all include spreads in displayed prices and the explicit fee ratios starting at approximately 0.8%.[7] Coinbase, Kraken, and Crypto.com operate and, to the best of our knowledge, execute retail trades on their own exchanges in addition to their brokerage platforms.

In contrast, Robinhood does not charge explicit fees for standard PFOF transactions; instead, those transactions include a 0.85% spread embedded in the displayed price. While Robinhood acquired crypto exchange Bitstamp in June 2025, their current execution methods allow execution across multiple exchanges. Appendix Table A.2 provides additional details for each broker, including screenshots of account trading interfaces and disclosed spreads and fees.

[7]Traders can bypass these explicit fees to a limited extent via subscriptions. For example, a "Coinbase One" subscription costs $4.99 per month and waives explicit fees for up to $500 of monthly trading volume.

Columns 2 and 3 of Table 3 report the effective spreads, comparing the trade price to the local midquote. This approach limits the sample to Coinbase, Kraken, and Crypto.com. For Robinhood trades, which do not have a local exchange benchmark, we instead use the quote midpoint from the paired exchange in the transaction. For example, in simultaneous Coinbase–Robinhood trade pairs, we use Coinbase's midpoint as the benchmark for Robinhood trades.

The effective spreads in Column 2 using displayed prices span a wide range from -1.5 to 481 bps. Coinbase exhibits small negative effective spreads across all tokens except ETH, for which the effective spread is positive but minimal at 0.3 bp. Robinhood offers the second lowest transaction costs, with effective spreads ranging from 133 to 147 bps. Kraken and Crypto.com have the largest effective spreads, ranging from 253 to 481 bps.

Column 3 reports effective spreads calculated using all in prices. Once explicit fees are incorporated, Coinbase becomes the most expensive broker, with effective spreads ranging from 702 to 834 bps. Thus, although Coinbase appears to offer exceptionally narrow effective spreads based on displayed prices in Column 2, its substantial explicit fees result in the highest overall trading costs. Kraken is the second most expensive platform, with effective spreads ranging from 493 to 591 bps, followed by Crypto.com, with spreads ranging from 253 to 481 bps. Robinhood becomes the least expensive platform, with effective spreads ranging from 133 to 147 bps. These results suggest that Coinbase's favorable displayed prices obscure the high cost of its explicit fees relative to competitors.

In Columns 4 and 5, which utilize the 3BBO mid price, the results for Coinbase, Kraken, and Crypto.com are mostly similar to those in Columns 2 and 3, confirming that the results are insensitive to the use of either midpoint benchmark.[8]

It is worth noting that these large fees in the crypto market make it impractical for us to construct a sample of crypto trades as large as Schwarz et al. (2025) in the equity market.

Table 4 compares our transaction costs with several alternative benchmarks: simultaneous trades on Robinhood (Columns 1 and 4), trades from the Kaiko exchange order book within a one minute window before and after each of our actual trades (Columns 2 and 5), and ETF trades within a one minute window before and after each of our actual trades (Columns 3 and 6). Panel A calculates effective spreads using displayed prices provided by the broker at the time of execution, while Panel B calculates effective spreads using all-in prices that include explicit fees. Columns 1 to 3 use the midpoint quote from the Kaiko exchange that corresponds to the retail broker's local exchange, whereas Columns 4 to 6 use the Kaiko 3BBO midpoint quote.

To ensure that our benchmarks (trades from Kaiko and TAQ) are not driven by any

[8]Under the 3BBO framework, the difference in effective spreads across platforms is proportional to their nominal price difference because the shared 3BBO midquote benchmark cancels out in the numerator. We retain the ESP terminology here to maintain consistency with the subsequent tables.

potential extreme observation, we do not simply use the nearest trade in time, but instead compute the equally weighted average across all trades executed during the pre- and post-trade one-minute intervals.

[Place Table 4 about here]

Column 1 reports the mean difference in effective spread, measured in basis points, between trades executed on Coinbase, Kraken, or Crypto.com and simultaneous trades on Robinhood (e.g., $ESP_{Coinbase,t}^{Our\ trades} - ESP_{Robinhood,t}^{Our\ trades}$). For BTC and ETH, Kraken exhibits the highest effective spreads, ranging from 174 to 249 bps above simultaneous Robinhood trades. Crypto.com is generally less expensive than Kraken but remain significantly more costly than Robinhood. Crypto.com spreads range from 84 to 109 bps higher. For SOL, Crypto.com exhibits the highest effective spread at 314 bps above Robinhood, followed by Kraken at 270 bps. Coinbase is significantly cheaper than Robinhood.

Column 2 compares our transaction costs with trades from the exchange order book within a one minute window before and after each of our actual trades (e.g.,$ESP_{Coinbase,t}^{Our\ trades} - ESP_{Coinbase,t}^{Kaiko\ trades}$). Similar to the results in Column 1, Kraken exhibits the highest effective spreads for BTC and ETH, followed by Crypto.com.

Column 3 compares our transaction costs with ETF trades executed within a one minute window before and after each of our actual trades (e.g., $ESP_{Coinbase,t}^{Our\ trades}$ - $ESP(NBBO)_{Coinbase,t}^{ETF\ trades}$).[9] Kraken and Crypto.com exhibit higher effective spreads than ETFs, whereas effective spreads for Coinbase are lower than those for ETFs. For Robinhood, effective spreads are higher relative to ETFs for BTC and ETH, but lower for SOL. The lower spreads for SOL are likely due to the small number of observations obtained for SOL ETFs as a consequence of their recent introduction and relatively low liquidity during the sample period. Columns 4 to 6 use the Kaiko 3BBO midpoint quotes to calculate effective spreads for our trades (e.g., Column 4: $ESP(3BBO)_{Coinbase,t}^{Our\ trades} - ESP(3BBO)_{Robinhood,t}^{Our\ trades}$;
Column 5: $ESP(3BBO)_{Coinbase,t}^{Our\ trades} - ESP(3BBO)_{Coinbase,t}^{Kaiko\ trades}$;
Column 6: $ESP(3BBO)_{Coinbase,t}^{Our\ trades} - ESP(NBBO)_{Coinbase,t}^{ETF\ trades}$). The results for Coinbase, Kraken, and Crypto.com remain largely similar to those reported in Columns 1 to 3. Relative to ETF trades in Column 6, Robinhood exhibits transaction costs that are approximately 129 bps higher for BTC and 100 bps higher for ETH, while appearing less expensive than SOL ETFs.

