Trading Fees and Intermarket Competition

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Abstract

Regulators, exchanges, and politicians are considering reining in maker-taker pricing, which is used as a competitive tool by trading venues to acquire order flow. Examining the 2013 reduction in trading fees operated by BATS on its European venues, we document significant effects on market quality and market share both on BATS and in competing venues. Interestingly, we identify cross-sectional differences which suggest that changes in trading fees have a different effect for large capitalization stocks compared to small capitalization stocks. Our results are consistent with the predictions derived from a model of two competing limit order books with trading fees.

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1. Introduction

In today's fragmented equity trading environment, venues use trading fees to compete for order flow. Most venues operate limit orders books, and rely on endogenous provision of liquidity. As a result, venues have an incentive to subsidize liquidity supply by offering a rebate (make fee) to traders submitting limit orders. However, venues have to generate revenues to cover their costs and therefore impose a higher positive fee (take fee) on market orders.[1] This type of pricing, called maker-taker pricing, is actively debated among academics, practitioners, market operators, and is currently under review by U.S. and European regulators. Maker-taker pricing is an important competitive tool for exchanges in today's fragmented markets, and may benefit investors to the extent that it allows intra tick trading thus reducing the trading frictions caused by the fact that prices are discrete. However, maker-taker pricing has recently been criticized for potentially exacerbating conflicts of interest between brokers and their customers, for contributing to market fragmentation and market complexity, and for undermining price transparency.[2]

This paper investigates the effects of changes in trading fees by studying the change to maker-taker pricing implemented by BATS Europe (BATS) in its European markets.[3] We derive empirical predictions from a model with two identical standard limit order books that compete for the provision of liquidity. We document significant changes in market shares and market quality following fee changes, both for the venues implementing the changes and for the competing venues, and significant cross-sectional differences in the response to fee changes. We also add to the theoretical literature by modeling two competing limit order books using trading fees.

Maker-taker pricing in the U.S. equity market was first adopted by the electronic trading platform Island ECN in the late 1990s in order to compete with exchanges. In response, other Alternative Trading Systems (ATSs) and exchanges also adopted maker-taker pricing. Starting from the mid-2000s, maker-taker pricing was the standard pricing model in the U.S. equity markets. Concerned about escalating access (take) fees, the U.S. Securities and Exchange Commission (SEC) imposed an access fee cap of 30 cents per 100 shares by adopting Rule 610 of Regulation NMS in 2005.[4] The 2007 MiFID I opened the European equity markets and

[1] According to the OICV-IOSCO (2013) report, there exists at least four types of fee structures: the symmetrical pricing model, with both the active and passive side of a trade paying the same fee; the asymmetrical pricing model, with both the active and the passive side of a trade paying a fee, but the fee paid is not the same; the maker-taker pricing model, with the provider of liquidity (maker) receiving a rebate and the taker of liquidity (taker) paying a fee; and the inverted maker-taker pricing model, with the provider of liquidity paying a fee and the taker of liquidity receiving the rebate.

[2] For extensive background and critical review on access fees, see the SEC Market Structure Advisory Committee's October 20, 2015, Memorandum "Maker-Taker Fees on Equities Exchanges."

[3] BATS Europe is a subsidiary of the U.S. exchange BATS.

[4] Securities Exchange Act Release No. 51808 (Jun. 9, 2005), 70 FR 37496, 3745 (Jun. 29, 2005) (File No. S7-10-04).

allowed new trading platforms called Multilateral Trading Facilities (MTFs) to compete with exchanges by adopting maker-taker pricing.

In the ensuing decade, trading venues have frequently tweaked their maker-taker pricing models primarily to attract certain types of order flow. The liquidity rebates are particularly attractive to High Frequency Traders (HFTs) who have developed rebate harvesting strategies by acting as two-sided liquidity providers. Menkveld (2013) shows that the liquidity rebates can represent a significant fraction of a HFT trading firm's profits. As HFTs share of trading volume in both U.S. and European markets grew rapidly, reaching close to 70% in the U.S. and 30% in Europe, the incentive to cater to this particular group of traders motivated even more aggressive competition for order flow using maker-taker pricing, often with added volume-based incentives.[5]

