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# Exchange market share, market makers, and murky behavior: The impact of no-fee trading on cryptocurrency market quality

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ABSTRACT

This study examines the impact of zero fees on market quality. This issue is examined using a natural experiment in Bitcoin provided by the Binance exchange, which eliminated maker–taker trading fees for market participants in July 2022. I find that although zero fees increase investors' willingness to trade, thereby prima facie increasing liquidity, their elimination encourages market makers to widen the bid–ask spread and provide a shallower market depth, which in turn reduces liquidity. Liquidity providers realize gains at the expense of liquidity takers, suggesting the emergence of new potential forms of unethical financial market conduct. Notably, despite the removal of trading fees, total transaction costs increased for customers. These outcomes, coupled with the boost in exchange market share, raise concerns about price integrity and investors' protection in the highly unregulated crypto environment, in turn implying that the elimination of maker–taker fees is harmful to the market.

## 1. Introduction

The financial market trading landscape has experienced major technological changes over the past few decades. Blockchain ecosystems and digital assets are among the latest developments, which, together with standard electronic financial markets such as equities, have brought a number of policy issues to light.[1] Amidst the emergence of new execution venues, the widespread adoption of maker–taker pricing is yet another important but controversial practice that may help fully elucidate the effects of this trading evolution (Foucault et al., 2013). Addressing this controversy is important because the stiff competition among shareholder-owned exchanges raises concerns about investors' protection and price integrity (Malinova and Park, 2015). Lightly regulated cryptocurrency centralized exchanges (CEXs), like stock exchanges, are shareholder-owned companies that profit from charging commissions on transactions and are thus motivated to increase trading volumes by promoting competition in trading services. Although competition among markets has certainly triggered a sharp decline in trading fees, it is less obvious whether this decline is necessarily good for investors (Colliard and Foucault, 2012). In this evolving competitive environment, it is thus more crucial than ever to comprehend the effects of trading platforms' structures, such as maker–taker pricing (Malinova and Park, 2015), especially on investors' protection.

This study examines the maker–taker pricing model's effects on market quality and market participants' costs and revenues. It does so in order to shed light on this issue from the perspective of a lightly regulated cryptocurrency market structure. The maker–taker trading fee is a pricing structure through which the maker of liquidity, represented by a passive limit order, receives a discount and the taker of liquidity, represented by an aggressive market order, pays a premium (IOSCO, 2011). However, this differs from equity markets. Cryptocurrency CEXs are self-regulated. Thus, they can decide how to implement trading services. In cryptocurrency markets, this pricing scheme rewards liquidity providers by charging (progressively lower) fees in lieu of rebates, thereby creating a regulatory conundrum. Examining the impact of cryptocurrency exchange trading venues (such

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[1] While existing regulations or policies are insufficient in the face of this rapid technological change, very recently, the European Markets in crypto-assets (MiCA) was released as the world's first comprehensive framework for crypto regulation.

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as their maker–taker trading fee) on market quality, as well as the costs and profits experienced by both liquidity makers and takers, can enable policymakers to better understand these threats and thus uphold the integrity of the markets.

In this study, I use the introduction of zero fees on the Binance exchange to examine the extent to which the elimination of maker–taker trading pricing affects market liquidity, trading activity, and market participants' earnings and costs. Before July 8, 2022, traders paid maker–taker fees on every cryptocurrency pair traded on the exchange.[2] As opposed to US equity markets, where makers receive a rebate from the exchange and takers pay a fee to the exchange, Binance charges both sides (liquidity makers and takers) with its pricing scheme, referred to as the take–take structure in jargon.[3] Starting on July 8, 2022, the Binance exchange offered zero (maker–taker) trading fees to a pilot group for its 5th Anniversary, which consisted of 13 Bitcoin trading pairs. For the remaining cryptocurrency pairs, market participants continued to incur the same (maker–taker) trading fees as before. Further, none of the other cryptocurrency CEXs launched or integrated such a program into their pricing scheme for that subset of digital assets, nor for any other cryptocurrency pairs.

The strength of this study lies in its novel and unique features: the structure of the Binance fee change, the cryptocurrency market environment, and the proprietary high-frequency data that I have access to. First, the Binance exchange launched zero-fee trading for only a subset of cryptocurrency pairs, enabling an analysis of the impact using a natural experiment design and a difference-in-differences approach. The elimination of trading fees paid directly to the exchange without the intervention of brokers or other intermediaries provides a clean setting to test whether the costs paid and the benefits capitalized by liquidity demand and supply change. The complete freedom from costs associated with limit or market orders results in incentives for both makers and takers in supposedly the same direction (both sides receiving a discount), which is a notable departure from previous works. Remarkably, the minimum tick size for cryptocurrency assets is close to being insignificant, permitting an even cleaner setting through which to test theoretical models compared to equity and option studies. Second, the only other study examining maker–taker fees in cryptocurrency markets (i.e., Brauneis et al., 2022) did so at a time when cryptocurrencies were arguably in their infancy in terms of market capitalization, and its focus on market liquidity was on the no longer attractive US cryptocurrency market. I examine this environment when the cryptocurrency market capitalization is 20 times higher[4] (i.e., valued in trillions of US dollars), and trading is concentrated in Asian markets and mostly on one exchange (namely, Binance). Lastly, unlike prior studies, the data are granular at the tick-by-tick millisecond level (and reveal who initiated the trade), allowing more accurate identification of changes in high-frequency transaction costs, trading activities, and liquidity measures with complete information from the order book.

To answer the question of whether maker–taker trading fees have an impact on liquidity, trading activity, and market participants' revenues and costs, I investigate a subset of cryptocurrency pairs in the pilot group with no fees. I then compare them with cryptocurrencies (different currencies based on the same assets) traded on the same exchange and also the same trading pairs traded on other exchanges that did not switch to zero maker–taker pricing. The elimination of the maker–taker trading fees in this new pricing scheme can then be used to explain the sign and magnitude of any shift seen for this "zero-fee" subset compared to the control samples. Drawing on the theoretical reasoning of Colliard and Foucault (2012), I hypothesize that a decrease in maker–taker fees corresponds, for the zero-fee group, to a decrease in the quoted bid–ask spread, increased volumes and trades, and a decrease in the effective spread. I test these propositions using the methods employed in previous research cited above.

At first glance, my empirical findings suggest that market efficiency improved and that the elimination of makers' fees resulted in increased earnings for participants supplying liquidity. However, one could not offer any economic justification for the rise in transaction costs as trading fees were eliminated for liquidity takers as well. Nonetheless, in practice, instead of tightening the bid–ask spreads due to lower limit order fees, market makers resorted to widening spreads, thereby effectively transferring transaction costs entirely to price takers. At least in the short term, the elimination of trading fees would attract investors to engage in transactions on the exchange due to the perception of lower transaction costs. This perception explains that theoretically consistent observed surge in the number of trades, which may, however, be driven by retail investors, the least sophisticated group of market participants, who, attracted by the apparent transaction cost discounts, start to trade more frequently by believing the zero fees would decrease their trading costs. This proposition is reinforced by the findings of decreased average trade sizes transacted on the exchange in the post-fee elimination period.[5] Consequently, Binance's market share increased despite the absence of revenues from trading fees. The fact that the elimination of the pricing scheme on which profits are based requires exchanges to differentiate their incentives to compete for trading volume, raises concerns about the possibility of potential connections between the exchange and market-maker trading firms.[6]

Although previous research examines the effects of introducing maker–taker pricing on liquidity and traders' behavior (see, e.g., Malinova and Park, 2015; Lutat, 2010; Berkman et al., 2011; Brauneis et al., 2022, among others), it does not examine the impact of eliminating such pricing schemes on market quality. As such, this study fills a gap in the literature as it allows me to examine a new research question; does the complete elimination of trading fees adversely affect market liquidity and trading activities? Furthermore, I can assess the effect of these trading venues on market quality by examining a significant shift in pricing from maker–taker to no-fee, in contrast to previous studies that only examine small increases or decreases in maker rebates (i.e., focusing on the breakdown of the exchange fees into maker rebates and taker fees). I also do so in a cleaner setting that is free of intermediation and size constraints. Third, although theory analyzes the potential influence of a decline in maker–taker fees on investors' welfare, empirical works are silent on this point as they are unable to disentangle who benefits most from this pricing scheme and thus assess whether investors lose welfare from changes in exchange trading fees. I provide empirical insights on this issue by examining market participants' revenues and costs in response to strategic exchange policy in a self-regulated environment.

To the best of my knowledge, this study makes a substantial contribution to the literature by presenting the first compelling empirical evidence of new complex forms of market conduct that might

[2] In cryptocurrency markets, the maker–taker pricing is a simple transaction's commission paid directly to the exchange by both market participants, which is also the only fee present in these markets. This fee is identical for both makers and takers on Binance, and it progressively decreases (at a higher rate for makers) as monthly order sizes increase for each participant in the market.

[3] An exception is the Cboe (formerly Chi-X) Australian equity market, where both makers and takers pay fees to the exchange, which, however, charges more for takers than makers (analogously to Binance). Another type of pricing scheme analyzed by the literature is the inverted maker–taker fee, where liquidity takers receive rebates from the exchange while liquidity makers pay fees to the exchange.

[4] Source: Statista (www.statista.com/statistics/730876/cryptocurrency-maket-value/).

[5] I leave the investigation of this cognitive bias as an avenue for future research.

[6] Because this study does not attempt to infer whether market maker entities receive special privileges from cryptocurrency exchanges that could potentially harm customers, nor whether the former engage in wash trading activities under the latter's request (see, e.g., Cong et al., 2023), these captivating scenarios are left as promising future research avenues.

be perceived as unethical in crypto-asset markets. First, it highlights the possibility of a potentially leveraged dominant position by the largest cryptocurrency exchange, a competition issue recently modeled by Cespa and Vives (2022) in equity markets that was raised by regulatory concerns for monopoly restrictions over the unilateral exchanges' fee-setting process. By eliminating trading fees, the exchange strategically increased its market share as per the attracted (or subtracted from competitors) trading activities and created a favorable environment for market makers who witnessed a significant rise in their quoting revenues. However, these benefits came at the expense of the protection of exchange customers, who were also misled by the seeming reduction in transaction costs (that paradoxically increased in practice).[7] Second, instead of resorting to tighter bid–ask spreads as a consequence of the elimination of liquidity-making fees, makers requested higher compensations on their quotes to not only benefit from the exchange discount program but also make larger profits which were meant for takers. Whether this behavior comprises potentially unethical market conduct is a matter of perspective heavily influenced by the specific norms and expectations of the crypto market in question. The key question is whether this behavior aligns with the intended spirit of the fee elimination and the overall health and fairness of the market. Given that the level of the exchange market share reverted to its previous status after the discontinuation of the zero-fee program[8] signaling a customer attraction strategy that went wrong, the question naturally arises as to whether the exchange had other hidden incentives to waive fees – the main source of its profits – to its market participants. The emergence of such findings reveals previously unexplored dimensions of financial market conduct that may be perceived as unethical, thereby giving rise to legitimate concerns within the academic, practitioner, and policymaker communities in light of recent industry scandals.

The rest of the paper is organized as follows. In Section 2, I discuss previous work that informs the study. In Section 3, I review trading on Binance and the details of the fee change. In Section 4, I describe the data and sample selection, and the empirical methodology is provided in Section 5. In Section 6, I discuss the empirical findings, Section 7 concludes the study.

## 2. Theoretical hypotheses

This study adds to the body of knowledge on exchange fees and transaction costs. In their empirical investigation of the impact of changing bid–ask spreads on volume and prices, Barclay et al. (1998) discovered that lower trading volume results from greater transaction costs. In contrast with the findings of this study, Lutat (2010) found that the Swiss Stock Exchange's decision to introduce maker–taker fees had no impact on bid–ask spreads but resulted in an increase in the depth of the limit order book, similar to Berkman et al. (2011) for the New Zealand Stock Exchange. Instead, Malinova and Park (2015) show that while maintaining a constant total fee constant, the bid–ask spreads on the Toronto Stock Exchange adjust after the change in the maker–taker fees, but transaction costs remain unaffected, which is partially similar to my results. Cardella et al. (2017) investigated several maker–taker fee adjustments made in the US between 2008 and 2010, finding that an exchange's trading volume is influenced by the overall amount it charges in comparison to other exchanges and that a change in the taker fee has a bigger impact than a change in the maker fee. By focusing on different features, such as broker routing decisions (Battalio et al., 2016a), US options markets (Anand et al., 2016; Battalio et al., 2016b), high-frequency and off-exchange responses (Lin et al., 2016), inverted taker–maker fee structure (Tham et al., 2017; Comerton-Forde et al., 2019; Di Maggio et al., 2020), market efficiency (Bourke et al., 2019; Black, 2018), and cryptocurrency markets (Brauneis et al., 2022), other studies have also produced mixed results. They mainly disagree on cum-fee execution costs, trading volume, and market depth responses to changes in the breakdown of maker–taker fees. The empirical literature thus remains inconclusive.

Although the empirical effects of maker–taker pricing schemes on market quality have been thoroughly examined, they still represent a theoretical puzzle in the existing literature. Angel et al. (2011) contend that introducing a maker rebate paid for by a taker fee should not have an impact because prices would adjust to reflect the rebate's value in competitive (and efficient) markets. Colliard and Foucault (2012) formalize the intuition of Angel et al. (2011) and demonstrate that in the absence of frictions, the maker–taker fees split does not matter in a model where all traders pay fees directly to the exchange because any change in maker–taker fees is neutralized by adjusting the raw bid–ask spread. Conversely, Foucault et al. (2013) and Chao et al. (2019) demonstrate that the fee breakdown matters in the presence of a minimum tick size, which causes makers to be unable to fully neutralize a change. Lin et al. (2021) extended the two previous models by accounting for arbitrage and informed trading, establishing that in a competitive trading environment with differential access, the exchange access fee's components matter greatly. Brolley and Malinova (2013), argue that the split matters because the broker does not fully pass through the fees to all investors. A model comparing both fees paid directly to the exchange and through flat commission is that of Brolley and Malinova (2020), which concentrates on the brokerage results. However, the predictions of those latter models are not the focus of this study as they account for broker intervention and tick size, features that are absent in the setting of my analysis. Therefore, in line with Brauneis et al. (2022), I base the derivation of my hypotheses on Colliard and Foucault's (2012) model, whose assumptions are based on zero tick size.

In the model, a dealer market and a limit order market coexist competitively. In the latter, an exogenous order processing cost governs the bid–ask spread. The spread in the market for limit orders is endogenous and is influenced by traders' strategies when submitting orders. The trader eventually conducts their trade in the dealer market if the limit order they submitted to is not executed. Trading with limit orders causes delayed trade execution because the model is sequential. The trading model includes both patient and impatient traders, with the latter disliking delays. Impatient traders use limit orders less frequently as they suffer higher costs when their deals are delayed.

This study investigates a comparable situation wherein both makers' compensation and takers' fees are eliminated, complete nullifying the exchange's total fees. Colliard and Foucault (2012) underscore the significance of differentiating between alterations in the distribution of the overall exchange fee into a maker rebate and a taker fee and changes in the total exchange fee itself as only the latter holds economic relevance. Focusing on the effects of changes in the total exchange fee, Colliard and Foucault (2012) demonstrate that these changes influence traders' choice of order type. Although Colliard and Foucault's predictions provide insights into the effects of implementing maker–taker pricing and modifying the total exchange fee through changes in maker rebates and taker fees, I adopt their theoretical rationale to formulate the null hypotheses in my empirical analysis.

Unlike equity and option markets, cryptocurrency markets operate differently in terms of liquidity provision incentives. In these markets, makers do not receive a rebate for providing liquidity and pay a commission instead. However, this commission is comparatively smaller than the taker fees, serving as an incentivizing mechanism implemented by exchanges. In cases where a cryptocurrency exchange excludes maker fees and alters the total fee it perceives by also canceling taker fees, both the relative cost of executing a market order and that of a limit order decrease. As a result, there is an increase in the number of posted limit orders, accompanied by a contemporaneous rise in the

[7] These reasons make a zero-fee pricing structure paradoxically not optimal for investors' welfare in cryptocurrency markets, an issue recently modeled by Euch et al. (2021) for market-making regulation.

[8] Source: Kaiko Research (https://research.kaiko.com).

probability of executing each individual limit order, which translates into a growing number of market order transactions. In the absence of friction, the advantages derived from decreased taker and maker fees are offset by a tighter bid–ask spread. In this study, a decrease in maker fees is summed to a decrease in taker fees, affecting the overall exchange fee in the same direction (i.e., both liquidity sides receive a discount at the expense of the exchange fees). Hence, the elimination of the total fee should impact trading behavior as per the following hypotheses:

**Hypothesis 1.** Regardless of the fee breakdown into maker rebate and taker fee, the elimination of maker–taker fees leads to,

(a) a decrease in the absolute quoted spread;
(b) an increase in posted quotes;
(c) increased fraction of marketable orders; and
(d) an increase in executed trades.

Moreover, when matchmakers (i.e., exchanges) apply distinct exchange fees, trading activity gravitates toward the limit order market featuring the lower exchange fee (Colliard and Foucault, 2012, proposition 3.1), leading to a spike in trade volume in exchanges with no fee at all. Unlike the previous literature (e.g., Malinova and Park, 2015; Brauneis et al., 2022), I am thus able to clearly predict the following:

**Hypothesis 2.** The elimination of maker–taker fees leads to increased trading volumes.

As empirically predicted in Malinova and Park (2015) by relying on the null of Colliard and Foucault (2012), a downward (upward) adjustment in the total exchange fee corresponds to a decline (rise) in the cum fee effective spread. Therefore, by taking into account the complete exclusion of exchange fees, I formulate the following hypothesis:

**Hypothesis 3.** The elimination of maker–taker fees leads to a decrease in the effective spread and the cum-fee bid–ask spread (i.e., implicit and total transaction costs).

The model developed by Colliard and Foucault (2012) does not provide a basis for deriving hypotheses regarding market depth and average trade size. However, based on their intuitive grounding, Brauneis et al. (2022) can predict higher average trade size and increased quoted depth as a result of a decrease in taker fees and an increase in maker fees, respectively. Brauneis et al. (2022) find evidence rejecting the predicted increase in depth, suggesting an unsubstantiated hypothesis in liquidity makers' behaviors. Although the derivation of their hypotheses is somewhat convoluted and rejected by their findings, I examine a setting with a similar incentive for takers given the decrease in trading fees and opposite incentives for makers given their fee reduction, as opposed to the increase examined in Brauneis et al. (2022). The overall effect is a little unclear, but it enables me to develop the following hypotheses by taking into account a prediction for limit orders and a parallel result for market orders that diverge from the conclusions of earlier research:

**Hypothesis 4.** The elimination of maker–taker fees results in

(a) higher trade sizes; and
(b) an increase in market depth.