Panel B calculates effective spreads using all-in prices that include explicit fees, and the results remain broadly consistent with those reported in Panel A using displayed prices. Except for Coinbase, which now is identified as the most expensive crypto exchange,

[9] As in Section 2.4, we use the $ESP(NBBO)$ because there is no $ESP(Local)$ for ETF trades. Note that $ESP(NBBO)_{Coinbase,t}^{ETF\ trades}$ represents the $ESP(NBBO)$ for ETF trades executed within a one minute window before and after each of our Coinbase trades.

consistent with results of Table 3. Overall, the all-in, round-trip-equivalent transaction costs (effective spreads) we incurred through the basic retail interfaces of Coinbase, Kraken, and Crypto.com is substantially higher, often several percentage points higher, than the corresponding costs implied by each of our three benchmarks.

To make all-in trading costs fully comparable between our actual crypto trades and ETF trades, however, the ETF effective spreads would also need to incorporate explicit transaction costs. These costs are generally small for U.S. investors and are unlikely to materially affect our conclusions. For example, Interactive Brokers charges no commission for U.S.-listed stocks and ETFs under IBKR Lite, while IBKR Pro Fixed charges $0.005 per share, subject to a $1 minimum and a maximum of 1% of trade value.[10]

It is important to note that all three exchanges exhibit significantly higher all-in transaction costs through their basic retail interfaces than those implied by their order-book data. This difference is not driven solely by separately charged fees: even before such fees are added, the costs implied by the displayed execution prices on Kraken and Crypto.com exceed their corresponding order-book estimates. For Coinbase and Kraken, incorporating separately itemized fees widens the gap further; for Crypto.com, the relevant charge is already embedded in the displayed execution price.

This divergence likely reflects differences in access channels. Our analysis examines trades executed through basic retail interfaces, whereas the more favorable order-book prices may reflect executions through advanced trading platforms, such as Kraken Pro. Nevertheless, the results raise an important question about representativeness. Although exchange-reported order-book data may accurately characterize executions in the professional market segment, they may not capture the prices available to customers trading through basic retail interfaces.

3.2 Multivariate Results

Next, we examine the execution quality measures in a multivariate framework. In addition to quoted spreads and effective spreads, we further calculate realized spread and price impact using the one-minute future midpoint, as well as price improvement.[11] Robinhood is the omitted reference category, so all coefficients are interpreted relative to this baseline group. Panel A of Table 5 includes results without controls while Panel B includes the natural logarithm of dollar trade size as a control variable and token fixed effects. We use heteroskedasticity-robust standard errors.

[Place Table 5 about here]

[10] See https://www.interactivebrokers.com/en/pricing/commissions-stocks.php?region=americas, accessed on 2026-09-25.

[11] Using 5-minute and 10-minute future midpoints to calculate realized spreads and price impact produce similar results.

Using the local exchange midpoint benchmark, Coinbase exhibits lower local effective spreads than the baseline group, Robinhood, for displayed prices, though this difference is statistically insignificant (-142.26 bps). In contrast, Kraken and Crypto.com exhibit significantly higher displayed price effective spreads than Robinhood, by 222.08 bps and 200.62 bps, respectively. However, when evaluating all-in prices, Coinbase becomes the most expensive trading platform, with an all-in effective spread that is 606.62 bps higher than Robinhood's. Kraken is the second most expensive venue, exceeding Robinhood by 421.30 bps, while Crypto.com remains significantly more costly by 200.62 bps.

The regression results for realized spreads closely mirror those of the effective spreads. Because realized spreads capture trade profitability before revenue-sharing or inventory adjustments, these highly significant, positive coefficients indicate that market makers or liquidity providers on Kraken and Crypto.com retain substantial execution revenues. On Coinbase, this source of revenue is entirely driven by explicit fees, as evidenced by the swing from a negative displayed realized spread (-141.03 bps) to a large, statistically significant all-in realized spread (607.86 bps).

The results for price improvement are the opposite of the spread metrics. Platforms with higher effective and realized spreads show significantly negative price improvement relative to the baseline. For example, using displayed prices, Kraken and Crypto.com reduce price improvement by 221.87 bps and 200.79 bps, respectively, compared to Robinhood.

The results remain robust in Panel B after controlling for trade size and adding token fixed effects. This implies that the execution cost differences across these platforms are stable and not driven by variations in trade volume or underlying asset composition.

[Place Table 6 about here]

Table 6 reports the regression results based on the 3BBO midquote benchmark. These are our preferred specifications because they account for cross-venue pricing opportunities, rendering the performance differences across trading platforms sharper and more economically meaningful. Overall, the results remain structurally consistent with the local midpoint specifications in Table 5.

These findings are consistent with the equity payment-for-order-flow (PFOF) literature (e.g., Battalio and Holden, 2001; Schwarz et al., 2025). In our setting, the PFOF-based platform (Robinhood) provides lower all-in transaction costs than fee-based retail platforms, whose explicit fees substantially increase total trading costs.

[Place Table 7 about here]

[Place Table 8 about here]

Tables 7 and 8 report the regression results for our execution quality measures: quoted spread, effective spread, realized spread, price impact, and price improvement. These measures are based on trades and quotes in the exchange order book at the time of our actual trades using Kaiko data. Because the Kaiko data cover only Coinbase, Kraken, and Crypto.com, these analyses are restricted to those three exchanges, with Coinbase serving as the reference group. Table 7 reports the results based on the local mid price, while Table 8 is based on the 3BBO mid price.

Table 7, Column 1 reports the regression results for local quoted spreads. Relative to the baseline group, Coinbase, there is no statistically significant difference for Kraken, while Crypto.com exhibits slightly smaller local quoted spreads. In Panel B, after controlling for trade size and token fixed effects, Kraken's local quoted spread is slightly higher at the 10% significance level, while Crypto.com remains slightly lower. In Columns 2, 3 and 4, there are no statistically significant differences across the exchanges for local effective spreads, realized spreads, and price improvement, respectively. In Column 5, the price impact component is generally small and statistically indistinguishable across brokers, suggesting that execution venue rather than adverse selection drives the cost differences. This is consistent with the notion that retail crypto trades are relatively uninformed, with brokers competing primarily on the spread and fee dimensions rather than managing adverse selection risk. After controlling for trade size and token fixed effects in Panel B, the results for Columns 2 through 5 remain largely consistent.

Table 8 reports the results based on the 3BBO mid price. Relative to the Coinbase baseline, there is no significant difference in 3BBO quoted spreads for Kraken or Crypto.com. The remaining variables—effective spread, realized spread, price improvement, and price impact—remain statistically insignificant across trading platforms. Panel B specifications, which control for trade size and token fixed effects, remain entirely consistent. Taken together, these results indicate that execution quality measures do not vary dramatically among the main trading platforms.

Overall, the results in this section naturally raise the question of why our trading costs are so large, even though the effective spreads reported by crypto exchanges (and captured by Kaiko) are small, and alternative ETFs also offer better execution.