While maker-taker pricing has enabled new entrants to compete effectively with incumbent exchanges, potentially leading to narrower quoted spreads, the practice has been also criticized. Angel, Harris, and Spatt (2015) argue that maker-taker pricing obfuscates true spreads, that it distorts order routing decisions, and that it hurts both internalizing dealers and venues that do not use maker-taker pricing.[6] Harris (2013) further argues that rebates allow traders to circumvent the minimum price variation (tick size), thus by-passing Regulation NMS order protection rules. Angel et al. (2015) recommend that the SEC either requires that all brokers pass through access fees and liquidity rebates to their clients and clarify that best execution obligations apply to net prices instead of quoted prices, or prohibit maker-taker pricing altogether.

On the other hand, Malinova, Park, and Riordan (2018) see no reason to abolish maker-taker pricing as academic evidence suggest that HFTs and other traders pass through a significant fraction of the rebates to active traders.[7] Instead, they support initiatives to provide investors with better information about execution quality that includes maker-taker fees. Foucault (2012) shows that the make-take fee breakdown can affect the mix of market and limit orders and may even increase market participants' welfare. Consequently, he advocates that exchanges and regulators conduct pilot experiments to assess the effect of maker-taker fees on the composition of order flow (market vs. limit orders) before contemplating any changes to the current rules.

Not surprisingly, industry participants and exchanges and even members of Congress have also weighed in on the maker-taker pricing debate. The Intercontinental Exchange Group, Inc. (ICE) and the Securities Industry Financial Markets Association (SIFMA) argue that

[5] Brogaard (2010) documents that HFTs represent 68% of Nasdaq trade volume, and Jarnecic and Snape (2011) document that HFTs represent 28% of total LSE volume.

[6] This concern has been validated using options market data, Battalio, Corwin, and Jennings (2016) who show that retail brokers appear to route orders to maximize order flow payments: selling market orders and sending limit orders to the venues paying large liquidity rebates, and that retail traders limit order execution quality is negatively related to the level of the liquidity rebates.

[7] Hendershott and Riordan (2013) also show that HFT market makers pass through some of the rebates to active traders.

the maker-taker pricing contributes to market complexity and that the SEC should reduce or eliminate maker-taker pricing and lower the cap on access fees from $0.003 per share to $0.0005 per share. BATS agrees that access fees should be lowered for the most liquid stocks, but argues that a tiered approach based on securities' characteristics should be applied for less liquid stocks. On March 3, 2015, Congressman Stephen F. Lynch introduced The Maker-Taker Conflict of Interest Reform Act of 2015 (H.R. 1216) which would require the SEC to carry out a pilot program to assess the impact of an alternative maker-taker pricing model.[8] On March 14, 2018, the SEC proposed a Transaction Fee Pilot for NMS stocks with the goal to "facilitate an informed, data-driven discussion about transaction fees and rebates and their impact on order routing behavior, execution quality and market quality in general" according to SEC Chairman Jay Clayton.[9] The proposed SEC Transaction Fee Pilot has not yet been implemented.

Equity markets are fragmented with several competing venues operating electronic limit order books with discrete prices, while the existing theoretical literature focuses either on a single venue with discrete prices (Foucault, Kadan, and Kandel (2005)), or on competing venues without price discreteness (Colliard and Foucault (2012)), or on the optimal fee structure (Chao, Yao, and Ye (2018) and Riccó, Rindi, and Seppi (2020)). To help us frame the empirical analysis, we develop a model of a dynamic limit order book with a discrete pricing grid that faces competition from another identical limit order book. Our model draws on Riccó et al. (2020) and departs from Buti, Rindi, and Werner (2017) in that it has endogenous liquidity supply, trading fees and a competing limit order book.[10] We use the model to derive predictions on the effects of a change in fees on market quality and market share in a fragmented market. The new feature of our model is that it includes both frictions (tick size) and a competing venue. Our model complements both the Colliard and Foucault (2012) model in that it has a tick size, and the Foucault et al. (2005) in that it includes a competing market. Moreover, unlike the Chao et al. (2018) and the Riccó et al. (2020) models which focus on the optimal fee structure, our focus is on the effects of a change in fees on the quality of the limit order book.