Although the applicability of previous empirical studies on maker and taker fees to cryptocurrency markets under analysis is uncertain Brauneis et al. (2022), the theoretical foundation of previous models remains intact, suggesting that any unjustified behavior observed would likely be attributed to the unregulated nature of the environment analyzed.

## 3. The binance exchange and its trading fees

Founded in 2017 in Shanghai, Binance is a self-regulated blockchain-based ecosystem that lists crypto-to-crypto trading in more than 360 cryptocurrencies, including the most traded and popular altcoins as well as Binance's own BNB token. For my sample period in 2022, the Binance exchange was the largest cryptocurrency exchange in the world in terms of market capitalization, normalized 24*h* dollar trading volume, and liquidity.[9] Despite having a global footprint, Binance is restricted by regulations in some nations, including the United States and the United Kingdom.

Limit and market orders are the primary types of trade orders supported by the Binance exchange. To execute limit orders, Binance uses only the limit price that the trader has specified. Interestingly, using a limit order on Binance does not guarantee that a client order will be a maker order. Market orders are carried out instantly at the lowest (highest) offer (bid) price if buying (selling). In addition to those types of orders, stop-limit, one-cancels-the-other, limit immediate or cancel, limit fill or kill, and limit Good Until Canceled orders are also accepted by the exchange; the latter can be traded as both taker and maker orders. Like equity markets, Binance operates as an electronic (online) limit order book that follows price-time priority. Differently from most equities, cryptocurrencies traded on CEXs usually carry a negligible tick-size threshold for trade execution (Brauneis et al., 2022). For example, for Bitcoin against Tether traded on Binance, the minimum trade amount is 0.00001 BTC or, as in Brauneis et al. (2022), 0.01 USDT.

Binance does not charge fees on deposits for cryptocurrencies, although withdrawals have a transaction fee attached that fluctuates based on cryptocurrency and transaction volume. Instead, for exchange transactions, Binance charges the so-called maker–taker trading fees (or take–take in this case). These are equal to 0.10% for both sides (liquidity supply and demand) when the 30-day trade volume is smaller than 1,000,000 Binance Dollars (BUSD)[10] and is differentiated for higher volumes at 9 sub-levels.[11] Regardless of those different fee proportions to be paid by both parties (makers and takers), Binance introduced zero-fee trading at 2 p.m. (UTC time) on the July 8, 2022, covering the following 13 Bitcoin (BTC) spot trading pairs: BTCAUD, BTCBIDR, BTCBRL, BTCBUSD, BTCEUR, BTCGBP, BTCRUB, BTCTRY, BTCTUSD, BTCUAH, BTCUSDC, BTCUSDP, and BTCUSDT. Before this day, these cryptocurrency pairs were subject to the normal maker–taker pricing scheme, as are all the other pairs not listed above. Practically speaking, both liquidity makers and takers were paying transaction fees to Binance before the introduction of zero fee. Regular users paid the same fees in both make–take parties (i.e., 0.10%), while decreasing until a 10th trade-volume level where the maker paid half of the fee amount paid by the taker (i.e., 0.012% for makers and 0.024% for takers). After July 8th, neither makers nor takers paid fees to the exchange anymore. During this phase, the interested subgroup of BTC spot pairs was excluded from any other discounts or fee adjustments.

The 2022 fee modification was initially meant to be a six-month trial. Although Binance justified the elimination of the maker–taker fee structure as a promotion for celebrating its 5th Anniversary, it neither explained the choice of the trial group nor the motivation for the extension of the validity period of the promotion. In my opinion, Binance demonstrated a strategic inclination toward sustaining competitiveness in the realm of cryptocurrency trading following the significant collapse of stablecoins in May 2022. Furthermore, in light of the recent

[9] Source: CoinMarketCap (www.coinmarketcap.com), TokenInsight (www.tokeninsight.com), CoinGeko (www.coingeko.com).

[10] Binance does not provide the possibility to trade pairs against the US dollar on its exchange but it rather prefers its own stablecoin (i.e., BUSD) or BNB token.

[11] For more details please see Binance website at www.binance.com/en/fee/schedule.

insolvency of FTX—a prominent player in the cryptocurrency exchange industry—Binance may have opted to extend the implementation of a zero-fee pricing scheme beyond its originally planned duration due to concerns regarding potential client attrition. Similarly to what is argued by Malinova and Park (2015), the trial group can arguably be considered an exogenous group, even though it was not chosen at random. However, I do recognize that the shift from maker–taker to zero-fee pricing may result in irrational changes in traders' behavior for which I have no theoretical explanations.

## 4. Data and sample selection

This study uses proprietary trade and quote data for Bitcoin/Tether (BTCUSDT) and Ethereum/Tether (ETHUSDT) pairs traded on the Binance exchange and for the BTCUSDT spot pair traded on Kucoin and FTX. Consistent with Brauneis et al. (2022), the sample spans a two-week period from July 1, 2022, to July 15, 2022,[12] and covers a symmetrical pre- and post-period of one week around the elimination of the maker–taker fee scheme.[13] The tick-by-tick high-frequency data is sourced from the Refinitiv Tick History (RTH) database, which is provided by Refinitiv, a London Stock Exchange Group (LSEG) business, and collected from the Binance exchange.[14] The unique microstructure data set comprises trade prices, volumes, turnovers, and trade side indicators (if it is a buyer- or seller-initiated transaction), the best bid and ask prices and sizes of the quotes that triggered the trade, and the date and time stamp accurate to the nearest thousandth of a second. I have not sampled data over specific daily trading hours as the cryptocurrency market is open 24/7.

I focus on the two most liquid cryptocurrencies traded on Binance, which are also the most liquid in the entire market:[15] BTCUSDT is included in the pilot group of 13 Bitcoin spot pairs, and ETHUSDT is part of the trading pairs not involved in the zero-fee promotion program. Furthermore, I chose two different exchanges in which BTCUSDT is also traded to compare liquidity and trading activity across exchanges and ensure that the market-wide fluctuations do not drive the results. As order book data for the second (OKX) and fourth (Bybit) largest cryptocurrency exchanges were unavailable from the database, I used the third and fifth largest exchanges,[16] namely, FTX and Kucoin, respectively.

The BTCUSDT traded on Binance is the treatment sample, whereas the ETHUSDT traded on Binance is used as a control sample. The BTCUSDT traded on Kucoin and FTX is taken as control samples. Any changes in liquidity measures influenced by the introduction of zero maker–taker fees should be reflected in the treatment, whereas the controls should remain unaffected by the change in the microstructure. As the zero fee of these BTC trading pairs was introduced sequentially, I could use a difference-in-differences (DiD) approach using a matched set of cum-fee cryptocurrencies to control for changes in market characteristics driven by factors other than the introduction of zero maker–taker trading fee. To test the hypotheses, I run a statistical analysis on the average change between the pre- and post-periods to examine any significant impact of zero fees. Any self-selection bias is prevented in the analysis by comparing pairs against the same cryptocurrency (USDT).

Finally, I run tests on three more less-liquid Bitcoin spot pairs of the pilot group available from the database: BTCEUR, BTCGBP, and BTCUSDC. Although data from FTX are unavailable for those cryptocurrencies, I use Kucoin for the pair against the USDC. Consistent with Brauneis et al. (2022), Bitfinex is used for the last two Bitcoin pairs against sterling and euro as data on Kucoin is unavailable in the database. ETH spot pairs traded on Binance against three cryptocurrencies (namely, ETHEUR, ETHBGP, and ETHUSDC) serve as additional sets of control for the experiment. However, I run (robustness) untabulated tests on Bitfinex control samples (the control used in Brauneis et al. (2022)) for all trading pairs analyzed and obtain qualitatively similar results.

## 5. Methodology

### 5.1. Market quality metrics

I compute different liquidity measures following the mainstream approach in the market microstructure literature (e.g., Aitken et al., 2017; Benenchia et al., 2024) and include recent developments (e.g., Hagströmer, 2021) as well as cryptocurrency-related adjustments (e.g., Brauneis et al., 2021). Consistent with Aitken et al. (2017), I measure liquidity in basis points first as the raw bid–ask spread:

$$AbsoluteSpread_{it} = a_{it} - b_{it}$$

where $a_{it}$ is the lowest asking price prevailing on either venue for cryptocurrency $i$ at time $t$, and $b_{it}$ is the highest bidding price. Following the same timestamp used in Brauneis et al. (2022), I calculate the measures within 1-minute intervals.

Although the focus of this paper and those examining maker–taker fees is on the "raw" bid–ask spread, the empirical literature also refers to the percentage spread in cents calculated as $RelativeSpread_{it} = \left(a_{it} - b_{it}\right)/m_{it}$, where $m_{it}$ is the prevailing midpoint between the best ask and best bid prices, simply as $m_{it} = \left(a_{it} + b_{it}\right)/2$. I obtain similar results from untabulated tests when using this measure.

Following both Malinova and Park (2015) and Aitken et al. (2017), I then calculate the cost of a round-trip transaction in basis points for the liquidity demanded, as measured by two times the difference between the transaction price and the prevailing quote midpoint:

$$EffectiveSpread_{it} = 2q_{it}\left(p_{it} - m_{it}\right)/m_{it}$$

where $p_{it}$ is the transaction price for cryptocurrency $i$ at time $t$, $m_{it}$ is the midpoint for cryptocurrency $i$ at the time of transaction $t$, and $q_{it}$ is the trade direction, with a value of 1 for buyer-initiated transactions and −1 for seller-initiated transactions. Consistent with Malinova and Park (2015), Aitken et al. (2017), and Brauneis et al. (2021), I consider the price impact in basis points, a metric for market resilience, which measures the direction of change in midpoint price after each transaction:

$$PriceImpact_{it} = 2q_{it}\left(m_{it+20} - m_{it}\right)/m_{it}$$

where $m_{it}$ is the midpoint for cryptocurrency $i$ at the time of transaction $t$, $m_{it+20}$ is the prevailing midpoint 20 s after the trade, and $q_{it}$ is the trade direction, with a value of 1 for buyer-initiated transactions and −1 for seller-initiated transactions.[17] This metric represents the difference between the implicit transaction costs that must be paid by those who demand liquidity and the portion of those costs attributed to liquidity supplier revenues. Realized spread is another liquidity measure, which is defined as the difference between the effective spread and any

[12] Further, I chose a short time period as Lin et al. (2016) argues that a fee change may have a rapid influence on market quality as high-frequency traders can respond instantaneously to changing conditions.

[13] However, in untabulated tests, I run robustness on a wider period of one month surrounding the event and get qualitatively similar results.

[14] RTH is one of the most reliable market microstructure databases worldwide, allowing me to avoid the issue analyzed in Alexander and Dakos (2020).

[15] Source: Coinranking (www.coinranking.com).

[16] Source: TokenInsight at www.tokeninsight.com/en/research/reports/crypto-exchanges-2022-annual-report.

[17] The choice of timing is consistent with Aitken et al. (2017), being the only study from the ones mentioned earlier using millisecond high-frequency data.

incurred price impact costs, which measures the trading profits due to liquidity provision:

$$RealizedSpread_{it} = EffectiveSpread_{it} - PriceImpact_{it}.$$

Finally, the cum-fee spreads are the last liquidity measures computed to measure the total transaction costs faced by liquidity takers and the total earnings captured by liquidity makers. I compute the cum-fee spreads following the method proposed by Malinova and Park (2015) by adding twice the taker fee, normalized by the midpoint, to the effective spread (total transaction costs for takers) and subtracting[18] twice the maker fee, normalized by the midpoint, to the realized spread (total revenues earned by makers):

$$Cum-Fee\ EffectiveSpread_{it} = EffectiveSpread_{it} + 2 \times TakerFee/m_{it}.$$

$$Cum-Fee\ RealizedSpread_{it} = RealizedSpread_{it} - 2 \times MakerFee/m_{it}.$$

I also consider market depth in terms of quoted sizes (coin lots), defined as:

$$MarketDepth_{it} = as_{it} + bs_{it}$$

where $as_{it}$ is the size of the best ask for cryptocurrency $i$ at time $t$ and $bs_{it}$ is the size of the best bid. Following Aitken et al. (2017), I focus on the value of the market depth in dollar terms, which also includes the information about the price of the quotes and is given by $ValueDepth_{it} = a_{it} \times as_{it} + b_{it} \times bs_{it}$. Subsequently, I adjust all the spread measures and the price impact following the suggestion in Hagströmer (2021), by using the weighted midpoint defined as the difference between the value of the market depth and the depth itself: $wm_{it} = \left(a_{it} \times as_{it} + b_{it} \times bs_{it}\right)/as_{it} + bs_{it}$. The untabulated tests using the weighted midpoint liquidity measures and the value of the market depth produced qualitatively similar results. I finally avoid the Amihud (2002) illiquidity metric as it performs poorly in cryptocurrency markets when looking for a measure that captures the time-series variation of liquidity (as suggested by Brauneis et al., 2021).

I calculate trading activity measures by counting the number of transactions and best quotes within the 1-minute intervals and dividing the sum of the trading volumes (in coin lots) by the number of trades each minute to find the average trade size. In my database, there is no information on the fraction of marketable orders. Therefore, consistent with the proxy suggested by Colliard and Foucault (2012) and applied in Malinova and Park (2015), I measure the fill rate by the number of successful market orders (trades) divided by the sum of the total number of market and best-posted limit orders (quotes) within each 1-minute bucket.

### 5.2. Experiment and DiD regressions

I use a methodology commonly used in the empirical literature onl market microstructure (see, e.g., Frino et al., 2022). I analyze data for all days in the sample period from July 1 to 15, 2022, which is two weeks around the elimination of total exchange fees on Binance on July 8, 2022. The specifications are set to examine the impact of introducing zero maker–taker trading fees on liquidity and trading activity. The first specification conducts a $t$-test on the null hypothesis of whether the difference between the means of the market metrics pertaining to the pre- and post-subperiods is equal to 0. I use this simpler approach to clearly show the magnitude and direction of the average difference, along with visual representations, and motivate the use of the following gold-standard method.

Consistent with Hendershott and Moulton (2011), Malinova and Park (2015), Aitken et al. (2017), and Brauneis et al. (2022), the following equation specifies the panel regression analysis of my second specification, using a DiD approach, which accounts for market-wide fluctuations:

$$\begin{aligned} y_{it} =& \alpha_0 + \beta_1 ZeroFee_t + \beta_2 Treatment_i + \beta_3 ZeroFee_t \times Treatment_i + \\ & \beta_4 Price_{it} + \beta_5 Turnover_{it} + \beta_6 Volatility_{it} + \beta_7 HHI_t + \beta_8 FE_{it} + \epsilon_{it} \end{aligned} \quad (1)$$

where $y_{it}$ is the market quality metric of interest for cryptocurrency $i$ at time $t$. $ZeroFee_t$ is an indicator variable equal to 1 from July 8, 2022, 2 pm, that is, the post-fee elimination period (for both treatment and control cryptocurrencies), and 0 otherwise. $Treatment_i$ is a dummy variable equal to 1 for securities receiving the zero-fee introduction and 0 for the control cryptocurrencies. The interaction term $ZeroFee_t \times Treatment_i$ is our variable of interest and captures the marginal effects of being a treatment cryptocurrency in the post-fee-elimination period. Following the aforementioned studies, I include a set of control variables. For regressions in which the dependent variable is presented in basis points, $Price_{it}$ is the inverse of the midpoint price of cryptocurrency $i$ at time $t$, whereas in all other regressions $Price_{it}$ is the natural logarithm of the midpoint price of the cryptocurrency $i$ at time $t$. $Turnover_{it}$ is the average trading turnover in coin value for cryptocurrency $i$ at time $t$. $Volatility_{it}$ is calculated as the natural logarithmic return of the midpoint price. $HHI_t$ is the daily Herfindahl–Hirschman Index, which captures market competitiveness by measuring the size of each crypto exchange relative to the size of the industry.[19] $FE_{it}$ are the crypto-time-fixed effects that control for heterogeneity in market quality at the crypto-asset level, which are unrelated to maker–taker pricing. The remaining $\alpha$ is the intercept.

Consistent with the method followed by Malinova and Park (2015), I conduct inference in all panel regressions using double-clustered standard errors, which are robust to cross-sectional correlation and idiosyncratic time-series persistence. Further, to avoid rejecting virtually all null hypotheses due to the large $n$ problem with high-frequency data, I average the data in 1-minute intervals to significantly decrease the number of observations in the regressions and simultaneously keep all the information present in the millisecond tick-by-tick data set.[20] I then perform several robustness tests using price data instead of the quoted midpoint and additional control variables in line with Brauneis et al. (2022), such as the squared coin log-return.[21] All those untabulated robustness tests led to qualitatively similar findings.

## 6. Empirical findings

### 6.1. Descriptive evidence and experiment on the most liquid crypto-asset

I report descriptive statistics for the Bitcoin trading pairs against the stablecoin USDT in Table 1 based on trades and quotes high-frequency data at the millisecond level from the RTH database. The investigation period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC. This timeframe encompasses one week before and after the maker–taker fee elimination (20,160 one-minute intervals).[22]

[18] Here the sign is inverted compared to Malinova and Park (2015) as liquidity makers in cryptocurrency markets pay a maker fee to the exchange instead of receiving a rebate as in equity markets.

[19] Data on the 11 largest cryptocurrency exchanges was bought from CoinGecko at www.coingecko.com.

[20] This also contradicts the possible presence of outliers. It is important to note that potential outliers are unlikely to influence the findings significantly due to the large number of observations. Instead, they might serve as a potential bias against finding statistically significant results.

[21] However, I do not use the number of trades per minute as a control variable in the robustness analysis to avoid any endogeneity biases in the coefficient estimates and over-fitting issues.

[22] The control sample of BTCUSDT traded on FTX shows fewer observations as the database did not contain order book information for a few hours during my sample period. I was, therefore, unable to compute market quality metrics for those intervals, which however did not influence the balance of the control sample as per the small magnitude of the drop in the number of observations.