One possible explanation is that exchanges obscure trading costs by displaying only a single displayed price rather than separate bid and ask prices. In addition, not all exchanges clearly indicate how much spread and fees are charged, which makes cross platform comparisons difficult. Even so, the magnitude of the costs remains strikingly high.

4 Policy Implications

Our findings document large differences in retail crypto trading costs across platforms and substantial gaps between those costs and exchange-based benchmarks. These comparisons do not identify the effects of regulation, but they point to three policy priorities: clearer retail cost disclosures, more comparable market-wide benchmarks, and better information about alternative ways to obtain crypto exposure.

4.1 Retail Cost Disclosure and Best Execution

Regulators should prioritize standardized disclosure of all-in trading costs across retail platforms and access channels. Disclosures should distinguish displayed execution prices, separately charged fees, and any disclosed charges embedded in prices, and report their combined effect on transaction costs. Aggregate execution statistics should identify the trading interface, order size, and reference benchmark. These distinctions matter because low order-book spreads need not imply low costs through a platform's basic retail interface, as we find, for example, for Coinbase which uses variable fees per transaction.

Best-execution standards for retail crypto transactions warrant consideration alongside these disclosures. Assessments should distinguish execution quality from separately charged fees while considering the total cost to the customer and the availability of alternative execution arrangements. Related evidence illustrates the potential value of these comparisons. Ernst et al. (2025b) document price improvement from off-exchange crypto liquidity relative to an exchange-based benchmark. In equities, Ernst et al. (2025a) show that brokers allocate more orders to wholesalers with better past execution performance, giving wholesalers incentives to compete for future order flow.

The comparison across business models also argues for evaluating outcomes rather than fee labels alone. Robinhood's PFOF-based executions have lower all-in costs than the basic retail interfaces of the three exchanges in our sample. This finding does not identify the effect of PFOF, but it shows that the absence of PFOF is insufficient to ensure lower customer costs. Execution assessments should therefore consider all-in costs together with routing incentives and potential conflicts of interest.

4.2 Consolidated Reporting and Cross-Exchange Benchmarks

Policymakers should consider standardized reporting of crypto quotes and transactions as a basis for cross-exchange execution benchmarks. Such reporting would make prices easier to compare and provide a common reference for evaluating execution quality. A credible benchmark requires clear rules for venue inclusion, synchronized timestamps, quote freshness, executable depth, and the treatment of fees. Negative quoted spreads in our synthetic 3BBO illustrate the importance of these choices: crossed recorded quotes

do not by themselves establish profitable arbitrage after accounting for timing, access constraints, and trading costs.

Consolidating order-book data alone would not resolve the measurement problem documented here. A benchmark could accurately summarize exchange quotes while omitting charges incurred through basic retail interfaces. Consolidated market reporting should therefore be complemented by disclosures of actual retail execution prices and fees. This combination would allow investors and regulators to assess both underlying market conditions and the additional costs associated with particular access channels, without presuming that a consolidated benchmark would itself eliminate those costs.

4.3 ETFs as an Alternative Access Channel

An additional policy lever that has received increasing attention is the approval and expansion of cryptocurrency exchange-traded funds (ETFs). While ETFs are often discussed primarily in the context of investor access, a substantial body of literature suggests that they also have important implications for market quality, liquidity, and price efficiency. For example, ETF arbitrage may affect underlying-market liquidity, consistent with the role of arbitrage as liquidity provision in segmented markets (Rösch, 2021). ETFs could also place competitive pressure on retail crypto platforms by offering an alternative access channel.

However, our findings suggest that improving institutional spot liquidity is insufficient to directly resolve the substantial effective spreads faced by retail investors. The large all-in effective spreads documented in our study seem primarily driven by opaque dealer markups within fragmented retail platforms, rather than a lack of underlying global liquidity.

Instead of mechanically fixing retail execution costs, the primary policy benefit of the spot crypto ETF is that it acts as a transparent, highly regulated substitute. By providing a traditional access point with clearly defined fees and tightly constrained secondary market spreads, the ETF establishes a public benchmark for execution costs. Retail investors can effectively bypass the larger spreads of crypto brokers by routing their demand through traditional brokerage accounts. Over time, this substitution effect may introduce competitive pressure. To prevent a potential exodus of market share to crypto ETF issuers, retail crypto platforms may be forced to compress their hidden markups and transition to more retail-friendly fee structures.

5 Conclusion

This paper provides the first systematic measurement of all-in retail trading costs in U.S. cryptocurrency markets, using a controlled experiment across four major brokers and four

tokens over several months. Our key finding is that all-in effective spreads in crypto market are extraordinarily large, dwarfing the trading costs in equity and options markets. The magnitude of these costs implies that retail crypto investors pay hundreds or thousands of dollars per year in avoidable trading costs, costs that are largely invisible because they are at least in part bundled into prices rather than disclosed as explicit commissions. More importantly, benchmarks based on Kaiko data or token-tracking ETF trades substantially understate the transaction costs we observe through basic retail crypto interfaces.

This finding has important implications for studies that evaluate cryptocurrency trading strategies using exchange-based transaction-cost estimates. For example, Liu et al. (2022) find that several strategies remain profitable after accounting for estimated fees and bid–ask spreads of less than 1% (p. 1167). While our estimates based on Kaiko data are similarly small, the costs implied by our actual trades are substantially larger, with all-in transaction costs ranging from approximately 2.5% to more than 8%. These markedly higher costs suggest that strategies that appear profitable using exchange-based cost estimates may generate negative net returns for retail investors.

We document substantial variation in all-in costs across brokers. Robinhood's PFOF-based executions have the lowest costs, while trading through the basic retail interfaces of Coinbase, Kraken, and Crypto.com is substantially more expensive. Separately charged fees are particularly important at Coinbase, where they turn displayed prices close to the midpoint into the highest all-in costs in our sample. These findings show that a fee-based business model does not necessarily deliver lower transaction costs.

Our multivariate analysis confirms these patterns after controlling for token and dollar trade size. 3BBO-based regressions reveal that Coinbase is the most expensive option, running about 600 bps higher than Robinhood. Kraken and Crypto.com are also pricier, though by smaller margins of about 480 and 185 bps, respectively. Price impact is economically small and statistically indistinguishable across brokers, indicating that execution venue selection—not adverse selection—drives the cross-broker cost differences. Smaller retail trades face higher per-unit costs, with implications for the equitable distribution of market-access costs across the retail investor population.