Colliard and Foucault (2012) show that in a competitive market without tick size, traders

[8]The Maker-Taker Conflict of Interest Reform Act of 2015 would require the SEC to identify a random sample of 50 of the 100 most heavily traded US stocks, and prohibit the payment of rebates market-wide for those stocks for six months.

[9]https://www.sec.gov/news/press-release/2018-43. The new rule is called Rule 610T of Regulation NMS (SEC Release No. 34-82873) and divides NMS stocks with a share price at or above $2 per share into three test groups: Group 1 with a $0.0015 fee cap for removing & providing displayed liquidity (no cap on rebates); Group 2 with a $0.0005 cap for removing & providing displayed liquidity (no cap on rebates); and Group 3 with rebates and linked pricing prohibited for removing & providing displayed & undisplayed liquidity (Rule 610(c)'s cap continues to apply to fees for removing displayed liquidity); and a control group (Rule 610(c)'s cap continues to apply to fees for removing displayed liquidity).

[10]The first version of this paper included a model of a limit order book competing with a crossing network. We thank Charles Jones, Björn Hagströmer, and Satchit Sagade for suggesting to investigate the model with two competing limit order books.

perfectly neutralize a change in fees breakdown so that such a change has no effects on the spread net of fees (cum-fee spread). Foucault et al. (2005) instead show that in a single market limit order book, the make-take fee breakdown matters for spreads. With the support of our model we show how fee changes affect different metrics of market quality in a market that has a tick size and at the same time faces competition from another trading venue.

Our model show that in a fragmented market, a change in fees on one venue is likely to affect traders' order routing decisions, and hence result in a migration of orders between venues.

We then use the model to construct hypotheses and frame our empirical analysis of the effects of changes in make-take fees implemented in January 2013 by BATS on its two lit venues – BXE and CXE. Specifically, CXE reduced its make fee while leaving its take fee constant and BXE reduced both the rebate on the make fee and the take fee. We study the effect of these fee changes on BXE and CXE market quality and market share relative to Turquoise (TQ) where the fees remained unchanged.

Our model predicts that a decrease in the rebate on the take fee in the primary market that competes with an identical trading platform generates an outflow of order flow to the competing trading platform which deteriorates market quality and market share in the primary venue - stronger for large stocks - to the benefit of the competing market. The model also predicts that a simultaneous decrease in the rebate on the make fee and of the positive charge on the take fee in the primary market generates a migration of order flow to the primary market resulting in an improvement in market quality and market share for the primary market and that this effect should be stronger for small stocks.

In real markets, it is the relative fees that matter for traders' order selection and order routing decisions. Hence, when testing our model predictions we consider the net change in trading fees. Therefore, not only we consider the direct reduction in CXE rebate with respect to TQ that did not change its pricing, as well as the direct reduction in BXE rebate on MF and TF with respect to TQ, but we also consider the net reduction in BXE trading fees with respect to CXE that reduced its rebate on MF.

Our results are consistent with the empirical predictions of our model. We find that the effects of CXE change in rebate on MF result in a deterioration of market quality and market share - stronger for large stocks - for CXE, and an improvement of market quality and market share - stronger for large stocks - for the competing venue TQ. We also find that the BXE's fee reduction in rebate on MF and in the positive charge on TF resulted in an improvement of market quality and market share stronger for small BXE stocks.

Our paper contributes to the empirical literature by taking intermarket competition into account when studying the effects of make-take fee changes empirically. We show that both the change in rebate on the make fee and the simultaneous reduction in the make fee and the positive charge on the take fee have a different effect for large capitalization stocks compared to small capitalization stocks. Our sample is drawn from a recent time period, which is important as market structure and the ecosystem of traders has changed significantly over time.[11]

The paper is organized as follows. In Section 2 we briefly review the existing literature and in Section 3 we present the theoretical model and discussion of our empirical predictions. We present our data sets and the methodology in Section 4. In Section 5 we discuss our empirical results, Section 6 consists of conclusions and the policy implications of our findings.