**Table 1**
Descriptive statistics for pairs against USDT. This table presents the summary statistics based on high-frequency trades and quotes data. I obtain the absolute quoted spread (in basis points), the natural logarithm of the depth at the best bid and best offer (in lots), the cost of a round-trip trade (effective spread; in basis points), the adverse selection cost (price impact; in basis points), the liquidity supply earnings (realized spread; in basis points), and the number of best quotes from milliseconds order book data. The descriptives for transactions refer to tick-by-tick data, including the fraction of orders that are marketable (fill rate), the number of trades per minute, the average trade size and volume (in lots), the midpoint price (in coin value), the average turnover (in coin value expressed in millions), and the midpoint volatility. The upper (lower) panels show results for the treatment exchange Binance (control exchanges FTX, Kucoin and the ETH traded on Binance). The sample period is from July 1, 2022, 14:00 UTC to July 15, 2022, 14 UTC (= 20,160 min).

| Variables | Mean | Median | Min | Max | Std dev | Skew | Kurt | # Obs |
|---|---|---|---|---|---|---|---|---|
| *Panel A: BTCUSDT on Binance (treatment)* | | | | | | | | |
| Quoted spread (bps) | 0.9954 | 1.0169 | 0.01 | 31.905 | 0.9107 | 3.4405 | 77.8712 | 20,160 |
| LN Market depth (lots) | 6.0846 | 6.4359 | −1.8996 | 10.4917 | 1.0735 | −0.2626 | −1.1161 | 20,160 |
| Effective spread (bps) | 1.8918 | 1.6481 | −34.9426 | 39.8223 | 1.6543 | 5.0177 | 79.0735 | 20,160 |
| Price Impact (bps) | 2.5706 | 1.563 | −34.6227 | 160.8705 | 3.8553 | 10.1244 | 253.4564 | 20,160 |
| Realized Spread (bps) | −0.6789 | −0.0426 | −132.6676 | 17.1129 | 3.1148 | −9.4739 | 251.8644 | 20,160 |
| Number of Quotes | 532.2481 | 503 | 4 | 4184 | 357.8237 | 0.7467 | 0.4329 | 20,160 |
| Fill Rate | 0.7205 | 0.7208 | 0.0136 | 0.9973 | 0.0689 | −0.3768 | 3.8444 | 20,160 |
| Number of Trades | 1593.8901 | 1353 | 20 | 13 534 | 1372.8384 | 1.8359 | 5.5474 | 20,160 |
| Trade Size (lots) | 0.0598 | 0.0521 | 0.0017 | 0.4167 | 0.0332 | 2.5415 | 13.0897 | 20,160 |
| Volume (lots) | 95.7528 | 60.3543 | 0.0337 | 3286.4391 | 174.1997 | 9.7266 | 121.7785 | 20,160 |
| Price (coin value) | 20 264.8331 | 20 202.0982 | 18 833.1161 | 22 380.509 | 844.9435 | 0.4244 | −0.9073 | 20,160 |
| Turnover (coin value in millions) | 1307.1315 | 889.2651 | 0.3358 | 8591.4922 | 1380.9729 | 2.6625 | 9.6355 | 20,160 |
| Volatility | 0 | 0 | −0.0688 | 0.0178 | 0.0009 | −21.8796 | 1740.6671 | 20,160 |
| *Panel B: BTCUSDT on FTX (control)* | | | | | | | | |
| Quoted spread (bps) | 1.8602 | 1.69 | 0.9213 | 23.1926 | 0.7876 | 7.9566 | 139.5231 | 19,408 |
| LN Market depth (lots) | 6.0658 | 6.1217 | 0.0485 | 8.4234 | 0.6854 | −0.7998 | 2.3382 | 19,408 |
| Effective spread (bps) | 2.9268 | 2.3381 | −9.7879 | 77.9727 | 2.7415 | 5.5707 | 78.9894 | 19,408 |
| Price Impact (bps) | 4.2642 | 2.8475 | −142.5 | 525.3953 | 9.4692 | 13.6584 | 588.9346 | 19,408 |
| Realized Spread (bps) | −1.3374 | −0.2831 | −449.8969 | 149.8158 | 8.5904 | −11.7994 | 503.6019 | 19,408 |
| Number of Quotes | 429.9987 | 361 | 2 | 2603 | 294.9508 | 1.6983 | 4.1365 | 19,408 |
| Fill Rate | 0.0869 | 0.0786 | 0.0023 | 0.9048 | 0.0443 | 2.7154 | 20.1157 | 19,408 |
| Number of Trades | 39.7531 | 30 | 1 | 879 | 37.7269 | 4.4063 | 43.273 | 19,408 |
| Trade Size (lots) | 0.043 | 0.0319 | 0.0001 | 0.9387 | 0.0471 | 5.2068 | 52.3658 | 19,408 |
| Volume (lots) | 2.0902 | 0.9278 | 0.0001 | 181.8243 | 4.3724 | 12.5142 | 318.6326 | 19,408 |
| Price (coin value) | 20 263.5203 | 20 157.4827 | 18 828.929 | 22 371.6763 | 860.8614 | 0.4214 | −0.9795 | 19,408 |
| Turnover (coin value in millions) | 30.038 | 26.086 | 0.0047 | 92.7679 | 21.3316 | 0.8277 | 0.0079 | 19,408 |
| Volatility | 0 | 0 | −0.0685 | 0.0266 | 0.0009 | −19.7403 | 1665.6187 | 19,408 |
| *Panel C: BTCUSDT on Kucoin (control)* | | | | | | | | |
| Quoted spread (bps) | 0.4389 | 0.3849 | 0.0958 | 13.2688 | 0.3404 | 9.3181 | 210.8083 | 20,160 |
| LN Market depth (lots) | 8.3386 | 8.3932 | 1.3702 | 13.6782 | 0.586 | −0.7965 | 4.2943 | 20,160 |
| Effective spread (bps) | 1.8438 | 1.3069 | −25.3958 | 107.2388 | 2.582 | 11.3025 | 295.0657 | 20,160 |
| Price Impact (bps) | 3.8927 | 2.9385 | −92.8774 | 242.3064 | 6.6558 | 7.9383 | 232.9343 | 20,160 |
| Realized Spread (bps) | −2.0489 | −1.4947 | −212.5672 | 92.8774 | 6.1079 | −4.6636 | 171.4654 | 20,160 |
| Number of Quotes | 1596.2228 | 1399 | 6 | 6980 | 893.3169 | 1.2797 | 2.1044 | 20,160 |
| Fill Rate | 0.1031 | 0.0971 | 0.0003 | 0.9811 | 0.0457 | 3.6621 | 46.1813 | 20,160 |
| Number of Trades | 160.6606 | 151 | 1 | 386 | 70.6301 | 0.382 | −0.5953 | 20,160 |
| Trade Size (lots) | 0.0357 | 0.0333 | 2.81E−05 | 0.2851 | 0.0197 | 1.2347 | 4.485 | 20,160 |
| Volume (lots) | 6.1331 | 4.9465 | 2.81E−05 | 42.6322 | 4.8029 | 1.53 | 3.6958 | 20,160 |
| Price (coin value) | 20 264.2541 | 20 200.7818 | 18 843.2273 | 22 413.1466 | 844.4823 | 0.4265 | −0.9061 | 20,160 |
| Turnover (coin value in millions) | 89.3907 | 79.4609 | 0.0021 | 286.7367 | 59.9935 | 0.7171 | 0.0787 | 20,160 |
| Volatility | 0 | 0 | −0.0703 | 0.0212 | 0.0009 | −21.8154 | 1747.1403 | 20,160 |
| *Panel D: ETHUSDT on Binance (control)* | | | | | | | | |
| Quoted spread (bps) | 0.0261 | 0.0213 | 0.01 | 1.2537 | 0.0214 | 17.5531 | 742.2485 | 20,160 |
| LN Market depth (lots) | 9.1518 | 9.1286 | 4.4784 | 13.1956 | 0.4819 | 0.7322 | 5.1039 | 20,160 |
| Effective spread (bps) | 0.1514 | 0.1282 | −0.3361 | 2.2866 | 0.1169 | 3.268 | 25.0335 | 20,160 |
| Price Impact (bps) | 0.282 | 0.2116 | −2.4948 | 10.1166 | 0.3302 | 7.6425 | 163.2696 | 20,160 |
| Realized Spread (bps) | −0.1306 | −0.0796 | −8.6149 | 2.5548 | 0.2763 | −7.9209 | 182.2858 | 20,160 |
| Number of Quotes | 227.7661 | 209 | 2 | 1225 | 81.9404 | 1.5751 | 4.7455 | 20,160 |
| Fill Rate | 0.6009 | 0.5858 | 0.0269 | 0.997 | 0.1136 | 0.4283 | 0.0652 | 20,160 |
| Number of Trades | 459.2411 | 306 | 14 | 8653 | 460.876 | 3.4294 | 20.9542 | 20,160 |
| Trade Size (lots) | 1.6493 | 1.4794 | 0.0614 | 11.8631 | 0.9353 | 2.1708 | 7.9633 | 20,160 |
| Volume (lots) | 770.4374 | 464.4622 | 0.8599 | 14 400.7644 | 951.2974 | 4.0797 | 26.438 | 20,160 |
| Price (coin value) | 1133.8872 | 1137.2584 | 1014.2503 | 1270.6415 | 63.8437 | 0.1687 | −1.3034 | 20,160 |
| Turnover (coin value in millions) | 608.3638 | 521.1804 | 0.1663 | 1782.5558 | 430.0413 | 0.6652 | −0.487 | 20,160 |
| Volatility | 0 | 0 | −0.1391 | 0.0194 | 0.0014 | −51.6517 | 5262.5025 | 20,160 |

The table is divided into four panels, each corresponding to different exchanges or assets: Panel A for BTCUSDT traded on Binance (treatment sample), Panel B for BTCUSDT traded on FTX (control sample), Panel C for BTCUSDT traded on Kucoin (control sample), and Panel D for ETHUSDT traded on Binance (control sample).

The mean and median of the quoted spread and transaction costs are higher on FTX (at 1.8602 and 1.69 bps, respectively, for bid–ask spread, and at 2.9268 and 2.3381 bps, respectively, for effective spread) than on any other exchange. Conversely, on average, the market depth is higher for the ETHUSDT traded on Binance and lower for BTCUSDT

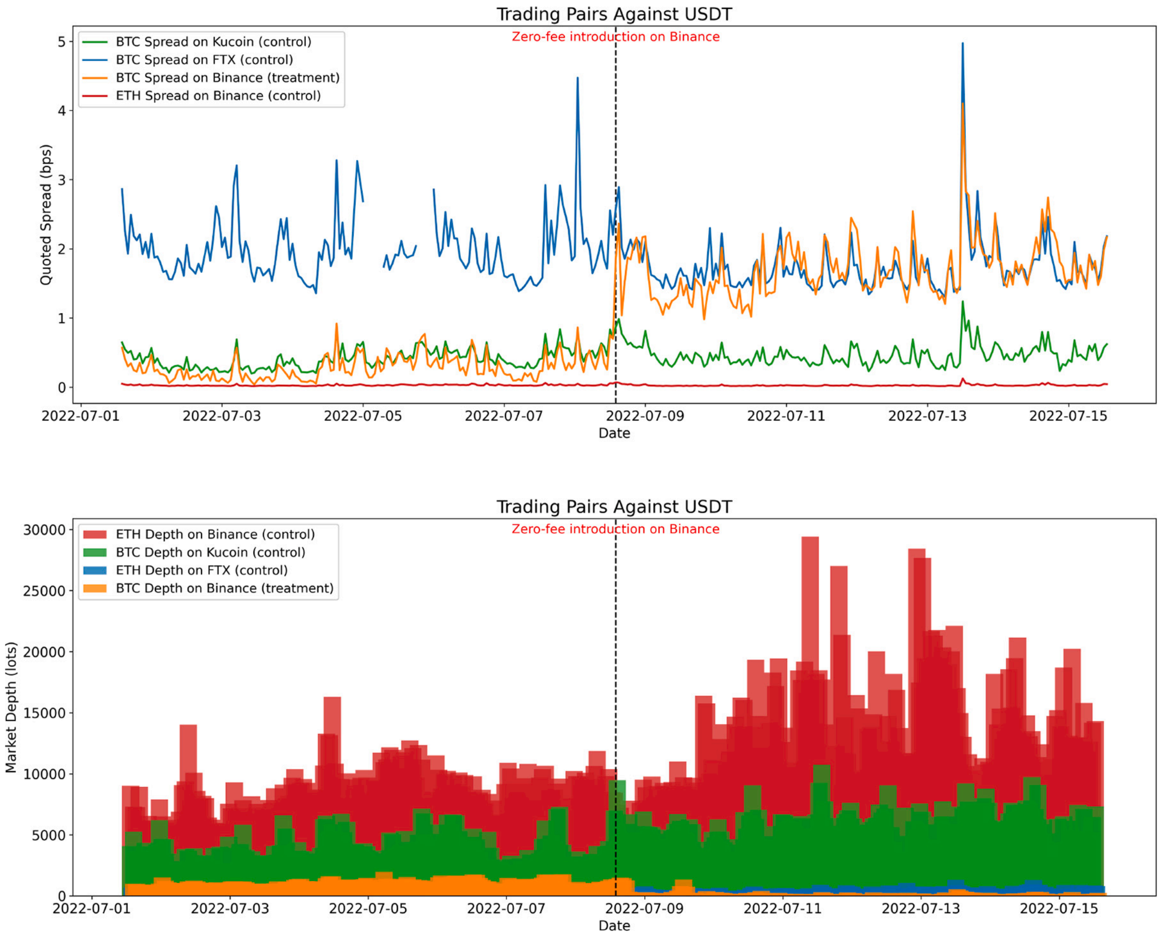


**Fig. 1.** Hourly Quoted Spread and Market Depth comparison for trading pairs against USDT. This figure plots the quoted spreads (in basis points) and the market depth (in lots) for BTCUSDT traded on Binance (treatment sample), FTX and Kucoin, and the ETHUSDT traded on Binance (control samples) before and after the introduction of zero maker–taker fees at Binance. The vertical dotted line depicts the starting period of the zero maker–taker fees, while the orange depicts the treatment sample and the other lines the control samples. Investigation period: 01/07/2022 14:00 UTC to 15/07/2022 14:00 UTC (= 336 h). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
*Source:* RTH database.

traded on FTX (with Kucoin at the middle level). The distribution of the natural logarithm of market depth exhibits a negative skew in all panels except for the panel corresponding to ETHUSDT. Although the quoted spread and effective spread distributions present a positive skewness and excess kurtosis for all assets, the distribution of the liquidity makers' earnings (realized spread) is negatively skewed for all assets analyzed. On average, trading activities for the BTCUSDT appear more frequent and larger in magnitude on Binance, with the number of limit orders on Kucoin matching the number of trades. ETHUSDT, with its extensive depth of the order book, exhibits higher volumes and trade sizes but a lower turnover than the BTCUSDT traded on Binance. Finally, across all assets, the volatility presents a mean and median of 0, and the price distribution showsminimal skewness and negative kurtosis. Additional descriptive statistics (Table A.1, Table A.2, and Table A.3) for the other BTC trading pairs are presented in Appendix A.

Figs. 1 and 2 illustrate the liquidity measures over the sample period (plotted in an hourly frequency for clarity) for the BTCUSDT traded on Binance (treatment sample) in orange, the BTCUSDT traded on FTX (control sample) in blue, the BTCUSDT traded on Kucoin (control sample) in green, and the ETHUSDT traded on Binance (control sample) in red. FTX, the dead cryptocurrency exchange, shows the worst liquidity. Interestingly, the elimination of maker–taker fees on Binance led to an almost immediate increase in the BTCUSDT bid–ask spread from a level lower than that of Kucoin to a higher (worse) level, aligning with that of FTX–the exchange that is accused of having provided privileges to its market makers.

Similarly, after the introduction of zero fees, the market depth for the treatment sample dropped to the level of the bankrupted exchange FTX. In contrast, other assets traded on Binance and Kucoin appear to have increased their depth during the post-fee elimination period. As expected, the adverse selection costs (price impact) decreased to the lowest level (on average) in the treatment group because the posted quotes did not have to impound maker fee adjustments. The liquidity makers' earnings (realized spread) surprisingly became positive after eliminating maker–taker fees, whereas the transaction costs for liquidity takers (effective spread) appeared to remain relatively stable as per the chart.

Fig. 3 shows the change in the trading activities in terms of the number of best-posted limit orders and executed market orders, and traded volumes. Compared to all control samples, the BTCUSDT traded on Binance experienced a substantial increase in the number of quotes and trades, consistent with the proposition that a reduction in costs of

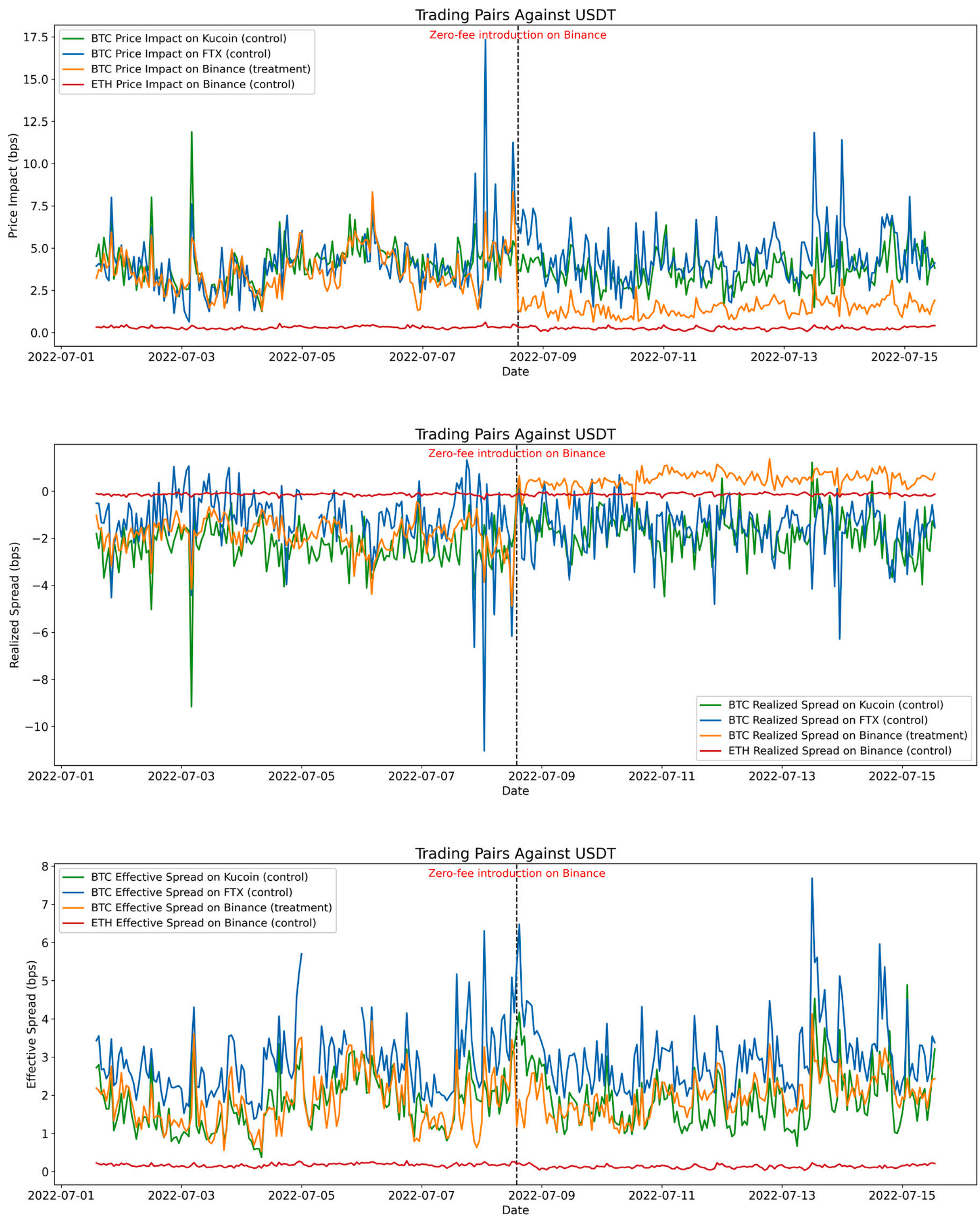


**Fig. 2.** Hourly Price Impact, Realized and Effective Spread comparison for trading pairs against USDT. This figure plots the adverse selection costs (price impact; in basis points), the liquidity supply earnings (realized spread; in basis points), and the cost of a round trip transaction (effective spread; in basis points) for BTCUSDT traded on Binance (treatment sample), FTX and Kucoin, and the ETHUSDT traded on Binance (control samples) before and after the introduction of zero maker–taker fees at Binance. The vertical dotted line depicts the starting period of the zero maker–taker fees, while the orange line depicts the treatment sample and the other lines the control samples. Investigation period: 01/07/2022 14:00 UTC to 15/07/2022 14:00 UTC (= 336 h). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

*Source:* RTH database.