Negative 3BBO quoted spreads for BTC, ETH, and SOL indicate crossed quotes across exchanges, although establishing executable arbitrage requires accounting for quote timing, market access, and trading costs. Our findings support standardized, Rule 605-style disclosures of all-in retail execution costs as an immediate policy priority. Policymakers should also consider consolidated quote and transaction reporting, a crypto NBBO with clear venue eligibility criteria, and best-execution standards that account for accessible liquidity and total customer costs. Consolidated order-book data alone might remain insufficient if they omit charges incurred through variable explicit fees, as used by Coinbase.

These measures could facilitate comparison and competition and potentially reduce trading costs. In equities, Ernst et al. (2025a) show that brokers allocate more orders to

wholesalers with better execution performance, creating incentives to compete on execution quality. Our evidence motivates greater transparency in crypto markets by documenting substantial cost differences across retail platforms that conventional exchange-based benchmarks do not capture.

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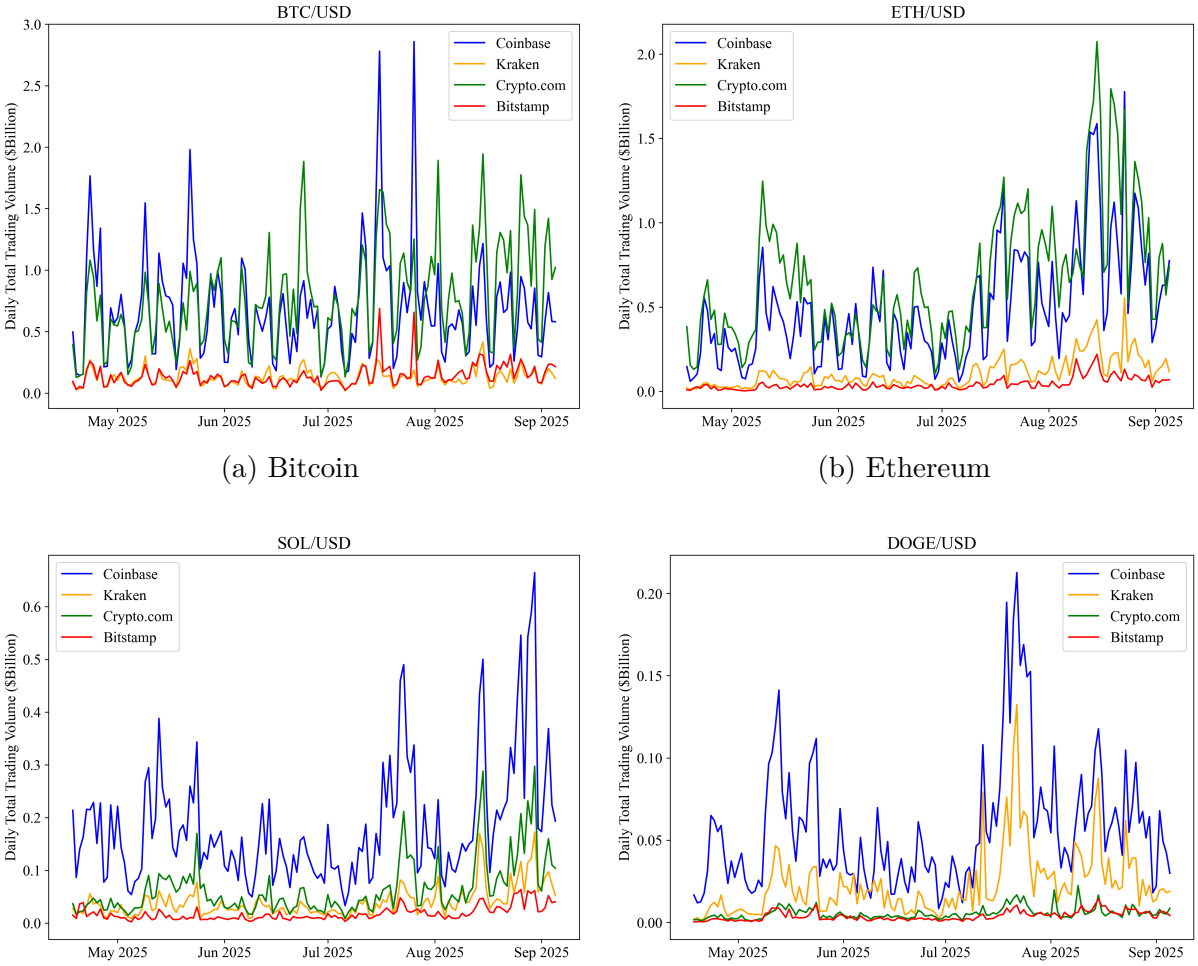
Tables & Figures



(a) Bitcoin

(b) Ethereum

(c) Solana

(d) Dogecoin

Figure 1: Daily Total Trading Volume across Exchange for Each Token.
This figure displays daily total trading volume (in $billion) for each of the four tokens (Bitcoin, Ethereum, Solana, and Dogecoin) across four exchanges (Coinbase, Kraken, Crypto.com, and Bitstamp) using Kaiko data.

Table 1: Transaction and Dollar Volume Summary for Actual Trades
This table presents a breakdown of our trading activity from April 17, 2025 to September 3, 2025 across exchanges for each token. Panel A details the transaction counts categorized by buy and sell orders, including aggregate totals per exchange and per token. Panel B reports our total dollar trading volume for the same categories.

Panel A – Transaction count by exchange and symbol

Exchange		BTC	ETH	SOL	DOGE	Total Buy/Sell per exchange
Coinbase	Buy	10	10	10	10	40
	Sell	8	9	10	9	36
Kraken	Buy	7	10	10	10	37
	Sell	7	8	10	10	35
Crypto.com	Buy	15	10	8	8	41
	Sell	15	10	7	7	39
Robinhood	Buy	32	30	28	28	118
	Sell	30	27	27	26	110
Total trades per token		124	114	110	108	
					Total Buy	236
					Total Sell	220

Panel B – Total dollar trading volume by exchange and symbol

Exchange		BTC	ETH	SOL	DOGE
Coinbase	Buy	$1973.21	$1267.04	$1751.49	$1700.00
	Sell	$1908.36	$1181.09	$1850.16	$1335.00
Kraken	Buy	$1550.59	$2000.00	$2000.19	$1520.00
	Sell	$1389.96	$1695.00	$1700.52	$1400.00
Crypto.com	Buy	$2300.00	$1500.00	$900.00	$900.00
	Sell	$2080.00	$1300.00	$700.00	$700.00
Robinhood	Buy	$5823.80	$4767.05	$4651.68	$4120.00
	Sell	$5378.32	$4176.09	$4250.68	$3435.00
Total value per token		$22,404.24	$17,886.27	$17,804.72	$15,110.00

Table 2: Summary Statistics for Kaiko and ETF Benchmarks
This table reports summary statistics computed within a one-minute window before and after each of our actual trades. Panel A covers Kaiko exchange order book data, and Panel B covers ETF trade data. Reported metrics include the total number of trades ($\#Trades$), average dollar trade size ($\$Size$), total dollar trading volume ($\$Volume$), average quoted spread in bps (QSP), and average effective spread in bps (ESP). Average values are calculated as follows: we first compute the equally weighted average within the one-minute window surrounding each of our actual trades. We then take the equally weighted mean within each subset (e.g., Coinbase BTC).