2. Literature review

Theoretical models of make-take fees have initially focused on whether the breakdown of the total fee charged by a venue into rebate and take fee matters for order flow composition, market quality, and welfare. Colliard and Foucault (2012) model a dealer market that competes with a limit order book with no tick size to show that the breakdown does not affect the order flow composition, the trading rate, or welfare. Foucault, Kadan, and Kandel (2013) model of a limit order book with a positive tick size, populated by two distinct groups of algorithmic traders with monitoring costs – market makers and market takers,– to show that the total fee breakdown matters. Brolley and Malinova (2013)) model a dealer market with informed limit order traders to show that the breakdown of the total fee matters when investors pay a flat fee while liquidity providers incur take fees and receive rebates. More recently, two papers study the optimal market access pricing. Chao et al. (2018) model a 2-period limit order book with a tick size equal to the support of all traders' personal evaluations to show that in equilibrium the optimal fee structure is either the maker-taker or -symmetrically- the taker-maker. They show that an exchange setting make and take fees simultaneously chooses the price of the execution service (make fee) and the quality of the execution service (take fee). This simultaneous choice creates an incentive for the owner - say - of two trading platforms like BATS Europe to engage in second-degree price discrimination and set different fee structures across the two trading platforms. Chao et al. (2018) conclude that the monopolistic owner of two trading venues may use fees to discriminate across different customers but that 'such simultaneous choices of price and quality' destroy any pure-strategy equilibrium when there is competition between two exchanges. Riccó et al. (2020) extend Chao et al. (2018) by considering different regulatory restrictions, a third period and HFTs to show that optimal access pricing depends on the population in the market and that with large gains from trade it can result in strictly positive fees. They also show that the widespread use of rebate-based access pricing can be explained by the growing importance of HFT post Reg-NMS. Finally, they show that with sequential bargaining between competing exchanges pure-strategy equilibria exist.

[11]We also study the introduction of fee schedules that depend on the value traded as in Malinova and Park (2015), but this analysis is available from the authors upon request.

To date, empirical work on make-take fees is relatively limited. Lutat (2010) studies the October 2008 introduction of a maker-taker pricing model on the Swiss exchange and find a decrease in depth but no significant effect on spreads. Malinova and Park (2015) study the 2005 switch by the Toronto Stock Exchange from a value-based to a volume based make-take fee schedule that was accompanied by an increase both in the rebate and the take fee, and they find that for the stocks that did not experience a change in total fee, quoted spread declined but cum-fee spreads (quoted spread plus twice the take fee) remained unaffected ostensibly supporting Colliard and Foucault (2012).[12] We instead find that a decrease in make and take fees is related to changes in both quoted and cum-fee spreads.[13] Tham, Sojli, and Skjeltorp (2018) using data from the Nasdaq OMX BX and exogenous changes in make-take fees and a technological shock to liquidity takers to show that cross-side liquidity externalities exist and conclude that the reason is that an increase in market makers' monitoring benefits market takers as predicted by Foucault et al. (2013). The same experiment is studied by Black (2018) who documents that a simultaneous reduction in make and take fees results in lower market efficiency. Cardella, Hao, and Kalcheva (2017) investigate 108 instances of fee changes for U.S. exchanges in 2008-2010 and find that an increase in take fees has a larger impact on trading activity than an increase in make fees. He, Jarnecic, and Liu (2015) study the entry of Chi-X in Europe, Australia, and Japan and find that Chi-X's market share is negatively related to total trading fees and latency, while positively related to liquidity relative to the listing exchanges. Clapham, Gomber, Lausen, and Panz (2017) study the Xetra Liquidity Provider Program at Deutsche Boerse which introduced liquidity rebates and find that the program results in higher liquidity, larger contribution to market-wide liquidity and a higher market share for the venue implementing the rebates, but that market-wide turnover and liquidity do not change. Anand, Hua, and McCormick (2016) study the 2012 introduction of maker-taker pricing in the NYSE Arca options market, and document that execution costs (including fees) for liquidity demanders decline and that the maker-taker pricing encourages market makers to improve quoted prices. Finally, Comerton-Forde, Grégoire, and Zhong (2019) and Lin, Swan, et al. (2017) study the effects of the U.S. tick size pilot on venues with different maker-taker (and inverted) pricing models and document that an increase in the tick size results in redistribution of volume towards inverted fee venues.