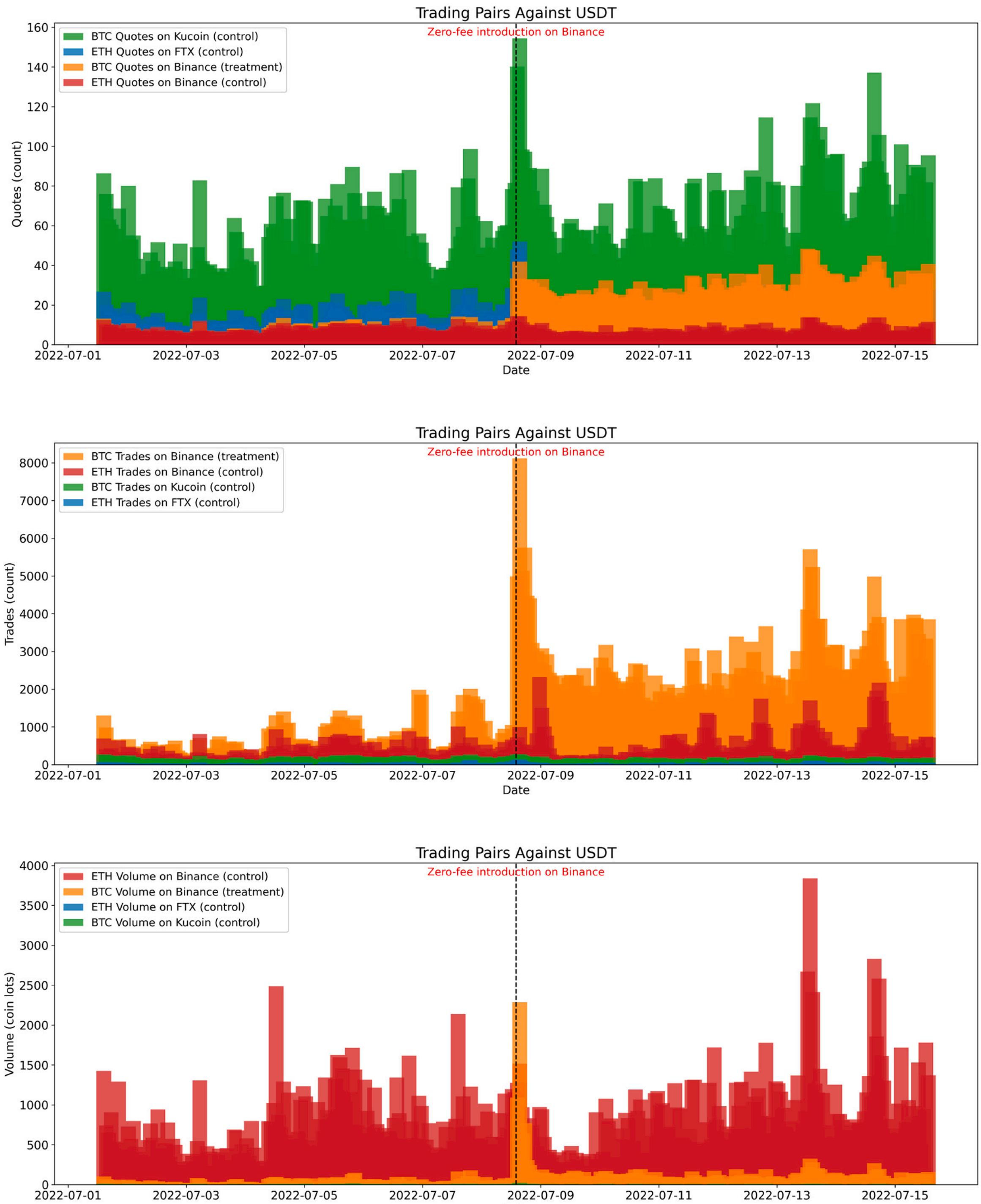


**Fig. 3.** Hourly number of Quotes, Trades, and Volume comparison for trading pairs against USDT. This figure plots the number of best-posted quotes, the number of transactions, and the trading volumes for BTCUSDT traded on Binance (treatment sample), FTX and Kucoin, and the ETHUSDT traded on Binance (control samples) before and after the introduction of zero maker–taker fees at Binance. The vertical dotted line depicts the starting period of the zero maker–taker fees, while the orange line depicts the treatment sample and the other lines the control samples. Investigation period: 01/07/2022 14:00 UTC to 15/07/2022 14:00 UTC (= 336 h). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
*Source:* RTH database.

**Table 2**
Natural experiment statistics for trading pairs against USDT in the pre- and post-periods. This table presents the mean of the pre- and post-periods surrounding the introduction of zero maker–taker fees and the results of the T-tests on the difference between the means. The dependent variables in Panel A, the measures of liquidity, are the quoted spread, the natural logarithm of market depth, the cost of a roundtrip transaction (effective spread), the adverse selection cost (price impact), and the liquidity supply earnings (realized spread). Panel B presents the dependent variables for trading activity, namely the number of quotes per minute, the fraction of marketable orders — fill rate, the number of trades per minute, the average trade size, and the volume. The BTCUSDT traded on Binance is the treatment sample, while the FTX and Kucoin exchanges and ETHUSDT traded on Binance are the control samples. The *, **, *** indicate statistical significance at the 0.1%, 1%, and 5% levels, respectively. The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC (= 20,160 min).

*Panel A: Liquidity*

| Samples | Periods | Quoted spread | | LN market depth | | Effective spread | | Price impact | | Realized spread | | # Obs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mean | t-test | mean | t-test | mean | t-test | mean | t-test | mean | t-test | |
| BTCUSDT | pre | 0.2872 | | 7.0192 | | 1.8047 | | 3.6688 | | −1.8641 | | 10,080 |
| on Binance | post | 1.7036 | | 5.1500 | | 1.9788 | | 1.4724 | | 0.5064 | | 10,080 |
| (treatment) | difference | 1.4164 | 175.62* | −1.8692 | −251.28* | 0.1741 | 7.48* | −2.1964 | −42.19* | 2.3704 | 58.42* | 20,160 |
| BTCUSDT | pre | 1.9849 | | 5.8737 | | 2.8084 | | 3.9633 | | −1.1549 | | 9,328 |
| on FTX | post | 1.7448 | | 6.2436 | | 3.0363 | | 4.5427 | | −1.5063 | | 10,080 |
| (control) | difference | −0.2401 | −21.47* | 0.3699 | 39.00* | 0.2279 | 5.79* | 0.5793 | 4.26* | −0.3514 | −2.85** | 19,408 |
| BTCUSDT | pre | 0.4112 | | 8.1204 | | 1.765 | | 4.0998 | | −2.3348 | | 10,080 |
| on Kucoin | post | 0.4665 | | 8.5568 | | 1.9226 | | 3.6855 | | −1.7629 | | 10,080 |
| (control) | difference | 0.0554 | 11.59* | 0.4364 | 56.96* | 0.1576 | 4.33* | −0.4143 | −4.42* | 0.5719 | 6.65* | 20,160 |
| ETHUSDT | pre | 0.0271 | | 8.9821 | | 0.1749 | | 0.3108 | | −0.1359 | | 10,080 |
| on Binance | post | 0.025 | | 9.3215 | | 0.1279 | | 0.2532 | | −0.1253 | | 10,080 |
| (control) | difference | −0.0021 | −7.07* | 0.3394 | 53.42* | −0.047 | −29.16* | −0.0576 | −12.42* | 0.0105 | 2.7** | 20,160 |

*Panel B: Trading activity*

| Samples | Periods | Number of Quotes | | Fill Rate | | Number of Trades | | Trade Size | | Volume | | # Obs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mean | t-test | mean | t-test | mean | t-test | mean | t-test | mean | t-test | |
| BTCUSDT | pre | 227.5713 | | 0.7055 | | 664.2939 | | 0.0719 | | 50.1768 | | 10,080 |
| on Binance | post | 836.9249 | | 0.7356 | | 2523.486 | | 0.0478 | | 141.3288 | | 10,080 |
| (treatment) | difference | 609.3536 | 230.55* | 0.0301 | 31.76* | 1859.1921 | 130.65* | −0.0241 | −55.48* | 91.152 | 38.49* | 20,160 |
| BTCUSDT | pre | 348.9415 | | 0.1044 | | 38.8813 | | 0.0445 | | 2.1416 | | 9,328 |
| on FTX | post | 505.0088 | | 0.0708 | | 40.5598 | | 0.0417 | | 2.0426 | | 10,080 |
| (control) | difference | 156.0673 | 38.19* | −0.1751 | −297.24* | 1.6785 | 3.10* | −0.0029 | −4.25* | −0.0989 | −1.57 | 19,408 |
| BTCUSDT | pre | 1349.706 | | 0.1243 | | 169.3213 | | 0.0365 | | 6.5913 | | 10,080 |
| on Kucoin | post | 1842.74 | | 0.0818 | | 151.9999 | | 0.035 | | 5.675 | | 10,080 |
| (control) | difference | 493.034 | 40.76* | −0.0425 | −74.43* | −17.3214 | −17.54* | −0.0015 | −5.27* | −0.9162 | −13.60* | 20,160 |
| ETHUSDT | pre | 227.761 | | 0.5729 | | 380.8475 | | 1.6056 | | 692.2538 | | 10,080 |
| on Binance | post | 227.7712 | | 0.6289 | | 537.6347 | | 1.693 | | 848.6211 | | 10,080 |
| (control) | difference | 0.0102 | 0.01 | 0.0560 | 36.10* | 156.7872 | 24.51* | 0.0875 | 6.65* | 156.3673 | 11.71* | 20,160 |

posting limit orders and executing market orders encourages market participants' activities on both liquidity sides (supply and demand). According to the news, trading volumes for BTCUSDT on Binance reached an all-time high on the day of the introduction of the zero-fee pilot program, catching the level of ETHUSDT.[23] those volumes also remained persistently higher during the post-period after the spike on the event date. Overall, all liquidity and trading activity measures showed a drastic change in the average level at the time of introducing zero-fee trading on Binance for BTCUSDT. Unlike Brauneis et al. (2022), every adjustment was instantaneous, suggesting the presence of high-frequency traders and reinforcing the contribution of this study.

I test the significance of these changes in Table 2 to show their magnitude and then run preliminary tests to assess their statistical inference. Surprisingly, Panel A shows a statistically significant increase in the effective spread from before to after the implementation of the zero-maker–taker pricing scheme, despite the small magnitude of the change. This is in sharp contrast to the common belief that eliminating trading fees should lead to lower transaction costs. Although liquidity takers did not have to pay fees to the exchange, they experienced higher costs for trading BTCUSDT on Binance. On the other hand, liquidity takers, who did not pay fees to the exchange after the implementation of zero trading fees, experienced a sharp rise in their quoting earnings (realized spread) of 2.4 basis points on average. It is interesting that liquidity makers on other exchanges and those supplying liquidity for the ETHUSDT on Binance, the same exchange that promoted zero-fee for other cryptocurrencies, continued to face negative realized spreads.

Eventually, liquidity makers not only benefited from the exchange fee discount but also potentially absorbed the benefits intended for liquidity takers. Additionally, both bid–ask spread and market depth significantly deteriorated the liquidity of the market for the exchange's customers, increasing by 1.4 basis points in the quoted spread, which is twice that found in Brauneis et al. (2022). This signals ambiguous market-making behavior because of an increase in revenues not justified by the exchange promotion program, which emphasizes that two out of three control samples witnessed a statistically significant decrease in quoted spreads (the latter experiencing a small increase of less than a quarter of that of the treatment). Finally, information asymmetry decreased as the quoted bids and offers did not have to impound the exchange trading fees, with a statistically significant decline in price impact of 2.2 basis points.

Panel B of Table 2 presents *t*-statistics for the mean change in trading activities. Transactions and posted quotes almost quadrupled after modifying trading fees for the pilot group, and the volume tripled, unlike the (small) decline in trade size. The fraction of marketable orders (fill rate) increased significantly for both crypto traded on

[23] Source: Kaiko Research (https://research.kaiko.com).

**Table 3**
DiD models for liquidity and trading activity measures of all the BTC trading pairs analyzed. This table presents the panel regression results of the DiD analysis for the baseline case with and without control variables and fixed effects, according to Eq. (1):

$y_{it} = \alpha_0 + \beta_1 ZeroFee_t + \beta_2 Treatment_i + \beta_3 ZeroFee_t \times Treatment_i + \beta_4 Price_{it} + \beta_5 Turnover_{it} + \beta_6 Volatility_{it} + \beta_7 HHI_t + \beta_8 FE_{it} + \epsilon_{it}$

The dependent variables in Panel A, the measures of liquidity, are the quoted spread for models (1–2), the natural logarithm of market depth for models (3–4), the cost of a roundtrip transaction (effective spread) for models (5–6), the adverse selection cost (price impact) for models (7–8), and the liquidity supply earnings (realized spread) for models (9–10). Panel B presents the baseline case of the model, with control variables, for trading activity dependent variables: number of quotes per minute, fraction of marketable orders — fill rate, number of trades per minute, average trade size, and volume. The table shows the interaction term $ZeroFee_t \times Treatment_i$ measuring the impact of the introduction of zero maker–taker fees at Binance on the dependent variables. Coefficients for the set of control variables (price, turnover, volatility, and the Herfindahl–Hirschman index of market concentration) are omitted for brevity. The *, **, and *** indicate statistical significance at the 0.1%, 1%, and 5% levels, respectively, while double-clustered standard errors are in parentheses. The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC.

| *Panel A: Liquidity* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quoted Spread | | LN Market Depth | | Effective Spread | | Price Impact | | Realized Spread | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| $ZeroFee_t \times Treatment_i$ | 3.6309 | 3.5233 | −0.8629 | −0.8868 | 1.4510 | 1.3819 | −0.4468 | −0.5000 | 1.8978 | 1.8819 |
| | (0.7717)* | (0.8542)* | (0.3953)*** | (0.4255)*** | (0.4084)* | (0.4870)** | (0.4018) | (0.4802) | (0.2722)* | (0.2652)* |
| Controls | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 33.27% | 30.86% | 13.34% | 11.27% | 1.53% | 1.16% | 0.07% | 0.02% | 0.31% | 0.30% |
| $F$-Statistic | 24047.7* | 107642* | 7424.42* | 30640.8* | 750.104* | 2826.37* | 35.6552* | 47.403* | 147.888* | 733.978* |
| # Obs | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 |
| *Panel B: Trading Activity* | | | | | | | | | | |
| | Number of Quotes | | Number of Trades | | Trade Size | | Volume | | Fill Rate | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| $ZeroFee_t \times Treatment_i$ | 80.3884 | 90.5730 | 365.8338 | 468.5203 | −0.1069 | −0.1095 | −12.2229 | 2.5233 | 0.0216 | 0.0248 |
| | (2.1314)* | (2.0990)* | (2.9933)* | (3.1857)* | (0.0028)* | (0.0028)* | (2.3061)* | (2.2619) | (0.0006)* | (0.0006)* |
| Controls | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 2.29% | 0.77% | 22.62% | 8.23% | 0.68% | 0.65% | 0.73% | 0.00% | 1.10% | 0.67% |
| $F$-Statistic | 1410.34* | 1861.94* | 17626.2* | 21629.4* | 410.968* | 1566.64* | 442.218* | 1.24449 | 667.598* | 1615.43* |
| # Obs | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 |

Binance as expected while decreasing on other exchanges. Although the frequency of posted quotes increased, the size of those quotes (market depth) decreased instead, in contrast to that on other exchanges.

Moreover, the introduction of zero trading fees on Binance led to reduced in trading volumes at other exchanges. Prima facie, Binance's decision to eliminate trading fees for a subgroup of Bitcoin spot pairs incentivized investors to migrate from other platforms to Binance. This migration was not only to trade assets belonging to the pilot group but also to engage in trading activities of other not-promoted cryptocurrencies (*i.e*, ETHUSDT traded on Binance saw an increase in the probability of executing limit orders, despite the latter being unchanged in the number of trades, in the average trade size executed, and volumes). Considering the magnitude and direction of all market quality metrics of the control samples, Table 2 also indicates that this decision had spillover effects to other exchanges, similar to the volatility transmission dominance of Binance analyzed in Alexander et al. (2022).

### 6.2. DiD panel regression results on liquidity and trading activity measures

To test the theoretical predictions, I conduct DiD panel regression analyses on the market quality metrics for all Bitcoin spot pairs available from the database. Eq. (1) includes a set of control variables to account for market-wide movements in prices, turnover, volatility, and the degree of market fragmentation (i.e., concentration), and 10 dependent variables, namely, absolute spread, natural logarithm of market depth, effective spread (i.e., implicit transaction costs), price impact (i.e., adverse selection costs from information asymmetry), and realized spread (i.e., liquidity supply revenues). Table 3 shows the results of the DiD model with and without control variables. It also accounts for crypto-time-fixed effects unrelated to maker–taker pricing, which control for heterogeneity in market quality at the crypto-asset level.