Panel A – Kaiko

					Local		3BBO	
		$\#Trades$	$\$Size$	$\$Volume$	QSP	ESP	QSP	ESP
Coinbase	BTC	16,913	1,640	29,517,197	0.0951	0.4317	-3.0446	0.1616
	ETH	9,078	308	3,039,663	0.1647	0.5888	-3.0854	0.8577
	SOL	17,992	311	6,439,643	0.6178	1.1704	-3.0618	1.4126
	DOGE	15,632	254	4,189,105	1.0469	2.9786	-0.3498	2.9439
Kraken	BTC	929	2,755	3,689,072	0.3759	1.4100	-3.0572	-0.9234
	ETH	505	1,049	512,886	0.3632	0.0563	-3.3594	-2.7378
	SOL	1,017	1,959	3,267,647	1.4888	1.2551	-1.7898	-0.6530
	DOGE	147	146	21,352			-1.0345	0.7170
Crypto.com	BTC	11,589	3,204	45,782,574	0.0011	0.5322	-3.2795	-0.3229
	ETH	22,774	2,149	48,198,376	0.0307	1.1829	-2.9357	-0.9226
	SOL	10,257	888	8,958,106	0.4958	1.6904	-2.9460	1.2995
	DOGE	1,904	146	355,509	0.5040	2.7589	-0.7340	-0.6396

Panel B – ETF

					Local		NBBO	
		$\#Trades$	$\$Size$	$\$Volume$	QSP	ESP	QSP	ESP
Coinbase	BTC	12,128	172	3,167,407			4.836	3.494
	ETH	16	247	3,514			33.974	28.399
Kraken	BTC	12,621	187	2,349,770			1.795	1.212
	ETH	675	335	224,012			4.722	3.147
Crypto.com	BTC	361	131	41,892			6.864	4.905
	SOL	13	118	1,281			409.0	302.8
Robinhood	BTC	25,111	165	5,559,158			4.412	3.144
	ETH	691	269	227,526			26.661	22.086
	SOL	13	118	1,281			409.0	302.8

Table 3: Transaction Costs for Our Actual Trades
This table reports the explicit fee ratio and the effective spreads (both in basis point) for our trades across exchanges for each token. The explicit fee ratio is defined as the per-token explicit fee relative to the all-in price, according to the following formula:

$$Explicit\ Fee\ Ratio_{i,t} = \frac{Explicit\ Fee_{i,t}}{All\ in\ Price_{i,t}}$$

Effective spreads relative to each exchange's midpoint are calculated using the following formula:

$$ESP(Local)_{i,t} = 2 \times BuySell_{i,t} \times \frac{Price_{i,t} - Local\ Mid_{i,t}}{Local\ Mid_{i,t}}$$

Effective spreads relative to the 3BBO midpoint are calculated using the following formula:

$$ESP(3BBO)_{i,t} = 2 \times BuySell_{i,t} \times \frac{Price_{i,t} - 3BBO\ Mid_{i,t}}{3BBO\ Mid_{i,t}}$$

$BuySell_{i,t}$ is the buy/sell indicator and takes a value of +1 (-1) for a buyer-initiated (seller-initiated) order at the time of trade t for exchange i. Two prices are used in the calculation: the displayed price (Displayed) and the all-in price (All-in), defined as total dollar trade size divided by the total number of tokens traded. Mid prices are from Kaiko, BuySell and trade prices are from our actual trade data. Note that, in contrast to Coinbase and Kraken, the displayed price for Crypto.com already incorporates the explicit fee.

		(1)	(2)	(3)	(4)	(5)
		Explicit Fee Ratio	*ESP(Local)*		*ESP(3BBO)*	
			Price Used			
			Displayed	All-in	Displayed	All-in
Coinbase	BTC	350.8	-1.5023	702.3	-1.9167	702.0
	ETH	415.8	0.2972	834.3	0.4774	834.5
	SOL	375.5	-0.4042	752.0	-1.1750	751.2
	DOGE	376.1	-0.1997	702.5	-0.0869	702.7
Kraken	BTC	99.43	294.4	493.3	293.3	492.1
	ETH	99.47	387.4	587.0	386.7	586.3
	SOL	99.52	391.4	590.5	390.9	590.0
	DOGE	99.62			567.8	767.0
Crypto.com	BTC	80	253.4	253.4	253.3	253.3
	ETH	80	277.9	277.9	278.1	278.1
	SOL	80	480.7	480.7	480.3	480.3
	DOGE	80	468.4	468.4	468.2	468.2
Robinhood	BTC	0	142.9	142.9	142.9	142.9
	ETH	0	147.1	147.1	147.1	147.1
	SOL	0	133.1	133.1	132.5	132.5
	DOGE	0	145.1	145.1	157.7	157.7

Table 4: Comparison of Transaction Costs Between Our Actual Trades and Benchmarks This table reports the mean differences in effective spread (ESP), measured in basis points, between our trades and several alternative benchmarks. The alternatives include simultaneous trades on Robinhood, trades from the Kaiko exchange order book within a one minute window before and after each of our actual trades, and ETF trades from TAQ within a one minute window before and after each of our actual trades. Panel A computes ESP using displayed prices, while Panel B uses all-in transaction prices. t-values are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A – Displayed price