[12] An important caveat is that the Colliard and Foucault (2012) model is based on a protocol without a tick size, whereas the Toronto Stock Exchange (TSX) on which Malinova and Park (2015) base their empirical analysis is a standard limit order book with a tick size grid.

[13] Using Rule 605 data O'Donoghue (2015) finds that changes in the split of trading fees between liquidity suppliers and demanders affect order choice and thereby execution quality.

3. Theoretical Background and Empirical Predictions

3.1. Model

In this section we briefly describe our model.[14] Traders arrive sequentially over the trading game that lasts N periods, $t_z = t_1, .., t_N$ and in the spirit of Riccó et al. (2020) we consider two different specifications with different investor-arrival frequency, one with three periods, $N = 3$, $t_z = \{t_1, t_2, t_3\}$, and one with four periods, $N = 4$, $t_z = \{t_1, t_2, t_3, t_4\}$. At each period t_z a risk-neutral investor comes to the market with a private evaluation equal to γ_{t_z} which is an i.i.d. drawn from a uniform distribution, $\gamma \sim U[\underline{\gamma}, \overline{\gamma}]$, $\underline{\gamma}$ being the lowest valuation and $\overline{\gamma}$ the highest valuation traders may have. The support width $S = \overline{\gamma} - \underline{\gamma}$ - symmetrically distributed around the asset value AV - indicates the dispersion of traders' gains from trade.

Traders coming to the market with extreme values of γ_{t_z} are more eager to trade by taking liquidity, whereas traders arriving with γ_{t_z} values close to AV are more willing to supply liquidity. The larger the support, the more heterogeneous investors' gains from trade are. The smaller the support, the less dispersed investors' gains from trade are around the asset value, and the more inclined investors are in supplying rather than taking liquidity. We consider two scenarios, one with a large support, $S = [0.0, 2.0]$, and one with a smaller support, $S = [0.05, 1.95]$. Trade size is unitary.

We model two identical limit order books that we label primary market (Prim) and competing market (Comp) respectively. Each limit order book, Prim or Comp, has a grid of four prices, $P_i^j = \left\{S_2^j, S_1^j, B_1^j, B_2^j\right\}$, for $j = Prim, Comp$, two on the ask and two on the bid side of the book around the same asset value AV. Both trading platforms have a tick size equal to τ, so the ask prices are equal to $S_1^j = AV + \frac{1}{2}\tau$ and to $S_2^j = AV + \frac{3}{2}\tau$ respectively for the inside and outside quotes, and symmetrically the bid prices are equal to $B_1^j = AV - \frac{1}{2}\tau$ and to $B_2^j = AV - \frac{3}{2}\tau$. The state of the limit order book of market j at time t_z is the vector $lob_{t_z}^j = \left\{l_{t_z}^{P_i^j}\right\}$, where $l_{t_z}^{P_i^j}$ is the depth (number of orders/shares) of the limit order book j at price P_i^j at time t_z.

In each period t_z, a trader arrives, observes the state of the two limit order books and chooses among different possible trading strategies, $y_{t_z}^j$, where $Y_{t_z}$is the set of possible trading strategies at time t_z. Table 1 reports the payoffs from the different orders that a trader can choose at t_z when arriving either at the primary or at the competing market. An investor can choose to post a limit order $(LO_{t_z}^j(P_i^j))$ or a market order $(MO_{t_z}^j(P_i^{j,b}))$ either to the primary market or to the competing market or can alternatively decide not to trade (NT_{t_z}).[15] Hence, $Y_{t_z} = \{LO_{t_z}^j(P_i^j), MO_{t_z}^j(P_i^{j,b}), NT_{t_z}\}$.

[14] See Appendix 1 for more detailed discussion on the model solution.
[15] We label the best ask and the best bid prices with the superscript "b".