Panel A of Table 3 presents the coefficients of the interaction terms $ZeroFee_t \times Treatment_i$ measuring the impact of the introduction of zero maker–taker fees for Binance's pilot group of Bitcoin trading pairs on the liquidity measures. Thus, I reject Hypotheses 1a and 4b as the absolute quoted spread sharply increased, on average, by 3.6 basis points. On the other hand, however, market depth decreased instead of growing. This implies that the introduction of zero maker–taker fees for the treated crypto-assets worsened the liquidity of the market. I also reject Hypothesis 3 because the effective spread increased by nearly 1.5 basis points, implying that liquidity takers faced higher implicit transaction costs after Binance offered free trading. The realized spread increased by 1.9 basis points, suggesting that liquidity makers increased their trading revenues after Binance offered free order submissions. The information asymmetry measured by the price impact remained unchanged as the negative coefficient is not statistically significant.

Panel B of Table 3 presents the coefficients of the interaction terms $ZeroFee_t \times Treatment_i$ measuring the impact of the introduction of zero maker–taker fees for Binance's pilot group of Bitcoin trading pairs on the trading activity measures. I find support for Hypotheses 1b and 1d, which state that introducing zero maker fees leads to a higher number of posted quotes and eliminating taker fees results in a larger number of executed trades. This is consistent with the proposition that eliminating trading fees for both sides of the market should incentivize liquidity supply and demand to interact on the exchange. Consistent with Foucault et al. (2013), a smaller increase in the number of quotes compared with the increase in the number of trades may signal differences in makers' and takers' incentives to enjoy lower fees on the exchange. From the demand side, I reject Hypothesis 4a, which states that zero maker–taker fees should lead to larger trade sizes. I find that the size of an average trade on Binance decreased by 0.11 lots, which is a substantial change considering the usual small tick size for Bitcoin spot pairs. This suggests that the no-trading fees launched by Binance attracted mainly (small) retail investors, the least sophisticated type of market participants, who were potentially misled

**Table 4**
DiD models for cum-fee effective and realized spread of all the BTC trading pairs analyzed. This table presents the panel regression results of the DiD analysis for the baseline case with and without control variables and fixed effects, according to Eq. (1):

$y_{it} = \alpha_0 + \beta_1 ZeroFee_t + \beta_2 Treatment_i + \beta_3 ZeroFee_t \times Treatment_i + \beta_4 Price_{it} + \beta_5 Turnover_{it} + \beta_6 Volatility_{it} + \beta_7 HHI_t + \beta_8 FE_{it} + \epsilon_{it}$

In Panel A, the dependent variables are represented by the cum-fee effective spreads for three distinct VIP taker fee levels. Conversely, Panel B presents the cum-fee realized spreads for three different VIP maker-fee levels as its dependent variables. The minimum VIP level (regular users) represents the level with the highest fees, while the maximum VIP level (most active users) represents the level with the lowest fees. The table shows the interaction term $ZeroFee_t \times Treatment_i$ measuring the impact of the introduction of zero maker–taker fees at Binance on the dependent variables. The coefficients for the set of control variables (price, turnover, volatility, and the Herfindahl–Hirschman index of market concentration) are omitted for brevity. The *, **, and *** indicate statistical significance at the 0.1%, 1%, and 5% levels, respectively, while double-clustered standard errors are in parentheses. The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC.

*Panel A: Cum-Fee Effective Spread*

| | Minimum Fee Level | | Average Fee Level | | Maximum Fee Level | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $ZeroFee_t \times Treatment_i$ | 1.4498 | 1.3808 | 1.4503 | 1.3812 | 1.4507 | 1.3816 |
| | (0.4084)* | (0.4870)** | (0.4084)* | (0.4870)** | (0.4084)* | (0.4870)** |
| Controls | Yes | No | Yes | No | Yes | No |
| Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 1.53% | 1.16% | 1.53% | 1.16% | 1.53% | 1.16% |
| $F$-Statistic | 749.35* | 2821.84* | 749.636* | 2823.56* | 749.923* | 2825.29* |
| # Obs | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 |

*Panel B: Cum-Fee Realized Spread*

| | Minimum Fee Level | | Average Fee Level | | Maximum Fee Level | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $ZeroFee_t \times Treatment_i$ | 1.8990 | 1.8830 | 1.8985 | 1.8825 | 1.8979 | 1.8820 |
| | (0.2721)* | (0.2651)* | (0.2721)* | (0.2651)* | (0.2722)* | (0.2651)* |
| Controls | Yes | No | Yes | No | Yes | No |
| Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.31% | 0.30% | 0.31% | 0.30% | 0.31% | 0.30% |
| $F$-Statistic | 148.067* | 734.843* | 147.988* | 734.462* | 147.909* | 734.082* |
| # Obs | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 | 261,328 |

by the apparent discount promotion on the exchange and did not realize that transaction costs actually increased.

Furthermore, I find evidence that aligns with Hypothesis 1c. The fraction of marketable orders, which represents the probability of executing each limit order, saw a significant increase, indicated by the positive coefficient of the dependent variable "fill rate". Finally, I find no supporting evidence for Hypothesis 2, which predicts an increase in trading volumes because of the elimination of the maker–taker fees. However, this result might be driven by the difference in the value of the control crypto-asset, specifically, the Ethereum, which is traded on the same Binance exchange, tends to have larger trading volumes than those of the Bitcoin spot pairs due to their difference in the reference price. The robustness tests presented in Section 6.4 ultimately reveal this difference through the tables in Appendix B. These robustness tests allow for a better interpretation of the results and their explanations by providing a linear version of the DiD model that separates each treated crypto-asset from the control samples. The findings of the linear regressions offer supporting evidence for Hypothesis 2 by showing a statistically significant positive coefficient of the interaction term when comparing the treated Bitcoin spot pair with the same asset traded on other exchanges.

### 6.3. Cum-fee total transaction costs

In this section, I run panel regression analysis of Eq. (1) on the cum-fee spreads. Consistent with Malinova and Park (2015), to compute the cum-fee spreads, I add double the taker fee, normalized by the mid-point, to the effective spread (total transaction costs for takers) and subtract twice the maker fee, normalized by the mid-point, from the realized spread (total revenues earned by makers). Considering the challenge of knowing the exact amount paid by each participant to each exchange for every limit and market order, I consider three fee levels for both treated and control exchanges: minimum, maximum, and the average of the two. Thus, I show the possible scenarios of cum-fee spreads: (i) for regular users paying the highest fee (minimum VIP fee level), (ii) for the most active market participant on the exchanges paying the lowest fee (maximum VIP fee level), and (iii) participants paying an average fee, calculated as the mean between the minimum and maximum fee levels. Table 4 shows the results of the DiD model both with and without control variables. It considers crypto-time-fixed effects that control for heterogeneity in market quality at the crypto-asset level that are unrelated to maker–taker pricing.

Panels A and B of Table 4 show the coefficients of the interaction terms $ZeroFee_t \times Treatment_i$ measuring the impact of eliminating maker–taker fees for Binance's pilot group of Bitcoin trading pairs on the cum-fee effective and realized spreads, respectively. On average, the cum-fee effective spread increased by 1.5 basis points, while the cum-fee realized spread raised by 1.9 basis points. It is clear that when Binance launched the zero-fee trading pilot program, liquidity takers faced higher total transaction costs while liquidity makers earned larger trading profits, regardless of the small differences in the VIP fee levels. This finding supports the results from the earlier section, indicating that market makers might be transferring the cost of adjusting maker–taker fees to the exchange's customers. This practice could potentially be seen as unethical, as it appears to prioritize their financial gain over the interests (and protection) of the exchange's clients.

### 6.4. Robustness tests on single cryptocurrencies

In this section, I apply a linear version of Eq. (1) for each BTC trading pair taken separately to run robustness tests. All regressions are inferred using the heteroskedasticity-consistent standard errors of White (1980). This is the most common OLS estimator of unbiased standard errors, which helps avoid any heteroskedasticity issues in testing the statistical significance of the results. Moreover, following Granger (1998), I focus on an interval level of 99.999% (i.e., $\alpha$ = 0.001 for significance level) to define statistically significant results, which helps avoid the rejection of virtually all null hypotheses, given the large $n$ problem with high-frequency data.

Table B.1 shows the results for the most liquid crypto-asset, BTCUSDT, which are discussed in Appendix B. I also offer additional interpretations of the results for three other cryptocurrencies belonging to the pilot group of zero maker–taker fees promoted by Binance. Regression tables (Table B.2, Table B.3, and Table B.4) for these crypto-assets are provided in Appendix B as well, along with some further figures (Fig. C.1, Fig. C.2, and Fig. C.3) in Appendix C. To ensure completeness, I test the validity of the findings through the regressions of the baseline model of Eq. (1) without control variables. These produced qualitatively similar results.

## 7. Conclusions

I conducted an empirical study on maker–taker pricing, the most popular—and yet debatable—exchange price structure in modern financial markets. To determine the impact of the elimination of the total trading fees retained by exchanges on the quality of cryptocurrency markets, I use the introduction of zero fees for passive limit orders and active market orders on Binance. My findings support the theoretical predictions of Colliard and Foucault (2012) over a large sample of cryptocurrencies and within a clean market microstructure setting with no broker interference or tick size influence. However, in contrast to theoretical predictions, I find that the elimination of the total exchange fees increases the raw bid–ask spread, effective spread, and cum-fee spread (and also decreases the market depth of limit orders), all proxies of trading costs faced by liquidity takers. This implies that mainstream market microstructure theory might need to be reexamined when studying crypto-asset markets and consider the various incentives in these self-regulated frameworks.

I concentrate on the group of cryptocurrencies for which the zero-fee pilot program applied to examine the impact of the elimination of the total fee on market quality and on market participant transaction costs and revenues. Consistent with the theories of Colliard and Foucault (2012) and Angel et al. (2011), the bid–ask spread for this group of cryptocurrencies widens to offset a decrease (i.e., elimination) in the maker–taker fee, although in the opposite predicted direction. Additionally, there is evidence of increasing trading activity, falling limit order sizes, declining price impact measured as the information impounded in quoted orders after a trade, and rising realized spreads (which serve as a proxy for the earnings of liquidity providers). I attribute the decrease in adverse selection costs and associated decreased price effect to the exchange deciding to eliminate trading fees. Zero commissions do not distinguish between trades that create or consume liquidity; therefore, these trades depend on posted spreads to make their choices, which is consistent with the assumption of Malinova and Park (2015). On the other hand, the increase in liquidity providers' revenues can be attributed to market makers decision to demand theoretically unjustified higher premiums (discounts) on buyer- (seller-) initiated transactions while not paying fees to the exchange.

Hence, the findings of this study imply that liquidity makers reap the benefits of zero trading fees at the expense of liquidity takers. Determining whether this behavior constitutes market misconduct is not straightforward, although it could be argued that such practices are potentially unethical. In traditional regulated markets, certain rules and norms guide market behavior. However, in self-regulated markets such as several crypto markets: (i) the lack of explicit regulations makes it difficult to legally categorize such behavior as misconduct, and (ii) from an ethical standpoint, it might be argued that the liquidity makers are exploiting the fee elimination to increase their profits at the expense of liquidity takers. In a more regulated market, such behavior might already be scrutinized under fair trading practices. Therefore, some of the policy implications of this study may not be generalized to regular markets. In the less-regulated crypto market, it might be perceived as a strategic adaptation to changing market conditions. When interpreting my findings, it is, therefore, crucial to remember that cryptocurrency markets are still severely unregulated and that the SEC has early accused (bankrupted) fraudulent cryptocurrency exchanges of giving special treatment to "connected" trading firms.

Indeed, it is often suggested that a trading platform can expand its market share by strategically adjusting the make/take fee breakdown to favor makers, based on a comparison of its exchange fee with that of its competitors. This strategy is considered essential to attract traders to migrate from other platforms (Colliard and Foucault, 2012).[24] Ceteris paribus, facilitated by the exchange's fee elimination, market makers increased their profits. Binance's strategic maneuver contributed to a remarkable surge in the exchange's market share after the ambiguous launch of zero-fee for 13 Bitcoin spot trading pairs, surpassing that of its rivals by more than 20%.[25] This ultimately reveals the winners over customers' savings. It might also signal further concerns about possible corporate misconduct, namely the potential collusion between the exchange and market makers. I nevertheless have no evidence for this explanation of my empirical findings and leave it as an avenue for future investigations. Intriguingly, though, after Binance halted the zero-fee program, the market share of the 13 BTC pairs reverted to their prior levels.[26] Examining the impact of reintroducing maker–taker fees on the quality of the cryptocurrency market is another possible avenue for future research.

The maker–taker pricing model is claimed to yield negative outcomes for cryptocurrency investors. The study findings should, therefore, be relevant to regulators and policymakers interested in developing new Regulation Technology (RegTech) solutions with computerized surveillance, in line with the recently proposed consultation report by the International Organization of Securities Commissions (see IOSCO, 2023). Further, it appears necessary to isolate market makers from the influence of the exchanges they operate in – a policy implication that may also extend to other regular financial markets given the competition incentives provided by the shareholder-owned structure of stock exchanges. These solutions could help prevent potential misconduct in this largely unsupervised ecosystem while also leveraging the potential benefits of technological innovation in crypto-assets (IMF, 2023). The SEC has recently filed 13 charges against Binance, accusing the exchange and its CEO of actively attracting US customers to their unregulated global exchange, mixing investor funds with their own, and contravening securities laws.[27]

Interestingly, the cryptocurrency market dynamics saw a significant shift in terms of supply dominance from the U.S. (during 2020–2021) to the Asia in July 2022 (with the former witnessing an 11% decline since then), coincidentally when the Cayman Islands-based exchange eliminated its trading fees.[28] Binance's unilateral decision to remove trading fees raises serious concerns about its potentially leveraged dominant position amongst CEXs. Malinova and Park (2015) highlighted the need to understand how investors modify their pricing in response to changes in maker–taker fees, which is critical to interpreting the impacts of maker–taker pricing.

Despite focusing on centralized cryptocurrency exchanges, this study also has significant implications for trading execution, risk management, and investment decision-making in all crypto-asset markets, whether centralized or decentralized. This is because of the intrinsic interconnection between the two. Likewise, the effects of shifts in maker–taker fees on market dynamics presented in this study could also serve

[24] As an example, see the joint task force CFTC-SEC report investigating the flash crash of May 2010 at www.sec.gov/spotlight/sec-cftcjointcommittee/021811-report.pdf.

[25] Source: Kaiko Research (https://research.kaiko.com).

[26] Source: Kaiko Research (https://research.kaiko.com).

[27] See SEC official document at www.sec.gov/files/litigation/complaints/2023/comp-pr2023-101.pdf. However, it seems that the exchange has now reached a settlement.

[28] Source: Glassnode (www.glassnode.com).

**Table A.1**
Descriptive statistics for pairs against EUR. This table presents summary statistics based on high-frequency trades and quotes data. I obtain the absolute quoted spread (in basis points), natural logarithm of the depth at the best bid and best offer (market depth; in lots), cost of a round-trip trade (effective spread; in basis points), adverse selection cost (price impact; in basis points), liquidity supply earnings (realized spread; in basis points), and number of best quotes from milliseconds order book data. The descriptives for transactions refer to tick-by-tick data, including the fraction of orders that are marketable (fill rate), number of transactions per minute (trades per minute), average trade size and volume (in lots), midpoint price (in coin value), average turnover (in coin value expressed in thousands), and midpoint volatility. The upper (lower) panels show results for the treatment exchange Binance (control exchange Bitfinex and the ETH traded on Binance). The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC.