		(1)	(2)	(3)	(4)	(5)	(6)
		$ESP(Local)$			$ESP(3BBO)$		
		vs Robinhood	vs Kaiko	vs ETF	vs Robinhood	vs Kaiko	vs ETF
Coinbase	BTC	-117.13***	-1.93	-3.84***	-117.13***	-2.08	-4.22***
		(-103.41)	(-1.65)	(-6.11)	(-103.44)	(-1.37)	(-4.55)
	ETH	-131.26***	-0.29	-28.59***	-131.26***	-0.38	-28.46***
		(-60.58)	(-0.97)	(-4.36)	(-60.57)	(-0.71)	(-4.71)
	SOL	-119.10***	-1.57***		-119.09***	-2.59**	
		(-211.40)	(-4.47)		(-211.57)	(-2.34)	
	DOGE	-125.37***	-3.18		-125.38***	-3.03	
		(-116.17)	(-0.01)		(-116.08)	(-0.01)	
Kraken	BTC	172.65***	293.02***	293.22***	172.64***	294.20***	292.06***
		(66.01)	(191.39)	(206.96)	(65.92)	(132.83)	(148.01)
	ETH	248.38***	387.31***	338.32***	248.35***	389.42***	330.99**
		(65.88)	(91.17)	(66.40)	(65.80)	(92.87)	(47.32)
	SOL	269.80***	390.17***		269.81***	391.58***	
		(180.20)	(334.22)		(180.73)	(200.76)	
	DOGE				397.48***	567.10***	
					(27.60)	(39.88)	
Crypto.com	BTC	84.27***	252.84***	321.40***	84.27***	253.64***	321.26***
		(7.50)	(22.40)	(131.79)	(7.50)	(22.32)	(143.97)
	ETH	108.57***	276.70***		108.57***	278.98***	
		(38.29)	(97.00)		(38.30)	(99.07)	
	SOL	313.23***	479.03***	179.77**	313.24***	479.00***	176.59**
		(53.27)	(91.43)	(4.01)	(53.19)	(84.49)	(3.97)
	DOGE	298.03***	465.62***		298.02***	468.84***	
		(23.59)	(38.02)		(23.59)	(37.90)	
Robinhood	BTC			129.86***			129.31***
				(38.08)			(37.68)
	ETH			101.22***			99.51***
				(12.56)			(14.58)
	SOL			-131.11**			-134.30**
				(-3.32)			(-3.43)

Panel B – All-in price

		(1)	(2)	(3)	(4)	(5)	(6)
		$ESP(Local)$			$ESP(3BBO)$		
		vs Robinhood	vs Kaiko	vs ETF	vs Robinhood	vs Kaiko	vs ETF
Coinbase	BTC	586.70***	701.89***	707.04***	586.74***	701.80***	706.73***
		(13.76)	(16.44)	(15.91)	(13.76)	(16.44)	(15.89)
	ETH	702.73***	833.70***	875.23***	702.73***	833.61***	875.37***
		(15.98)	(19.41)	(9.71)	(15.98)	(19.38)	(9.63)
	SOL	633.34***	750.87***		633.27***	749.77***	
		(14.29)	(16.90)		(14.29)	(16.91)	
	DOGE	577.37***	699.56*		577.39***	699.74*	
		(13.65)	(1.92)		(13.65)	(1.92)	
Kraken	BTC	371.53***	491.91***	492.11***	371.52***	493.07***	490.94***
		(121.04)	(230.67)	(238.64)	(120.87)	(177.32)	(206.59)
	ETH	448.00***	586.92***	541.74***	447.93***	589.01***	534.33***
		(122.69)	(133.14)	(104.88)	(122.39)	(140.50)	(75.43)
	SOL	468.88***	589.26***		468.90***	590.67***	
		(205.90)	(278.86)		(206.46)	(218.52)	
	DOGE				596.68***	766.30***	
					(41.96)	(54.56)	
Crypto.com	BTC	84.27***	252.84***	321.40***	84.27***	253.64***	321.26***
		(7.50)	(22.40)	(131.79)	(7.50)	(22.32)	(143.97)
	ETH	108.57***	276.70***		108.57***	278.98***	
		(38.29)	(97.00)		(38.30)	(99.07)	
	SOL	313.23***	479.03***	179.77**	313.24***	479.00***	176.59**
		(53.27)	(91.43)	(4.01)	(53.19)	(84.49)	(3.97)
	DOGE	298.03***	465.62***		298.02***	468.84***	
		(23.59)	(38.02)		(23.59)	(37.90)	
Robinhood	BTC			129.86***			129.31***
				(38.08)			(37.68)
	ETH			101.22***			99.51***
				(12.56)			(14.58)
	SOL			-131.11**			-134.30**
				(-3.32)			(-3.43)
	DOGE						

Table 5: Regression Results for Liquidity Measures for Our Trades using local mid
This table reports regression results for various measures of execution quality of our actual trades across trading platforms. Robinhood is the omitted reference category, so all coefficients are interpreted relative to this baseline group. The dependent variables include effective spreads relative to local mid (ESP ($Local$)), realized spreads relative to local mid (RSP ($Local$)), and price improvement relative to local mid ($PIMPROVE$ ($Local$)). For each measure, results are presented across two prices: the displayed price from our transaction (Displayed), and the all-in price from our transaction (All-in) calculated as total dollar trade size divided by the total number of tokens traded. Panel A presents results without controls, while Panel B includes the natural logarithm of dollar trade size as a control variable and token fixed effects. We use heteroskedasticity-robust standard errors. t-values are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A – Without controls

	(1)	(2)	(3)	(4)	(5)	(6)
	ESP ($Local$)		RSP ($Local$)		$PIMPROVE$ ($Local$)	
price used	Displayed	All-in	Displayed	All-in	Displayed	All-in
Coinbase	-142.26	606.62***	-141.03	607.86***	142.29	-606.60***
	(-1.50)	(6.26)	(-1.49)	(6.27)	(1.50)	(-6.26)
Kraken	222.08***	421.30***	221.59***	420.80***	-221.87***	-421.08***
	(6.71)	(12.72)	(6.68)	(12.68)	(-6.70)	(-12.71)
Crypto.com	200.62***	200.62***	199.77***	199.77***	-200.79***	-200.79***
	(5.75)	(5.75)	(5.72)	(5.72)	(-5.76)	(-5.76)
Constant	141.82***	141.82***	141.33***	141.33***	-141.40***	-141.40***
	(4.36)	(4.36)	(4.33)	(4.33)	(-4.34)	(-4.34)
Num.Obs.	416	416	416	416	416	416
R^2	0.068	0.199	0.067	0.199	0.068	0.199
Token FE	NO	NO	NO	NO	NO	NO

Panel B – With controls

	(1)	(2)	(3)	(4)	(5)	(6)
	ESP ($Local$)		RSP ($Local$)		$PIMPROVE$ ($Local$)	
price used	Displayed	All-in	Displayed	All-in	Displayed	All-in
Coinbase	-145.84	608.34***	-144.60	609.58***	145.79	-608.39***
	(-1.59)	(6.55)	(-1.58)	(6.56)	(1.59)	(-6.55)
Kraken	227.84***	440.25***	227.06***	439.46***	-227.57***	-439.98***
	(8.87)	(16.49)	(8.82)	(16.47)	(-8.86)	(-16.47)
Crypto.com	200.04***	185.38***	199.39***	184.72***	-200.17***	-185.50***
	(5.58)	(5.11)	(5.54)	(5.08)	(-5.58)	(-5.12)
log($\$Size$)	-18.34	-101.90*	-17.49	-101.05*	18.37	101.93*
	(-0.36)	(-1.93)	(-0.34)	(-1.92)	(0.36)	(1.93)
Constant	206.07	625.71**	201.28	620.92**	-206.18	-625.82**
	(0.79)	(2.34)	(0.77)	(2.32)	(-0.79)	(-2.34)
Num.Obs.	416	416	416	416	416	416
R^2	0.070	0.207	0.069	0.207	0.070	0.207
Token FE	YES	YES	YES	YES	YES	YES