[Insert Table 1 about here]

At t_1 both the primary and the competing markets open empty and therefore traders will only be able to offer liquidity by posting limit orders. At t_2 (t_2 and t_3) traders can either take or make liquidity via market or limit orders, and at t_3 (t_4), which is the last period of the trading game if $N = 3$ ($N = 4$), traders will only post market orders or decide not to trade as the execution probability of a limit order is zero. Conditional on their personal valuation and the state of the two limit order books, traders opt not to trade (NT_{t_z}) in any period t_z when the payoffs of the possible $LO_{t_z}(P_i^j)$ and $MO_{t_z}(P_i^{j,b})$ are non-positive. Traders face trading fees that can be positive or negative (rebates). In particular a trader will face a take fee TF (tf) if he takes liquidity by posting a market order on the primary market (competing market); a trader will face a make fee MF (mf) if he posts a limit order on the primary market (competing market). For example, if the primary market opts for a maker-taker pricing structure that consists in a positive take fee ($TF > 0$) and a negative make fee ($MF < 0$) a market participant sending a market order to the primary market will have to pay a TF to the trading platform when the market order is executed. Traders opting instead to post a limit order on the primary market will receive a rebate (MF) when the limit order is executed. In this case, the rebate is a reward that traders receive when they supply liquidity to the limit order book, whereas the take fee is a charge traders have to pay when they take liquidity.

Both the primary and the competing market are governed by standard price and time priority rules. If at time t_1 a trader posts, for example, a limit sell order to the primary market at the second level of the book, the next period a trader can undercut the resting limit order by posting a more aggressive limit sell order on the first level on either the primary or the competing limit order book. Furthermore, he can hit the limit order initially posted on the primary market with a market buy order, or he can post a limit buy order to the competing market at the second level of the book. He can finally decide not to trade.

A trader arriving at time t_z will choose the order, $y_{t_z}^j$, that maximizes the expected payoff, $\pi_{t_z}^j$, given his personal valuation of the asset, γ_{t_z}, the state of the two limit order books, $lob_{t_{z-1}}^j = \left\{ l_{t_{z-1},i}^{Pj} \right\}$, and the trading fees, Ω^j, where $\Omega^{Prim} = \{MF, TF\}$ and $\Omega^{Comp} = \{mf, tf\}$:

$$max_{y_{t_z}^j \in Y_{t_z}} \pi_{t_z}^j \left\{ y_{t_z}^j \mid \gamma_{t_z}, lob_{t_z}^{Prim}, lob_{t_z}^{Comp}, \Omega^{Prim}, \Omega^{Comp}, N, S \right\} \tag{1}$$

When choosing their order submission strategies, traders face a trade-off between non-execution costs and price opportunity costs. If they opt for $MO_{t_z}^j(P_i^{j,b})$, they get immediate execution at the best ask price, $S_{t_z}^{j,b} = min \left\{ S_{t_z,i}^j | l_{t_z,i}^{S^{Prim}}, l_{t_z,i}^{S^{Comp}}, \Omega^{Prim}, \Omega^{Comp}, N, S \right\}$ if it is a buy order or at the best bid price, $B_{t_z}^{j,b} = max \left\{ B_{t_z,i}^j | l_{t_z,i}^{B^{Prim}}, l_{t_z,i}^{B^{Comp}}, \Omega^{Prim}, \Omega^{Comp}, N, S \right\}$, if it is a sell order, where $l^{S^j}_{t_z,i}$ ($l^{B^j}_{t_z,i}$) indicates the number of shares available at the i-th price level of the ask side (bid side) of the j-th market. If instead they choose a $LO^j_{t_z}(P^j_i)$, they face execution uncertainty but they will get a better price if the order executes. When the expected payoffs for an order routed either to the primary or to the competing limit order book are the same, we assume that the trader randomizes and routes the order with equal probability to both trading platforms.

Following Colliard and Foucault (2012), the model is solved by backward induction, and as in Chao et al. (2018), conditional on the pricing grid characterized by the tick size, τ, and the support of traders' valuation, S, it has a closed-form solution for each set of trading fees, Ω.[16] We start from the end of the trading game, t_3 (for $N = 3$), when traders rationally submit only $MO^j_{t_3}(P^{j,b}_i)$, and solve the model for the equilibrium market buy and market sell orders, $y^j_{t_3}$. As the equilibrium probabilities of market buy and market sell orders at t_3 are the execution probabilities of $LO^j_{t_2}(P^j_i)$ (to sell and to buy respectively) at t_2, the model can then be solved at t_2, and recursively at t_1 (see Appendix 1). [17]