| Variables | Mean | Median | Min | Max | Std dev | Skew | Kurt | # Obs |
|---|---|---|---|---|---|---|---|---|
| *Panel A: BTCEUR on Binance (treatment)* | | | | | | | | |
| Quoted spread (bps) | 5.7556 | 5.4537 | 0.01 | 40.5278 | 3.5666 | 0.8471 | 1.364 | 20,160 |
| LN Market depth (lots) | 3.2311 | 3.2968 | −1.3526 | 5.9193 | 0.6241 | −0.7796 | 2.0511 | 20,160 |
| Effective spread (bps) | 4.7054 | 3.9802 | −15.2833 | 44.8026 | 3.5466 | 2.0729 | 10.4571 | 20,160 |
| Price Impact (bps) | 4.2229 | 2.8682 | −67.4192 | 175.3551 | 7.6477 | 4.0486 | 59.3821 | 20,160 |
| Realized Spread (bps) | 0.4825 | 0.9947 | −155.5685 | 81.285 | 7.0287 | −2.7852 | 49.5234 | 20,160 |
| Quotes per minute | 227.0118 | 214 | 1 | 670 | 111.8065 | 0.5974 | −0.0196 | 20,160 |
| Fill Rate | 0.1458 | 0.136 | 0.0031 | 1 | 0.0715 | 1.094 | 3.4455 | 20,160 |
| Trades per minute | 40.5584 | 30 | 1 | 622 | 37.1046 | 3.2509 | 19.2285 | 20,160 |
| Trade Size (lots) | 0.0304 | 0.0278 | 0.0005 | 0.3404 | 0.0164 | 2.2788 | 17.4482 | 20,160 |
| Volume (lots) | 1.4022 | 0.847 | 0.0005 | 33.6072 | 1.8515 | 4.6174 | 38.1684 | 20,160 |
| Price (coin value) | 19 851.8164 | 19 831.1127 | 18 065.1403 | 21 913.787 | 976.5026 | −0.0038 | −1.0454 | 20,160 |
| Turnover (coin value) | 19.841 | 16.1773 | 0.0031 | 66.5815 | 15.1075 | 0.7616 | −0.202 | 20,160 |
| Volatility | 0 | 0 | −0.1036 | 0.0194 | 0.001 | −50.0531 | 5086.3614 | 20,160 |
| *Panel B: BTCEUR on Bitfinex (control)* | | | | | | | | |
| Quoted spread (bps) | 3.129 | 2.9123 | 0.8058 | 14.8822 | 1.1469 | 1.2083 | 3.4937 | 20,160 |
| LN Market depth (lots) | 5.1945 | 5.187 | −2.9496 | 10.1444 | 0.843 | −0.2586 | 5.2409 | 20,160 |
| Effective spread (bps) | 2.2052 | 1.1667 | −58.3594 | 73.258 | 4.7619 | 2.5823 | 23.9154 | 20,160 |
| Price Impact (bps) | 3.9347 | 2.1183 | −100.1167 | 487.3251 | 18.1884 | 4.6871 | 101.9068 | 20,160 |
| Realized Spread (bps) | −1.7295 | −0.3175 | −440.5951 | 103.7936 | 17.0635 | −4.5713 | 101.9398 | 20,160 |
| Quotes per minute | 217.4994 | 198 | 1 | 1440 | 116.6244 | 1.3306 | 3.826 | 20,160 |
| Fill Rate | 0.0407 | 0.0202 | 0.0015 | 1 | 0.0599 | 4.04 | 24.9707 | 20,160 |
| Trades per minute | 9.3445 | 4 | 1 | 406 | 19.7504 | 7.1192 | 76.9945 | 20,160 |
| Trade Size (lots) | 0.0588 | 0.0203 | 1.00e−8 | 13.6844 | 0.2379 | 24.9151 | 907.3476 | 20,160 |
| Volume (lots) | 1.0674 | 0.0619 | 1.00e−8 | 200 | 5.4144 | 14.4163 | 297.196 | 20,160 |
| Price (coin value) | 19 839.6764 | 19 826.3824 | 18 051.0998 | 21 908.4108 | 969.9217 | −0.0013 | −1.0159 | 20,160 |
| Turnover (coin value) | 14.0329 | 4.0483 | 1.54e−6 | 91.8855 | 20.2721 | 1.968 | 3.3883 | 20,160 |
| Volatility | 0 | 0 | −0.0124 | 0.0177 | 0.0008 | 1.1157 | 41.0715 | 20,160 |
| *Panel C: ETHEUR on Binance (control)* | | | | | | | | |
| Quoted spread (bps) | 0.2358 | 0.2043 | 0.01 | 2.1757 | 0.1445 | 2.26 | 10.5534 | 20,160 |
| LN Market depth (lots) | 5.9141 | 5.9643 | 1.2627 | 8.6742 | 0.5854 | −0.7683 | 2.0008 | 20,160 |
| Effective spread (bps) | 0.2603 | 0.2186 | −0.64 | 3.3372 | 0.1894 | 2.7552 | 19.3625 | 20,160 |
| Price Impact (bps) | 0.3443 | 0.2458 | −3.452 | 14.5926 | 0.5421 | 3.8498 | 60.6896 | 20,160 |
| Realized Spread (bps) | −0.084 | −0.0182 | −14.0631 | 3.967 | 0.4835 | −3.183 | 56.6862 | 20,160 |
| Quotes per minute | 214.8193 | 201 | 2 | 642 | 98.2364 | 0.7473 | 0.4967 | 20,160 |
| Fill Rate | 0.1671 | 0.1586 | 0.0018 | 1 | 0.0712 | 0.8174 | 1.5447 | 20,160 |
| Trades per minute | 45.5097 | 37 | 1 | 416 | 35.0215 | 2.2802 | 8.8786 | 20,160 |
| Trade Size (lots) | 0.5594 | 0.4775 | 0.0099 | 8.5741 | 0.3237 | 3.5261 | 34.65 | 20,160 |
| Volume (lots) | 26.632 | 18.8542 | 0.0099 | 277.9145 | 25.563 | 2.3222 | 8.2168 | 20,160 |
| Price (coin value) | 1110.788 | 1108.5468 | 988.3923 | 1247.4534 | 69.1221 | 0.0448 | −1.2415 | 20,160 |
| Turnover (coin value) | 21.3525 | 18.1208 | 0.0062 | 85.491 | 16.156 | 0.9167 | 0.6964 | 20,160 |
| Volatility | −0.0001 | 0 | −3.0168 | 0.0195 | 0.0213 | −141.553 | 20 075.0952 | 20,160 |

as an important set of insights for the regulation of traditional financial markets, even though market participants largely vary (i.e., more sophisticated and more financially educated). A common policy implication for both traditional and digital financial markets could involve addressing regulatory concerns about monopoly restrictions over the unilateral exchanges' fee-setting process. Ultimately, regulators should pay close attention to exchange commissions charged by trading venues in both equities (or options and bonds) and cryptocurrencies, especially in such an unregulated environment as cryptocurrency markets.

## CRediT authorship contribution statement

**Luca Galati:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

## Data availability

The data that support the findings of this study are available from Refinitiv but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are available from the author upon reasonable request and with permission of Refinitiv and Rozetta.

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**Table A.2**
Descriptive statistics for pairs against GBP. This table presents summary statistics based on high-frequency trades and quotes data. I obtain the absolute quoted spread (in basis points), natural logarithm of the depth at the best bid and best offer (market depth; in lots), cost of a round-trip trade (effective spread; in basis points), adverse selection cost (price impact; in basis points), liquidity supply earnings (realized spread; in basis points), and number of best quotes from milliseconds order book data. The descriptives for transactions refer to tick-by-tick data, including the fraction of orders that are marketable (fill rate), number of transactions per minute (trades per minute), average trade size and volume (in lots), midpoint price (in coin value), average turnover (in coin value expressed in thousands), and midpoint volatility. The upper (lower) panels show results for the treatment exchange Binance (control exchange Bitfinex and the ETH traded on Binance). The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC.

| Variables | Mean | Median | Min | Max | Std dev | Skew | Kurt | # Obs |
|---|---|---|---|---|---|---|---|---|
| *Panel A: BTCGBP on Binance (treatment)* | | | | | | | | |
| Quoted spread (bps) | 7.5733 | 7.2371 | 0.01 | 36.0482 | 3.7186 | 0.9861 | 1.8812 | 20,160 |
| LN Market depth (lots) | 2.3945 | 2.5188 | −4.7444 | 6.3165 | 0.8198 | −1.0982 | 2.7929 | 20,160 |
| Effective spread (bps) | 4.5762 | 3.8988 | −24.766 | 149.3263 | 4.5947 | 2.9711 | 58.9932 | 20,160 |
| Price Impact (bps) | 4.0698 | 2.3529 | −127.245 | 418.546 | 11.6096 | 4.684 | 117.6789 | 20,160 |
| Realized Spread (bps) | 0.5065 | 1.3037 | −389.9857 | 138.1776 | 11.0645 | −3.6666 | 104.902 | 20,160 |
| Quotes per minute | 150.8436 | 132 | 1 | 624 | 93.5965 | 0.9353 | 0.7309 | 20,160 |
| Fill Rate | 0.1025 | 0.0842 | 0.0021 | 1 | 0.0784 | 2.0374 | 7.2332 | 20,160 |
| Trades per minute | 16.2336 | 11 | 1 | 392 | 18.302 | 4.9009 | 48.4932 | 20,160 |
| Trade Size (lots) | 0.0226 | 0.0205 | 1.00e−5 | 0.2353 | 0.0141 | 2.1341 | 11.6565 | 20,160 |
| Volume (lots) | 0.4247 | 0.2321 | 1.00e−5 | 29.4005 | 0.6966 | 9.2537 | 210.4225 | 20,160 |
| Price (coin value) | 16 898.286 | 16 882.3417 | 15 554.5993 | 18 545.1838 | 733.2431 | 0.1062 | −1.0227 | 20,160 |
| Turnover (coin value) | 4.9646 | 4.1528 | 0.0001 | 16.7133 | 3.7907 | 0.7745 | −0.1447 | 20,160 |
| Volatility | 0 | 0 | −0.085 | 0.0206 | 0.0009 | −35.7237 | 3303.6369 | 20,160 |
| *Panel B: BTCGBP on Bitfinex (control)* | | | | | | | | |
| Quoted spread (bps) | 2.789 | 2.6077 | 0.8333 | 30.01 | 0.9962 | 2.0621 | 30.1449 | 20,160 |
| LN Market depth (lots) | 5.2992 | 5.2885 | −5.3521 | 10.3836 | 0.8325 | −0.339 | 6.8936 | 20,160 |
| Effective spread (bps) | 3.173 | 2.25 | −86.193 | 82 | 4.3898 | 1.8642 | 34.4534 | 20,160 |
| Price Impact (bps) | 4.4258 | 2.7143 | −97.4137 | 450.6831 | 15.1188 | 3.5286 | 64.2272 | 20,160 |
| Realized Spread (bps) | −1.2528 | −0.2043 | −435.8916 | 96.9 | 13.951 | −3.4869 | 74.3221 | 20,160 |
| Quotes per minute | 218.6094 | 201 | 1 | 1317 | 112.4148 | 1.2149 | 3.3049 | 20,160 |
| Fill Rate | 0.0454 | 0.0292 | 0.0017 | 0.8562 | 0.0541 | 3.928 | 27.1754 | 20,160 |
| Trades per minute | 10.2476 | 5 | 1 | 401 | 16.179 | 7.5585 | 110.1944 | 20,160 |
| Trade Size (lots) | 0.0322 | 0.0043 | 1.00e−8 | 7.531 | 0.1095 | 41.8859 | 2489.0692 | 20,160 |
| Volume (lots) | 0.5723 | 0.023 | 1.00e−8 | 120.2194 | 2.8245 | 19.0539 | 508.822 | 20,160 |
| Price (coin value) | 16 896.6426 | 16 881.8832 | 15 550.8227 | 18 525.1624 | 726.4471 | 0.1189 | −1.0067 | 20,160 |
| Turnover (coin value) | 6.3729 | 2.9018 | 0 | 38.444 | 8.0629 | 2.0085 | 4.3266 | 20,160 |
| Volatility | 0 | 0 | −0.248 | 0.0182 | 0.0019 | −109.6161 | 14 289.8868 | 20,160 |
| *Panel C: ETHGBP on Binance (control)* | | | | | | | | |
| Quoted spread (bps) | 0.4283 | 0.3799 | 0.01 | 2.354 | 0.2364 | 1.1171 | 2.1734 | 20,160 |
| LN Market depth (lots) | 4.5396 | 4.7055 | −2.1507 | 7.3547 | 1.0283 | −1.0272 | 1.8379 | 20,160 |
| Effective spread (bps) | 0.2684 | 0.21 | −1.605 | 7.4409 | 0.3284 | 1.4534 | 15.5128 | 20,160 |
| Price Impact (bps) | 0.3857 | 0.2378 | −7.6606 | 19.1609 | 1.1832 | 1.5502 | 14.9684 | 20,160 |
| Realized Spread (bps) | −0.1174 | −0.0078 | −16.9427 | 8.4906 | 1.1198 | −1.3948 | 14.543 | 20,160 |
| Quotes per minute | 102.8686 | 84 | 1 | 504 | 74.2395 | 1.3357 | 2.1185 | 20,160 |
| Fill Rate | 0.1104 | 0.0782 | 0.0021 | 0.967 | 0.1041 | 2.1798 | 6.7674 | 20,160 |
| Trades per minute | 11.3666 | 7 | 1 | 213 | 12.6161 | 2.5026 | 10.8143 | 20,160 |
| Trade Size (lots) | 0.4351 | 0.3 | 0.0001 | 14.2993 | 0.4436 | 3.7556 | 57.4207 | 20,160 |
| Volume (lots) | 7.1273 | 2.1484 | 0.0001 | 239.4225 | 12.1002 | 3.7448 | 23.1439 | 20,160 |
| Price (coin value) | 945.5093 | 949.2899 | 849.6751 | 1054.696 | 54.5746 | 0.0787 | −1.2994 | 20,160 |
| Turnover (coin value) | 4.4455 | 2.089 | 0 | 29.8716 | 5.926 | 1.943 | 3.1841 | 20,160 |
| Volatility | 0 | 0 | −0.3189 | 0.0191 | 0.0024 | −111.209 | 14 558.8184 | 20,160 |

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## Appendix A. Additional descriptive tables

See Tables A.1, A.2 and A.3.

**Table A.3**
Descriptive statistics for pairs against USDC. This table presents summary statistics based on high-frequency trades and quotes data. I obtain the absolute quoted spread (in basis points), natural logarithm of the depth at the best bid and best offer (market depth; in lots), cost of a round-trip trade (effective spread; in basis points), adverse selection cost (price impact; in basis points), liquidity supply earnings (realized spread; in basis points), and number of best quotes from milliseconds order book data. The descriptives for transactions refer to tick-by-tick data, including the fraction of orders that are marketable (fill rate), number of transactions per minute (trades per minute), average trade size and volume (in lots), midpoint price (in coin value), average turnover (in coin value expressed in thousands), and midpoint volatility. The upper (lower) panels show results for the treatment exchange Binance (control exchange Bitfinex and the ETH traded on Binance). The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC.

| Variables | Mean | Median | Min | Max | Std dev | Skew | Kurt | # Obs |
|---|---|---|---|---|---|---|---|---|
| *Panel A: BTCUSDC on Binance (treatment)* | | | | | | | | |
| Quoted spread (bps) | 3.7461 | 3.6993 | 0.01 | 45.412 | 1.9528 | 2.0009 | 21.5449 | 20,160 |
| LN Market depth (lots) | 3.9982 | 4.0189 | −0.4993 | 9.2204 | 0.5995 | −0.0712 | 6.9055 | 20,160 |
| Effective spread (bps) | 4.3754 | 3.7526 | −11.5311 | 62.4997 | 3.4077 | 3.9595 | 36.6948 | 20,160 |
| Price Impact (bps) | 4.321 | 3.0425 | −137.4629 | 372.8741 | 8.4018 | 16.6978 | 654.4069 | 20,160 |
| Realized Spread (bps) | 0.0544 | 0.6118 | −335.3777 | 150.145 | 7.6892 | −14.5783 | 607.182 | 20,160 |
| Quotes per minute | 325.156 | 326 | 8 | 839 | 143.7845 | 0.2423 | −0.2566 | 20,160 |
| Fill Rate | 0.1894 | 0.1744 | 0.0045 | 0.8105 | 0.0944 | 0.9772 | 1.6289 | 20,160 |
| Trades per minute | 87.2218 | 66 | 1 | 1088 | 79.9827 | 2.5812 | 12.4594 | 20,160 |
| Trade Size (lots) | 0.0454 | 0.0422 | 0.0006 | 0.3938 | 0.0221 | 2.6204 | 16.6026 | 20,160 |
| Volume (lots) | 4.4633 | 2.7417 | 0.0006 | 141.3329 | 6.0227 | 5.7362 | 64.1013 | 20,160 |
| Price (coin value) | 20 246.9541 | 20 180.7327 | 18 819.1725 | 22 362.3291 | 848.2501 | 0.4235 | −0.9097 | 20,160 |
| Turnover (coin value) | 63.2136 | 48.7634 | 0.0092 | 236.7951 | 51.398 | 0.9855 | 0.3629 | 20,160 |
| Volatility | 0 | 0 | −0.012 | 0.0986 | 0.001 | 45.4794 | 4372.6099 | 20,160 |
| *Panel B: BTCUSDC on Kucoin (control)* | | | | | | | | |
| Quoted spread (bps) | 2.4535 | 2.0068 | 0.05 | 56.0319 | 2.0243 | 6.3161 | 93.1084 | 20,160 |
| LN Market depth (lots) | 4.2121 | 4.3687 | −2.7954 | 9.7089 | 0.9303 | −0.9751 | 2.4344 | 20,160 |
| Effective spread (bps) | 3.2678 | 1.6593 | −17.3571 | 222.8196 | 7.184 | 8.4541 | 134.2344 | 20,160 |
| Price Impact (bps) | 3.4095 | 1.7745 | −93 | 276.9981 | 14.9951 | 1.6453 | 18.258 | 20,160 |
| Realized Spread (bps) | −0.1417 | 0.4809 | −271.1279 | 196.137 | 14.4954 | −0.3191 | 18.9874 | 20,160 |
| Quotes per minute | 368.6285 | 304 | 1 | 2189 | 273.0683 | 1.2568 | 1.789 | 20,160 |
| Fill Rate | 0.0438 | 0.027 | 0.0006 | 1 | 0.0539 | 4.3492 | 35.9838 | 20,160 |
| Trades per minute | 13.8067 | 7 | 1 | 213 | 20.446 | 3.541 | 15.6886 | 20,160 |
| Trade Size (lots) | 0.045 | 0.0337 | 8.00e−8 | 0.7813 | 0.0457 | 2.2515 | 10.762 | 20,160 |
| Volume (lots) | 0.4713 | 0.2742 | 8.00e−8 | 21.1798 | 0.6555 | 5.7565 | 88.6953 | 20,160 |
| Price (coin value) | 20 246.0003 | 20 181.0277 | 18 793.3267 | 22 355.5101 | 848.3441 | 0.4243 | −0.9083 | 20,160 |
| Turnover (coin value) | 6.6654 | 5.1772 | 0.0001 | 24.3532 | 5.5222 | 1.2052 | 0.8077 | 20,160 |
| Volatility | 0 | 0 | −0.0697 | 0.0219 | 0.0009 | −22.0274 | 1797.2451 | 20,160 |
| *Panel C: USDC on Binance (control)* | | | | | | | | |
| Quoted spread (bps) | 0.2047 | 0.2032 | 0.0112 | 2.7611 | 0.1197 | 2.2621 | 20.8052 | 20,160 |
| LN Market depth (lots) | 6.0624 | 6.1428 | −0.6153 | 12.0803 | 0.898 | −0.2729 | 3.0864 | 20,160 |
| Effective spread (bps) | 0.2974 | 0.2602 | −3.1688 | 4.9163 | 0.2186 | 2.8629 | 35.513 | 20,160 |
| Price Impact (bps) | 0.3381 | 0.2519 | −3.3705 | 15.5331 | 0.6083 | 3.4103 | 57.0696 | 20,160 |
| Realized Spread (bps) | −0.0407 | 0.0004 | −10.6168 | 3.5706 | 0.5524 | −2.035 | 29.2994 | 20,160 |
| Quotes per minute | 249.7244 | 232 | 2 | 837 | 126.5623 | 0.7469 | 0.6056 | 20,160 |
| Fill Rate | 0.1501 | 0.1324 | 0.0026 | 0.9462 | 0.0862 | 1.5307 | 4.5631 | 20,160 |
| Trades per minute | 49.925 | 34 | 1 | 1249 | 53.9918 | 4.273 | 41.2538 | 20,160 |
| Trade Size (lots) | 0.5318 | 0.4531 | 0.0093 | 13.8006 | 0.418 | 5.9849 | 96.4213 | 20,160 |
| Volume (lots) | 34.9386 | 15.5974 | 0.0093 | 2039.8054 | 77.785 | 11.1939 | 194.1272 | 20,160 |
| Price (coin value) | 1132.8786 | 1136.1408 | 1013.7481 | 1269.8124 | 63.9917 | 0.1697 | −1.3031 | 20,160 |
| Turnover (coin value) | 26.5101 | 20.4678 | 0.0032 | 99.9847 | 21.8901 | 1.1164 | 0.6459 | 20,160 |
| Volatility | 0 | 0 | −0.0185 | 0.0265 | 0.001 | 1.4612 | 56.723 | 20,160 |

## Appendix B. Tables of robustness results

The (main) BTCUSDT results of the DiD linear regression of Eq. (1) presented in Table B.1, which account for market-wide fluctuations, confirm the panel regression findings. These agree with the theoretical predictions with the exception of the bid–ask and effective spreads that should have decreased, considering that neither liquidity providers nor takers faced a commission after the change in the microstructure rule on the exchange. This can be explained by the possible unethical behavior adopted by market makers to increase their revenues at the expense of takers' welfare. Specifically, in Panel A of Table B.1, the interaction terms between the dummy variable indicating the elimination period of trading fee and the dummy indicating the treatment sample, which measures the impact of the introduction of zero maker–taker fees at Binance on the absolute quoted spread, are significantly positive. An increase in spread following a sharp decrease in exchange fee contradicts the predictions of Colliard and Foucault (2012) in corollaries 1 and 7 and, therefore, rejects Hypothesis 1a.