Table 6: Regression Results for Liquidity Measures for Our Trades Using 3BBO Mid
This table reports regression results for various measures of execution quality of our actual trades across trading platforms. Robinhood is the omitted reference category, so all coefficients are interpreted relative to this baseline group. The dependent variables include effective spreads relative to 3BBO mid (ESP (3BBO)), realized spreads relative to 3BBO mid (RSP (3BBO)), and price improvement relative to 3BBO mid ($PIMPROVE$ (3BBO)). For each measure, results are presented across two prices: the displayed price from our transaction (Displayed), and the all-in price from our transaction calculated as total dollar trade size divided by the total number of tokens traded (All-in). Panel A presents results without controls, while Panel B includes the natural logarithm of dollar trade size as a control variable and token fixed effects. We use heteroskedasticity-robust standard errors. t-values are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A – Without controls

	(1)	(2)	(3)	(4)	(5)	(6)
	ESP (3BBO)		RSP (3BBO)		$PIMPROVE$ (3BBO)	
price used	Displayed	All-in	Displayed	All-in	Displayed	All-in
Coinbase	-145.60	603.29***	-144.35	604.54***	145.62	-603.27***
	(-1.64)	(6.62)	(-1.62)	(6.63)	(1.64)	(-6.62)
Kraken	275.08***	474.28***	275.27***	474.47***	-274.89***	-474.10***
	(22.09)	(38.08)	(22.03)	(37.95)	(-22.23)	(-38.33)
Crypto.com	197.42***	197.42***	196.89***	196.89***	-197.67***	-197.67***
	(15.65)	(15.65)	(15.66)	(15.66)	(-15.75)	(-15.75)
Constant	144.93***	144.93***	144.32***	144.32***	-147.34***	-147.34***
	(94.59)	(94.59)	(90.82)	(90.82)	(-96.25)	(-96.25)
Num.Obs.	456	456	456	456	456	456
R^2	0.158	0.352	0.157	0.352	0.158	0.352
Token FE	NO	NO	NO	NO	NO	NO

Panel B – With controls

	(1)	(2)	(3)	(4)	(5)	(6)
	ESP (3BBO)		RSP (3BBO)		$PIMPROVE$ (3BBO)	
price used	Displayed	All-in	Displayed	All-in	Displayed	All-in
Coinbase	-146.91*	605.35***	-145.71	606.55***	146.88*	-605.37***
	(-1.66)	(6.75)	(-1.65)	(6.76)	(1.66)	(-6.75)
Kraken	272.81***	484.23***	272.84***	484.25***	-272.76***	-484.17***
	(24.05)	(37.88)	(23.89)	(37.75)	(-23.99)	(-37.79)
Crypto.com	200.47***	185.27***	200.14***	184.93***	-200.54***	-185.34***
	(15.77)	(13.58)	(15.71)	(13.51)	(-15.76)	(-13.57)
log($\$Size$)	-19.40	-98.35***	-18.17	-97.12***	19.50	98.45***
	(-0.57)	(-2.73)	(-0.53)	(-2.70)	(0.57)	(2.73)
Constant	206.24	602.94***	199.67	596.38***	-209.89	-606.59***
	(1.16)	(3.23)	(1.12)	(3.19)	(-1.18)	(-3.24)
Num.Obs.	456	456	456	456	456	456
R^2	0.167	0.367	0.166	0.367	0.167	0.367
Token FE	YES	YES	YES	YES	YES	YES

Table 7: Regression Results for Liquidity Measures for Kaiko Trades Using Local Mid
This table reports regression results for various measures of execution quality of Kaiko trades across trading platforms. Coinbase is the omitted reference category, so all coefficients are interpreted relative to this baseline group. The dependent variables include Displayed spreads using local mid (QSP ($Local$)), effective spreads relative to local mid (ESP ($Local$)), realized spreads relative to local mid (RSP ($Local$)), price improvement relative to local mid ($PIMPROVE$ ($Local$)), and price impact using local mid ($PIMPACT$ ($Local$)). The price used for calculating ESP ($Local$), RSP ($Local$), and $PIMPROVE$ ($Local$) is the last execution trade price in each exchange's order book at the time of our trades. Panel A presents results without controls, while Panel B includes the natural logarithm of dollar trade size as a control variable and token fixed effects. We use heteroskedasticity-robust standard errors. t-values are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A – Without controls

	(1) QSP ($Local$)	(2) ESP ($Local$)	(3) RSP ($Local$)	(4) $PIMPROVE$ ($Local$)	(5) $PIMPACT$ ($Local$)
Kraken	0.20	0.14	-1.60	0.06	1.74
	(0.99)	(0.41)	(-1.01)	(0.13)	(1.09)
Crypto.com	-0.19**	-0.09	-2.17	-0.10	2.09
	(-2.48)	(-0.16)	(-1.22)	(-0.18)	(1.23)
Constant	0.45***	-0.27	0.47	0.72**	-0.74
	(8.01)	(-1.01)	(0.39)	(2.50)	(-0.60)
Num.Obs.	208	208	208	208	208
R^2	0.035	0.001	0.009	0.000	0.009
Token FE	NO	NO	NO	NO	NO

Panel B – With controls

	(1) QSP ($Local$)	(2) ESP ($Local$)	(3) RSP ($Local$)	(4) $PIMPROVE$ ($Local$)	(5) $PIMPACT$ ($Local$)
Kraken	0.34*	-0.10	-2.16	0.44	2.06
	(1.78)	(-0.29)	(-1.39)	(0.97)	(1.34)
Crypto.com	-0.09*	-0.28	-2.22	0.18	1.94
	(-1.66)	(-0.41)	(-1.17)	(0.26)	(1.10)
log($Size)	-0.04	-0.35	0.37	0.32	-0.72
	(-0.33)	(-0.59)	(0.22)	(0.51)	(-0.43)
Constant	0.22	2.02	-0.82	-1.80	2.84
	(0.36)	(0.61)	(-0.09)	(-0.52)	(0.32)
Num.Obs.	208	208	208	208	208
R^2	0.213	0.025	0.014	0.054	0.011
Token FE	YES	YES	YES	YES	YES