We solve our dual market framework under 4 scenarios that differ by trading frequency, N, and support of traders' valuation, S. We then solve the models under different regimes of make and take fees to show how a change in trading fees in one market affects traders' strategies, and in turn the equilibrium order flows and the quality of the two markets. Limit orders in each period t_z and in each market j, $LO^j_{t_z}(P^j_i)$, are computed as the weighted average of the probability of observing a limit order conditional on the different equilibrium states of the book, $lob^j_{t_z}$, where the weights are the probabilities of the different states of the book in period t_z : $E\left[LO^j_{t_z}|lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S\right]$. Market orders, $MO^j_{t_z}(P^{j,b}_i)$, are computed in a similar way: $E\left[MO^j_{t_z}|lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S\right]$. We build measures of quoted spread ($Quoted\,Spread^j$), effective spread ($Eff.Spread^j$), depth at the best bid-offer ($BBODepth^j$), total depth ($Depth^j(P_2) + Depth^j(P_1)$), depth at each price level ($Depth^j(P_i)$), and market share (MS^j) based on the equilibrium limit orders (LO^j) and market orders (MO^j) submission probabilities.

In each period t_z and in each market j the quoted spread, $Quoted\,Spread^j_{t_z}$, is computed as the weighted average of the probability of observing a particular inside spread conditional on the different equilibrium states of the book, $lob^j_{t_z}$, the set of fees involved, Ω^j, and the length of the trading game, N, where - as before - the weights are the probabilities of the different states of the book in period t_z : $E\left[\left(S^{j,b}_{t_z,i} - B^{j,b}_{t_z,i}\right)|lob^{Prim}_{t_z}, lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S\right]$.[18] Effective spread, $Eff.\,Spread^j_{t_z}$, is computed as the weighted average of the difference between

[16] Our model does not endogenize trading fees and therefore it has a closed-form solution given the set of fees considered.

[17] Similar arguments hold for $N = 4$.

[18] In our model liquidity supply is endogenous. When computing the quoted spread, we assume that when the book is empty, at either the ask or the bid side, the maximum possible spread is five ticks.

the transaction price $P^{j}_{t_z,i}$ and the asset value AV:
$E\left[I_{t_z} \times \left(P^{j,b}_{t_z,i} - AV\right) | lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S\right]$ - where I_{t_z} is an indicator function taking value $+1(-1)$ for buy (sell) orders. Depth at the best bid-offer, $BBODepth^{j}_{t_z}$ is computed as the weighted average of the sum of the shares available at the best bid and ask prices, $E\left[\left(l^{S^{j,b}}_{t_z} + l^{B^{j,b}}_{t_z}\right) | lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S\right]$. Depth at the different price levels, $Depth^{j}_{t_z}(P_i)$, as well as total depth, $Depth^{j}_{t_z}(P_2) + Depth^{j}_{t_z}(P_1)$, are computed in a similar way. Finally, we measure market share for the primary market, MS^{Prim}, as the average of market orders in the primary market over the same trading periods, divided by the sum of the average of market orders in the primary and in the competing market over the same periods, e.g., $MS^{Prim} = \frac{\sum_{t_z} MO^{Prim}_{t_z}/N}{\sum_{t_z} MO^{Prim}_{t_z}/N + \sum_{t_z} MO^{Comp}_{t_z}/N}$. We measure market share for the competing market in a similar way.

We then average our metrics over different periods (t_z), both including the last period of the trading game, and leaving the last period out. When $N = 3$ we compute the averages both over the two periods t_1 and t_2, and over the three periods, t_1, t_2 and t_3 of the trading game. When $N = 4$ we compute the averages both over the three periods t_1, t_2 and t_3, and over the four periods, t_1 through t_4. Appendix 1 shows how to solve the model for one set of trading fees, i.e., $MF = -0.001$ and $TF = 0.001$ and $mf = tf = 0.0$, and how to compute the market quality metrics. It is then straightforward to obtain the results for the other chosen sets of fees.