I also reject Hypothesis 3 against the prediction of Malinova and Park (2015), which states that a downward adjustment in the total exchange fee should correspond to a decline in the effective spread. I find that, against FTX and Kucoin control samples, the effective spread remains unchanged and even increased when compared to that of ETHUSDT after the introduction of zero maker–taker fees for the BTCUSDT and other Bitcoin trading pairs. Binance's customers trading BTCEUR, BTCGBP, and BTCUSDC all experienced statistically significant higher transaction costs upon the elimination of the exchange's fees, which is somewhat counterintuitive (see results in Appendix B). Two exceptions may be found because of the mechanical decomposition of these costs, namely, the liquidity-making earnings. In the last column of Panel A, I find that the realized spread increases on average by 2.3 basis points of the midpoint when accounting for market-wide fluctuations. This implies that to increase their revenues by exploiting the discount of the exchange, market makers tried to make liquidity takers pay the same transaction costs (and even higher without their knowledge) as before the promotion by resorting to wider bid–ask

**Table B.1**
DiD models for trading pairs against USDT. This table presents the regression results of the DiD analysis for the baseline case with control variables according to Eq. (1). The dependent variables in Panel A, the measures of liquidity, are the quoted spread for models (1–3), natural logarithm of market depth for models (4–6), cost of a round-trip transaction (effective spread) for models (7–9), adverse selection cost (price impact) for models (10–12), and liquidity supply earnings (realized spread) for models (13–15). Panel B presents the baseline case of the model for trading activity-dependent variables (number of quotes per minute, fraction of marketable orders — fill rate, number of trades per minute, average trade size, and volume) without control variables. The BTCUSDT traded on Binance is the treatment sample, while the FTX and Kucoin exchanges and ETHUSDT traded on Binance are the control samples. The table shows the regression intercept, the coefficients of the $ZeroFee_t$ dummy indicating the elimination period of trading fee, the $Treatment_i$ dummy indicating the BTCUSDT traded on Binance sample, and the interaction term $ZeroFee_t \times Treatment_i$ measuring the impact of the introduction of zero maker–taker fees at Binance on the dependent variables. Control variables (price, turnover, and volatility) are omitted for brevity. The * indicates statistical significance at the 0.1% level, while heteroskedasticity-consistent standard errors are in parentheses. The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC (= 20,160 min).

*Panel A: Liquidity*

| | Quoted Spread | | | LN Market Depth | | | Effective Spread | | | Price Impact | | | Realized Spread | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| Zero Fee | −0.252 | 0.051 | −0.005 | 0.352 | 0.435 | 0.336 | 0.184 | 0.079 | −0.05 | 0.338 | −5.585 | −0.062 | −0.155 | 0.638 | 0.012 |
| | (0.01)* | (0.00)* | (0.00)* | (0.01)* | (0.01)* | (0.01)* | (0.04)* | (0.04) | (0.00)* | (0.16) | (0.09)* | (0.00)* | (0.14) | (0.09)* | (0.00) |
| Treatment | −1.725 | −0.147 | 1.145 | 1.117 | −1.129 | −3.244 | −1.018 | 0.021 | 2.362 | −0.359 | −4.727 | 0.027 | −0.659 | 0.494 | 2.335 |
| | (0.01)* | (0.01)* | (0.11)* | (0.01)* | (0.01)* | (0.09)* | (0.03)* | (0.03) | (0.31)* | (0.11)* | (0.08)* | (0.79)* | (0.10)* | (0.07)* | (0.62)* |
| Zero Fee × | 1.611 | 1.31 | 1.393 | −2.289 | −2.361 | −2.264 | −0.094 | −0.003 | 0.189 | −2.727 | −1.799 | −2.272 | 2.634 | 1.796 | 2.462 |
| Treatment | (0.01)* | (0.01)* | (0.01)* | (0.01)* | (0.01)* | (0.01)* | (0.05) | (0.04) | (0.02)* | (0.15)* | (0.10)* | (0.06)* | (0.13)* | (0.09)* | (0.05)* |
| FTX (control) | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No | No |
| Kucoin (control) | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No |
| ETH (control) | No | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes |
| Adjusted $R^2$ | 51.27% | 61.66% | 75.59% | 56.76% | 85.85% | 92.14% | 5.45% | 0.30% | 36.88% | 2.91% | 3.90% | 22.81% | 2.23% | 5.47% | 16.58% |
| # Obs | 39,568 | 40,320 | 40,320 | 39,568 | 40,320 | 40,320 | 39,568 | 40,320 | 40,320 | 39,568 | 40,320 | 40,320 | 39,568 | 40,320 | 40,320 |

*Panel B: Trading Activity*

| | Number of Quotes | | | Fill Rate | | | Number of Trades | | | Trade Size | | | Volume | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| Zero Fee | 152.54 | 495.87 | 1.978 | −0.037 | −0.048 | 0.053 | −21.094 | −38.825 | 131.44 | −0.004 | −0.004 | 0.096 | −8.187 | −8.537 | 158.34 |
| | (4.28)* | (12.47)* | (1.21) | (0.00)* | (0.00)* | (0.00)* | (3.36)* | (3.30)* | (6.58)* | (0.00)* | (0.00)* | (0.01)* | (0.61)* | (0.57)* | (13.71)* |
| Treatment | −123.45 | −1127.9 | 364.75 | 0.594 | 0.575 | −0.085 | 518.64 | 399.62 | −936.72 | 0.026 | 0.034 | −0.48 | 32.701 | 30.13 | 263.2 |
| | (2.95)* | (8.02)* | (40.47)* | (0.00)* | (0.00)* | (0.03)* | (7.48)* | (7.19)* | (223.98)* | (0.00)* | (0.00)* | (0.23) | (1.26)* | (1.16)* | (250.38)* |
| Zero Fee × | 449.96 | 104.61 | 600.24 | 0.051 | 0.061 | −0.044 | 1666.2 | 1683.1 | 1510.4 | −0.024 | −0.025 | −0.1 | 64.391 | 64.773 | −121.56 |
| Treatment | (4.99)* | (12.38)* | (3.02)* | (0.00)* | (0.00)* | (0.00)* | (14.65)* | (14.71)* | (15.65)* | (0.00)* | (0.00)* | (0.01)* | (1.91)* | (1.90)* | (13.56)* |
| FTX (control) | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No | No |
| Kucoin (control) | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No |
| ETH (control) | No | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes | No | No | Yes |
| Adjusted $R^2$ | 47.88% | 48.24% | 76.95% | 97.10% | 97.03% | 34.77% | 68.14% | 66.35% | 57.14% | 8.87% | 26.31% | 59.19% | 21.66% | 21.02% | 20.74% |
| # Obs | 39,568 | 40,320 | 40,320 | 39,568 | 40,320 | 40,320 | 39,568 | 40,320 | 40,320 | 39,568 | 40,320 | 40,320 | 39,568 | 40,320 | 40,320 |

spreads. Those liquidity providers would have benefited from the zero-fee program even without alerting the level of best bids and offers, as the commissions they were paying to the exchange to post their quotes were eliminated after July 8, 2022.

The negative and statistically significant coefficients of the market depth interaction term in Panel A of Table B.1 reject Hypothesis 4b and, together with the odd increase in the quoted spread, provide evidence of liquidity deterioration for takers in the market on the introduction of zero fees. In Panel B of Table B.1 I test whether the elimination of trading fees on Binance for the treatment sample has any impact on trading activities. I find support for Hypotheses 1b, 1c, and 1d in line with the prediction of Colliard and Foucault (2012) and the findings of Malinova and Park (2015). When market participants do not have to pay fees to the exchange, both the cost of submitting limit orders and executing market orders fall,[29] in turn encouraging both liquidity makers and takers to frequently interact on the exchange, thus increasing the likelihood of executing each limit order. As evidenced previously in Panel B of Table 2, the fraction of marketable orders increased significantly for other assets traded on Binance, supporting the proposition that the decision to eliminate trading fees for a subset of cryptocurrencies attracted investors to engage on the platform even to trade alternative assets not in the pilot group, in turn boosting the exchange's market share. This is also strengthened by the results for ETHEUR and ETHGBP in Appendix A, which, for BTCGBP and BTCUSDC, provide support for Hypothesis 1c when controlled for a different exchange.

According to Hypothesis 2, trading volume tends toward the platform featuring the lowest exchange fees. Consistent with the null of Colliard and Foucault (2012), I find a statistically significant growth of traded volumes on Binance for the treatment BTCUSDT when controlled over different exchanges. The third coefficient of the interaction term signals what was found in the descriptive statistics of Table 1, namely that the trading volume for the different cryptos, specifically, Ethereum, is larger than that of Bitcoin. The lighter increase in ETHUSDT volumes, also seen in Table 2, is the result of the investors' attraction to the introduction of zero fees on the platform, which increased Binance's market share. Moreover, in Panel B of Table B.1, on factoring in fluctuations across the market, I observe a reduction in the trade sizes when buying or selling BTCUSDT on Binance, which contradicts the prediction in 4a. This implies that the decision to eliminate trading fees attracted mostly retail investors on the platform, which in turn is consistent with the proposition that the least sophisticated group of market participants were misled by the apparent transaction discounts launched by the exchange to compete for trading volumes. As a final remark, my models are more accurate than that of previous empirical studies, with an especially high adjusted $R^2$ when the dependent variable is represented by liquidity measures (see Table B.3).

[29] In cryptocurrency markets, this is the entire cost investors must pay to the exchange in order to complete their transaction, unlike equities or options, where there are additional fees to take into consideration, such as that for the brokers' intermediation.

**Table B.2**

DiD models for trading pairs against EUR. This table presents the regression results of the DiD analysis for the baseline case with control variables according to Eq. (1). The dependent variables in Panel A, the measures of liquidity, are the quoted spread for models (1–3), natural logarithm of market depth for models (4–6), cost of a round-trip transaction (effective spread) for models (7–9), adverse selection cost (price impact) for models (10–12), and liquidity supply earnings (realized spread) for models (13–15). Panel B presents the baseline case of the model for trading activity-dependent variables (number of quotes per minute, fraction of marketable orders — fill rate, number of trades per minute, average trade size, and volume) without control variables. The BTCUSDT traded on Binance is the treatment sample, while the FTX and Kucoin exchanges and ETHUSDT traded on Binance are the control samples. The table shows the regression intercept, the coefficients of the $ZeroFee_t$ dummy indicating the elimination period of trading fee, the $Treatment_i$ dummy indicating the BTCUSDT traded on Binance sample, and the interaction term $ZeroFee_t \times Treatment_i$ measuring the impact of the introduction of zero maker–taker fees at Binance on the dependent variables. Control variables (price, turnover, and volatility) are omitted for brevity. The * indicates statistical significance at the 0.1% level, while heteroskedasticity-consistent standard errors are in parentheses. The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC (= 20,160 min).

*Panel A: Liquidity*

| | Quoted Spread | | LN Market Depth | | Effective Spread | | Price Impact | | Realized Spread | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Zero Fee | −0.46 | −0.397 | 0.249 | 0.345 | −0.519 | −0.347 | −0.947 | −0.138 | 0.428 | −0.209 |
| | (0.02)* | (0.01)* | (0.01)* | (0.01)* | (0.07)* | (0.01)* | (0.27)* | (0.02)* | (0.26) | (0.02)* |
| Treatment | −0.338 | −5.242 | −1.792 | −3.579 | 0.842 | −1.525 | −0.263 | −0.136 | 1.105 | −1.389 |
| | (0.02)* | (0.30)* | (0.01)* | (0.10)* | (0.06)* | (0.46)* | (0.19) | (1.10) | (0.18)* | (1.01) |
| Zero Fee × Treatment | 5.628 | 5.417 | −0.392 | −0.498 | 3.004 | 2.758 | 0.737 | 0.03 | 2.266 | 2.729 |
| | (0.04)* | (0.04)* | (0.01)* | (0.01)* | (0.08)* | (0.05)* | (0.27) | (0.12) | (0.26)* | (0.11)* |
| Bitfinex (control) | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| ETH (control) | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Adjusted $R^2$ | 66.75% | 83.63% | 65.13% | 83.90% | 14.32% | 53.72% | 0.19% | 11.60% | 1.20% | 3.70% |
| # Obs | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 |

*Panel B: Trading Activity*

| | Number of Quotes | | Fill Rate | | Number of Trades | | Trade Size | | Volume | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Zero Fee | 40.184 | 4.101 | −0.018 | 0.019 | 1.437 | 4.826 | 0.032 | 0.242 | 0.355 | 12.499 |
| | (1.79)* | (1.52) | (0.00)* | (0.00)* | (0.28)* | (0.55)* | (0.00)* | (0.00)* | (0.09)* | (0.35)* |
| Treatment | 8.42 | −237.853 | 0.099 | −0.243 | 28.974 | −107.379 | −0.016 | −1.196 | 0.364 | −82.204 |
| | (1.51)* | (30.15)* | (0.00)* | (0.02)* | (0.35)* | (10.87)* | (0.00)* | (0.05)* | (0.04)* | (5.52)* |
| Zero Fee × Treatment | −3.36 | 31.986 | 0.006 | −0.03 | 4.48 | −1.383 | −0.031 | −0.259 | −0.348 | −13.784 |
| | (2.23)* | (2.10)* | (0.00)* | (0.00)* | (0.59)* | (0.73) | (0.00)* | (0.00)* | (0.07)* | (0.35)* |
| Bitfinex (control) | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| ETH (control) | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Adjusted $R^2$ | 4.37% | 2.37% | 40.25% | 7.06% | 22.02% | 2.60% | 1.60% | 64.63% | 1.72% | 38.66% |
| # Obs | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 |

**Table B.3**

DiD models for trading pairs against GBP. This table presents the regression results of the DiD analysis for the baseline case with control variables according to Eq. (1). The dependent variables in Panel A, the measures of liquidity, are the quoted spread for models (1–3), natural logarithm of market depth for models (4–6), cost of a round-trip transaction (effective spread) for models (7–9), adverse selection cost (price impact) for models (10–12), and liquidity supply earnings (realized spread) for models (13–15). Panel B presents the baseline case of the model for trading activity-dependent variables (number of quotes per minute, fraction of marketable orders — fill rate, number of trades per minute, average trade size, and volume) without control variables. The BTCUSDT traded on Binance is the treatment sample, while the FTX and Kucoin exchanges and ETHUSDT traded on Binance are the control samples. The table shows the regression intercept, the coefficients of the $ZeroFee_t$ dummy indicating the elimination period of trading fee, the $Treatment_i$ dummy indicating the BTCUSDT traded on Binance sample, and the interaction term $ZeroFee_t \times Treatment_i$ measuring the impact of the introduction of zero maker–taker fees at Binance on the dependent variables. Control variables (price, turnover, and volatility) are omitted for brevity. The * indicates statistical significance at the 0.1% level, while heteroskedasticity-consistent standard errors are in parentheses. The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC (= 20,160 min).

*Panel A: Liquidity*

| | Quoted Spread | | LN Market Depth | | Effective Spread | | Price Impact | | Realized Spread | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Zero Fee | −0.379 | −0.713 | 0.312 | 0.081 | −0.464 | −0.57 | −0.681 | −0.259 | 0.217 | −0.311 |
| | (0.02)* | (0.02)* | (0.01)* | (0.02)* | (0.06)* | (0.02)* | (0.23) | (0.06)* | (0.21) | (0.06)* |
| Treatment | 2.639 | −8.951 | −2.841 | (0.90) | 0.601 | −5.61 | −0.402 | −4.918 | 1.003 | −0.693 |
| | (0.03)* | (0.47)* | (0.01)* | (0.14)* | (0.06)* | (0.75)* | (0.19) | (2.11) | (0.17)* | (2.00) |
| Zero Fee × Treatment | 4.488 | 4.485 | −0.089 | 0.124 | 1.838 | 1.799 | 0.27 | −0.226 | 1.568 | 2.026 |
| | (0.04)* | (0.05)* | (0.01)* | (0.02)* | (0.09)* | (0.07)* | (0.27) | (0.21) | (0.25)* | (0.19)* |
| Bitfinex (control) | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| ETH (control) | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Adjusted $R^2$ | 65.46% | 79.57% | 76.57% | 59.87% | 5.88% | 34.16% | 0.29% | 4.90% | 0.88% | 0.85% |
| # Obs | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 |

(*continued on next page*)

I also run robustness tests on the other three Bitcoin trading pairs available from the database that fall within the zero-fee pilot group: BTCEUR, BTCGBP, and BTCUSDC. The key findings are qualitatively similar to those of BTCUSDT presented in the previous section, with slight differences in trading activities because of the lower liquidity of the assets. To speculate, the decrease in trading volumes for BTCEUR

**Table B.3** (*continued*).

*Panel B: Trading Activity*

| | Number of Quotes | | Fill Rate | | Number of Trades | | Trade Size | | Volume | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Zero Fee | 44.876 | 0.088 | −0.018 | 0.049 | −0.594 | 5.662 | 0.005 | 0.307 | 0.003 | 7.069 |
| | (1.61)* | (1.14) | (0.00)* | (0.00)* | (0.26) | (0.19)* | (0.00) | (0.01)* | (0.05) | (0.15)* |
| Treatment | −61.806 | 1000.148 | 0.05 | −0.539 | 3.704 | 37.545 | −0.008 | 1.189 | −0.152 | 16.593 |
| | (1.31)* | (23.88)* | (0.00)* | (0.03)* | (0.20)* | (4.28)* | (0.00)* | (0.08)* | (0.02)* | (2.14)* |
| Zero Fee × Treatment | −4.945 | 51.256 | 0.016 | −0.059 | 5.513 | −0.7 | −0.001 | −0.313 | 0.09 | −7.488 |
| | (1.99) | (1.68)* | (0.00)* | (0.00)* | (0.34)* | (0.31) | (0.00) | (0.01)* | (0.04) | (0.15)* |
| Bitfinex (control) | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| ETH (control) | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Adjusted $R^2$ | 15.58% | 13.52% | 16.66% | 12.88% | 5.61% | 9.98% | 0.63% | 46.69% | 1.00% | 30.77% |
| # Obs | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 |

**Table B.4**

DiD models for trading pairs against USDC. This table presents the regression results of the DiD analysis for the baseline case with control variables according to Eq. (1). The dependent variables in Panel A, the measures of liquidity, are the quoted spread for models (1–3), natural logarithm of market depth for models (4–6), cost of a round-trip transaction (effective spread) for models (7–9), adverse selection cost (price impact) for models (10–12), and liquidity supply earnings (realized spread) for models (13–15). Panel B presents the baseline case of the model for trading activity-dependent variables (number of quotes per minute, fraction of marketable orders - fill rate, number of trades per minute, average trade size, and volume) without control variables. The BTCUSDT traded on Binance is the treatment sample, while the FTX and Kucoin exchanges and ETHUSDT traded on Binance are the control samples. The table shows the regression intercept, the coefficients of the $ZeroFee_t$ dummy indicating the elimination period of trading fee, the $Treatment_i$ dummy indicating the BTCUSDT traded on Binance sample, and the interaction term $ZeroFee_t \times Treatment_i$ measuring the impact of the introduction of zero maker–taker fees at Binance on the dependent variables. Control variables (price, turnover, and volatility) are omitted for brevity. The * indicates statistical significance at the 0.1% level, while heteroskedasticity-consistent standard errors are in parentheses. The sample period spans from July 1, 2022, 14:00 UTC to July 15, 2022, 14:00 UTC (= 20,160 min).