Table 8: Regression Results for Liquidity Measures for Kaiko Trades Using 3BBO Mid
This table reports regression results for various measures of execution quality of Kaiko trades across trading platforms. Coinbase is the omitted reference category, so all coefficients are interpreted relative to this baseline group. The dependent variables include quoted spreads using 3BBO mid (QSP ($3BBO$)), effective spreads relative to 3BBO mid (ESP ($3BBO$)), realized spreads relative to 3BBO mid (RSP ($3BBO$)), price improvement relative to 3BBO mid ($PIMPROVE$ ($3BBO$)), and price impact using 3BBO mid ($PIMPACT$ ($3BBO$)). The price used for calculating ESP ($3BBO$), RSP ($3BBO$), and $PIMPROVE$ ($3BBO$) is the last execution trade price in each exchange's order book at the time of our trades. Panel A presents results without controls, while Panel B includes the natural logarithm of dollar trade size as a control variable and token fixed effects. We use heteroskedasticity-robust standard errors. t-values are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A – Without controls

	(1) QSP ($3BBO$)	(2) ESP ($3BBO$)	(3) RSP ($3BBO$)	(4) $PIMPROVE$ ($3BBO$)	(5) $PIMPACT$ ($3BBO$)
Kraken	0.17	-0.56	-1.63	0.73	1.06
	(0.48)	(-0.67)	(-1.00)	(0.84)	(0.72)
Crypto.com	-0.27	0.04	-1.74	-0.31	1.78
	(-0.84)	(0.06)	(-1.03)	(-0.40)	(1.12)
Constant	-2.39***	-0.49	0.15	-1.89***	-0.64
	(-10.16)	(-1.26)	(0.13)	(-4.07)	(-0.55)
Num.Obs.	228	228	228	228	228
R^2	0.008	0.003	0.006	0.007	0.006
Token FE	NO	NO	NO	NO	NO

Panel B – With controls

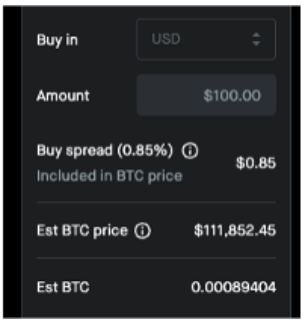
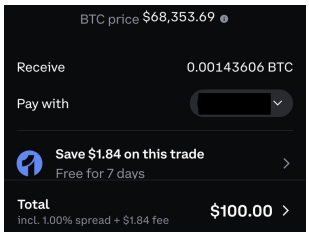
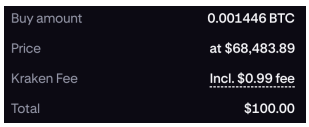
	(1) QSP ($3BBO$)	(2) ESP ($3BBO$)	(3) RSP ($3BBO$)	(4) $PIMPROVE$ ($3BBO$)	(5) $PIMPACT$ ($3BBO$)
Kraken	0.08	-0.44	-1.67	0.51	1.23
	(0.26)	(-0.51)	(-0.99)	(0.59)	(0.80)
Crypto.com	-0.05	-0.25	-1.66	0.21	1.41
	(-0.16)	(-0.32)	(-0.93)	(0.24)	(0.86)
log($\$Size$)	0.10	-0.84	0.79	0.94	-1.62
	(0.33)	(-0.97)	(0.49)	(1.10)	(-1.11)
Constant	-3.69**	4.13	-3.39	-7.82*	7.52
	(-2.16)	(0.89)	(-0.40)	(-1.70)	(0.98)
Num.Obs.	228	228	228	228	228
R^2	0.235	0.015	0.010	0.080	0.012
Token FE	YES	YES	YES	YES	YES

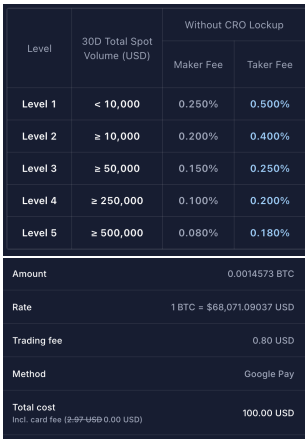
Appendix

Table A.1: Brokers Used for Experiment
For the brokers used to trade cryptocurrencies in our experiment, the table summarizes whether they accept payment for order flow (PFOF) for cryptocurrency trading, their corporate structure, and their regulatory environment.

Exchange	**PFOF**	**Public/Private**	**Regulatory Environment**
Robinhood	Yes	Public: Ticker: HOOD (IPO July 2021). Acquired Bitstamp June 2, 2025.	SEC-registered; U.S. regulated.
Robinhood Smart Router	No	Internal Tool	Operates under the Robinhood regulatory umbrella but functions as a non-PFOF execution path.
Coinbase	No	Public: Ticker: COIN (IPO April 2021).	SEC-registered; FINRA and SIPC member. U.S. regulated.
Kraken	No	Private	Wyoming-chartered SPDI (Kraken Financial); MSB with FinCEN. Partially U.S. regulated for custody.
Crypto.com	No	Private	U.S. registered MSB; operates globally with localized licenses across multiple jurisdictions.

Table A.2: Fee Information by Brokerage
This table provides details about each brokerage including screenshots of accounts and disclosed spreads/fees.

Exchange	Spreads	Fees	Screenshots
Robinhood Market Maker Routing	0.85% spread included in displayed price.	No fees.	
Robinhood Smart Router		0.85% flat fee for 30-day trading volume under $50K, decreases for higher volumes according to table. 0.02% goes to the executing partner exchange(s) and is included in fee. $0.01 minimum fee.	
Coinbase	1% spread included in displayed price.	Trading fee is "'calculated at the time you place your order and can be influenced by factors such as your chosen payment method, order size, market conditions, jurisdictional location, asset, and other costs we incur to facilitate your transaction.'"	
Kraken	Spread included in displayed price.	Fixed 1% trading fee.	

Exchange	Spreads	Fees	Screenshots
Crypto.com	Spread included in displayed price.	Estimates from actual trading find that the fee is approximately 0.7937%.	

Level	30D Total Spot Volume (USD)	Without CRO Lockup	
		Maker Fee	Taker Fee
Level 1	< 10,000	0.250%	0.500%
Level 2	≥ 10,000	0.200%	0.400%
Level 3	≥ 50,000	0.150%	0.250%
Level 4	≥ 250,000	0.100%	0.200%
Level 5	≥ 500,000	0.080%	0.180%

Amount	0.0014573 BTC
Rate	1 BTC = $68,071.09037 USD
Trading fee	0.80 USD
Method	Google Pay
Total cost Incl. card fee (~~2.97 USD~~ 0.00 USD)	100.00 USD