*Panel A: Liquidity*

| | Quoted Spread | | LN Market Depth | | Effective Spread | | Price Impact | | Realized Spread | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Zero Fee | −0.764 | −0.145 | 0.745 | 0.798 | −0.117 | −0.11 | −1.072 | −0.051 | 0.955 | −0.059 |
| | (0.03)* | (0.00)* | (0.01)* | (0.01)* | (0.11) | (0.00)* | (0.22)* | (0.01)* | (0.22)* | (0.01)* |
| Treatment | −0.439 | 6.284 | 0.241 | −3.837 | 0.377 | 8.593 | 0.582 | −0.747 | −0.206 | 9.34 |
| | (0.03)* | (0.30)* | (0.01)* | (0.11)* | (0.08)* | (0.62)* | (0.19) | (2.70)* | (0.18) | (2.45)* |
| Zero Fee × Treatment | 2.62 | 2.104 | −0.752 | −0.827 | 6.225 | 0.803 | 0.192 | −0.775 | 0.43 | 1.579 |
| | (0.04)* | (0.03)* | (0.01)* | (0.01)* | (0.12)* | (0.05)* | (0.24) | (0.15)* | (0.23) | (0.14)* |
| Kucoin (control) | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| ETH (control) | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Adjusted $R^2$ | 25.88% | 73.99% | 18.09% | 69.71% | 1.52% | 43.00% | 0.28% | 10.25% | 0.27% | 1.06% |
| # Obs | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 |

*Panel B: Trading Activity*

| | Number of Quotes | | Fill Rate | | Number of Trades | | Trade Size | | Volume | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Zero Fee | 201.93 | 54.054 | −0.04 | −0.013 | −6.814 | 2.264 | −0.015 | 0.169 | −0.473 | 9.134 |
| | (3.64)* | (1.78)* | (0.00)* | (0.00)* | (0.38)* | (0.81) | (0.00)* | (0.01)* | (0.02)* | (1.20)* |
| Treatment | 9.095 | −592.27 | 0.076 | −0.282 | 32.045 | −282.699 | −0.005 | −0.419 | 2.134 | −114.69 |
| | (2.52)* | (41.34)* | (0.00)* | (0.03)* | (0.65)* | (20.26)* | (0.00)* | (0.11)* | (0.06)* | (0.23)* |
| Zero Fee × Treatment | −85.807 | 65.824 | 0.107 | 0.08 | 73.661 | 63.44 | 0.009 | −0.189 | 2.97 | −10.553 |
| | (4.08)* | (2.56)* | (0.00)* | (0.00)* | (1.17)* | (1.29)* | (0.00)* | (0.01)* | (0.09)* | (1.08)* |
| Kucoin (control) | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| ETH (control) | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Adjusted $R^2$ | 18.08% | 19.62% | 57.95% | 17.01% | 43.66% | 21.91% | 2.10% | 42.94% | 23.86% | 7.92% |
| # Obs | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 | 40,320 |

might indicate that more sophisticated investors trade in euros, as those were not misled by the apparent reduction in transaction costs promoted with the zero maker–taker fees on Binance. This is strengthened by the greater financial literacy in crypto-assets demonstrated with the development of the world's first comprehensive framework for crypto regulation (i.e., the European MiCA). I also find that the bid–ask spread is even wider at nearly 5.5, 4.5, and 2.4 bps for Bitcoin spot pairs against EUR, GBP, and USDC, respectively. The increase in the overall transaction costs (effective spread) for takers is higher than those seen for BTCUSDT, while makers earn similarly on average. Unlike the findings for the main BTCUSDT, the adverse selection costs measured by the price impact remained largely unaffected, indicating greater information asymmetry when trading less liquid crypto-assets.

## Appendix C. Additional figures

See Figs. C.1, C.2 and C.3.

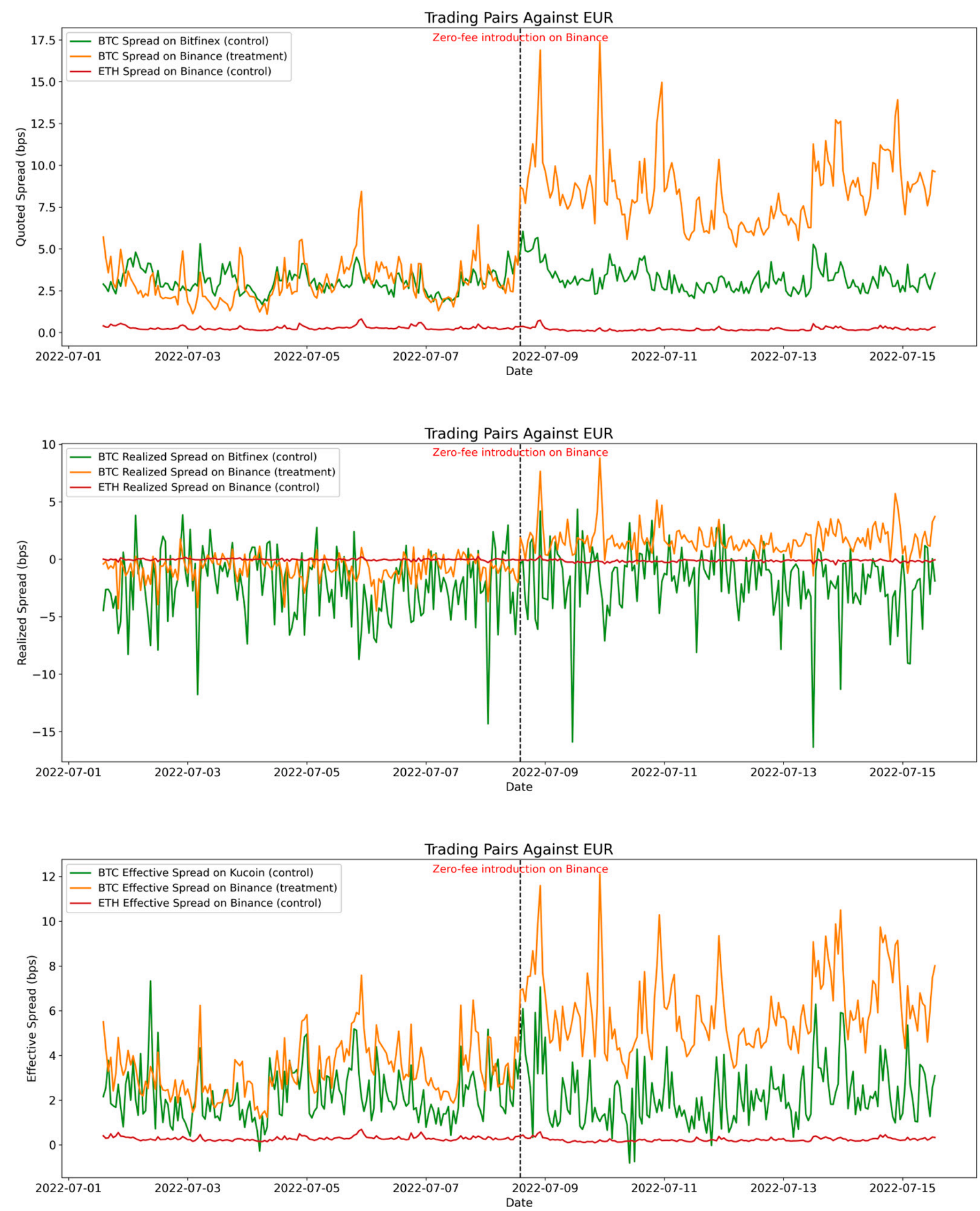


**Fig. C.1.** Hourly Quoted, Realized, and Effective Spreads comparison for trading pairs against EUR. This figure plots the quoted spread (in basis points), liquidity supply earnings (realized spread; in basis points), and cost of a round-trip transaction (effective spread; in basis points) for BTCEUR traded on Binance (treatment sample) and Bitfinex, and the ETHEUR traded on Binance (control samples) before and after the introduction of zero maker–taker fees at Binance. The vertical dotted line depicts the starting period of the zero maker–taker fees, while the orange line depicts the treatment sample and the other lines the control samples. Investigation period: 01/07/2022 14:00 UTC to 15/07/2022 14:00 UTC (= 336 h). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
*Source:* RTH database.

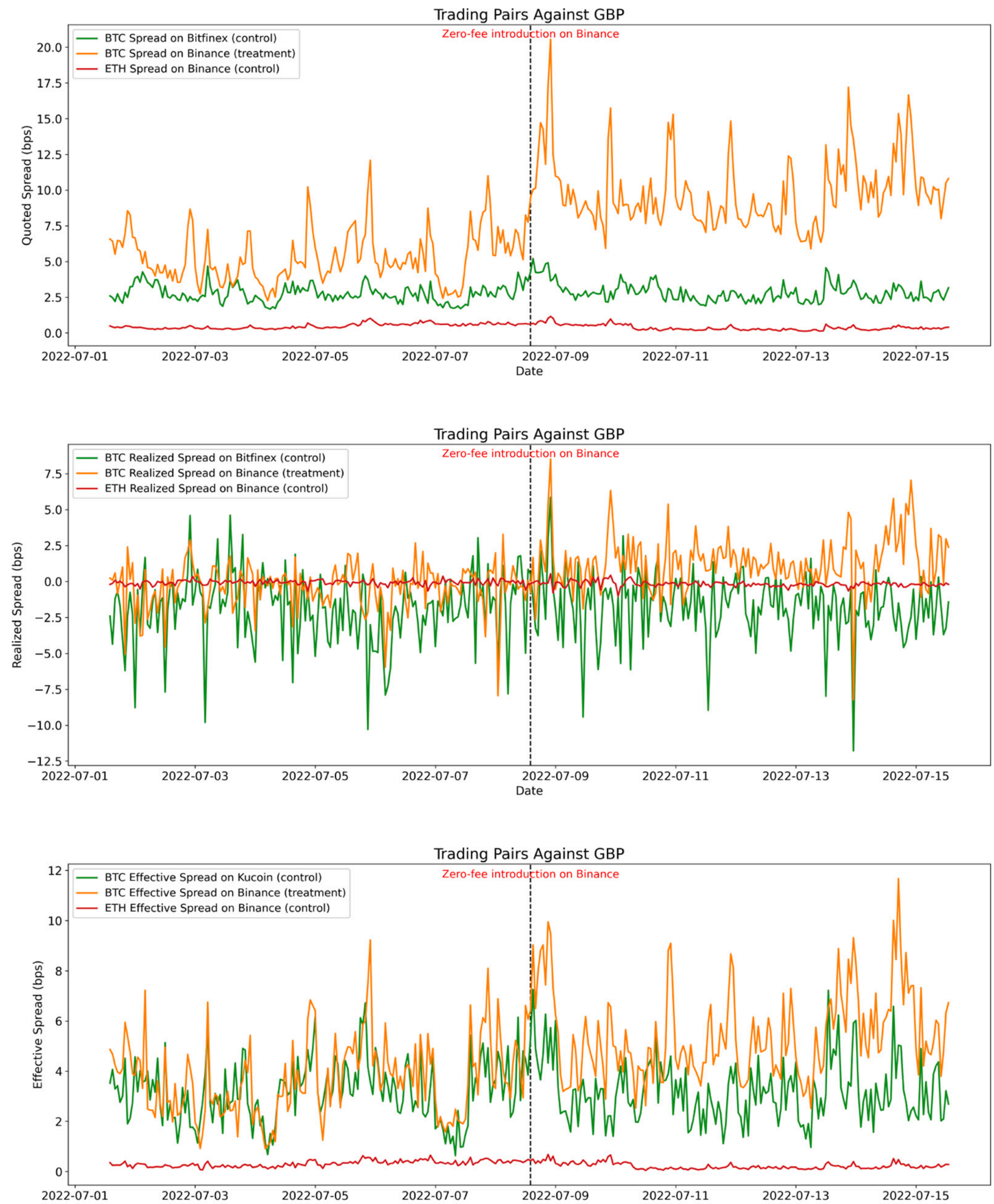


**Fig. C.2.** Hourly Quoted, Realized, and Effective Spreads comparison for trading pairs against GBP. This figure plots the quoted spread (in basis points), liquidity supply earnings (realized spread; in basis points), and cost of a round-trip transaction (effective spread; in basis points) for BTCGBP traded on Binance (treatment sample) and Bitfinex, and the ETHGBP traded on Binance (control samples) before and after the introduction of zero maker–taker fees at Binance. The vertical dotted line depicts the starting period of the zero maker–taker fees, while the orange line depicts the treatment sample and the other lines the control samples. Investigation period: 01/07/2022 14:00 UTC to 15/07/2022 14:00 UTC (= 336 h). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
*Source:* RTH database.

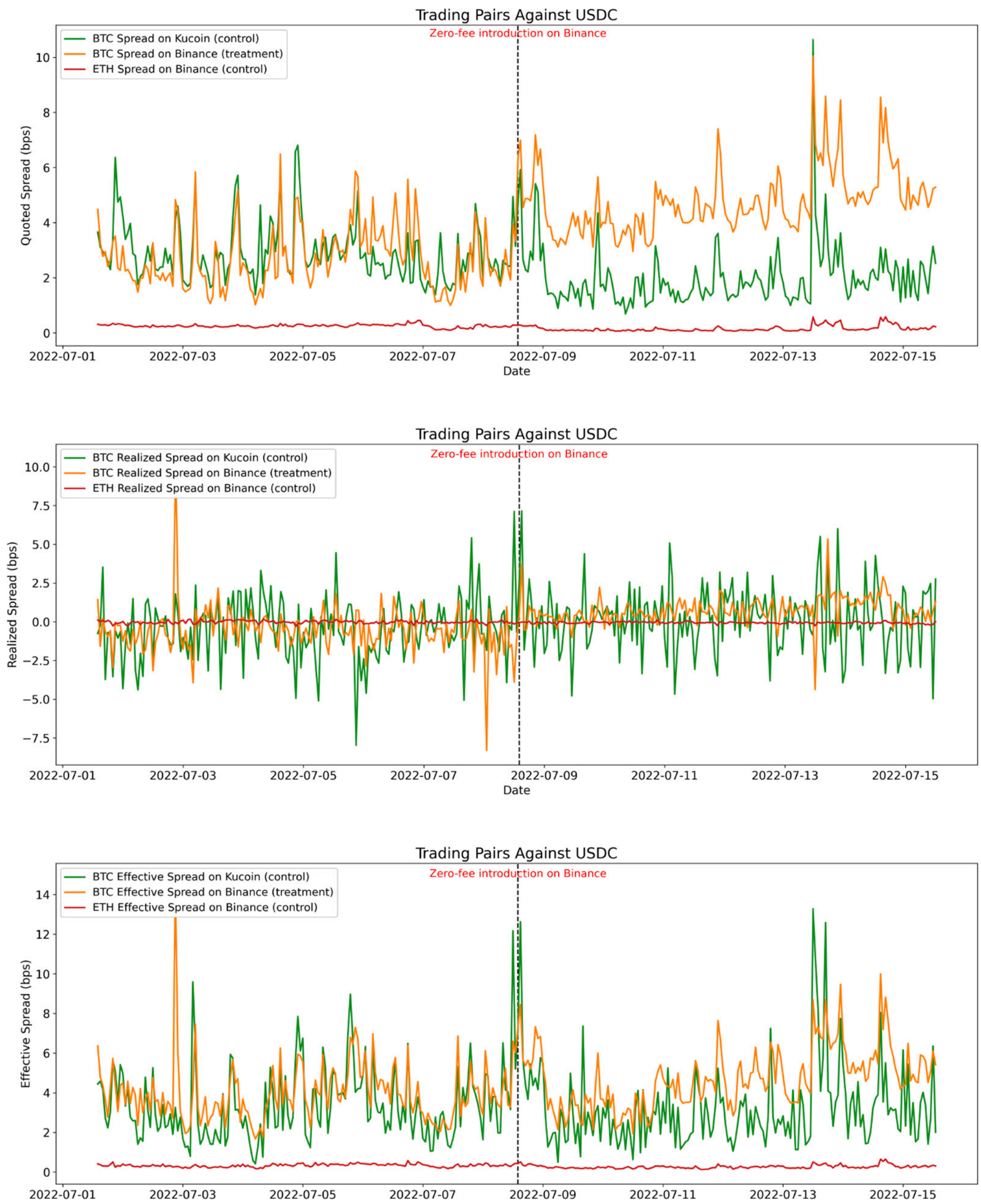


**Fig. C.3.** Hourly Quoted, Realized, and Effective Spreads comparison for trading pairs against USDC. This figure plots the quoted spread (in basis points), liquidity supply earnings (realized spread; in basis points), and cost of a round-trip transaction (effective spread; in basis points) for BTCUSDC traded on Binance (treatment sample) and Kucoin, and the ETHUSDC traded on Binance (control samples) before and after the introduction of zero maker–taker fees at Binance. The vertical dotted line depicts the starting period of the zero maker–taker fees, while the orange line depicts the treatment sample and the other lines the control samples. Investigation period: 01/07/2022 14:00 UTC to 15/07/2022 14:00 UTC (= 336 h). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
*Source:* RTH database.

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