We use the models to discuss the effects of a change in fees in the primary market on the equilibrium order submission probabilities and the derived order flows and market quality metrics of both the primary and the competing markets. While our framework may be considered a stylized model of intraday trading, all our results are averaged across the different periods of the trading game. Therefore our results allow us to draw predictions on how a change in trading fees affect the overall activity of the trading day captured by the daily data we use for our empirical analysis.

3.2. Model Results and Empirical Predictions

In this section we discuss the mechanisms that according to our models drive the change in market quality following a change in trading fees. We aim to draw predictions for our empirical experiment in which BATS decreased the make fee/rebate for CXE, and both the make fee/rebate and the positive take fee for BXE. We therefore study first the effects of a change in the MF/rebate and then a change in both the MF/rebate and the TF.[19]

Results on the effects of a change in make fee/rebate are presented in Tables 2 and A6 for the 3-period model, and in Tables 3 and A7 for the 4-period model, respectively for the

[19] To economize space we only report results for the values of the trading fees that allow us to discuss the main effects at work. Our results are robust to all parameter values within the ranges of fees considered.

primary and the competing market.[20] Results on the effects of a change in both the take fee and the make fee/rebate are presented in Tables 4 and A8 for the 3-period model, and in Tables 5 and A9 for the 4-period model, respectively for the primary and the competing market.

[Insert Table 2, 3, 4 and 5 about here]

Our model allows us to draw predictions for two markets that compete for the provision of liquidity having the same support and trading frequency. The assumption here is that if a stock is traded by investors having large heterogeneous gains from trade on one market, it is also traded by the same type of investors in the competing market; equally, if a stock is traded by speculative short term investors in one market, it is also traded by the same type of investors in the other market.

Table 2 (and Table 4) reports results for our 3-period model and compares them for the two protocols with a large support, $S = [0, 2]$, and a small support, $S = [0.05, 1.95]$, respectively. Table 3 (and Table 5) report results for our 4-period model and compares them for the same large and small support protocols. This way we can investigate first how - given the trading frequency $N = 3$ or $N = 4$ - our results change when we change the distribution of the gains from trade in such a way that investors' personal valuation are distributed over a smaller support - implying that overall gains from trade are less dispersed around the asset value; second, we can investigate how - given the support of investors' personal valuation - our results change when the market is characterized by a different trading frequency.

To understand how both the 3-period and the 4-period models change - all else equal - following a reduction in the support or/and an increase in trading frequency, consider the results for the equilibrium order submission probability of both limit and market order submissions, as well as the derived metrics of market quality reported in columns 2 and 7 of Tables 2 and 3. These results are obtained by solving the model for the regime with all the trading fees set equal to zero, $MF = TF = mf = tf = 0$.[21]

All else equal, when the support decreases from $S = [0, 2]$ to $S = [0.05, 1.95]$ both in the 3-period and in the 4-period model, traders willingness to supply liquidity increases thus increasing LO^j as well as $BBOdepth^{Prim}$, and total depth, $Depth^{Prim}(P_2) + Depth^{Prim}(P_1)$. When the support decreases, extreme gains from trade decrease and there are fewer traders willing to post aggressive limit orders at the inside quotes, thus explaining the small switch of limit orders from the inside, $LO^{Prim}(P_1)$, to the outside quotes, $LO^{Prim}(P_2)$, and the consequent switch of depth from the inside to the outside quotes. As a result, market orders,

[20] We report the results for the competing market in Appendix 1

[21] Appendix 1 shows how the metrics of market quality are obtained starting from the equilibrium order submission probabilities.

driven by the switch of limit orders, also slightly move from the inside $MO^{Prim}(P_1)$, to outside quotes, $MO^{Prim}(P_2)$.

All else equal, when the trading frequency increases from $N = 3$ to $N = 4$, the execution probability of limit orders increases as orders have an additional period to execute. As a consequence, some limit orders move from the inside to the outside quotes and overall liquidity supply increases.[22] This explains why $BBODepth^{Prim}$, $Depth^{Prim}(P_2) + Depth^{Prim}(P_1)$, and $Depth^{Prim}(P_2)$ increase and $Quoted\,Spread^{Prim}$ improves. As there are now more trading periods to execute orders, market orders increase which explains why $Eff.Spread^{Prim}$ deteriorates.

3.2.1. Change in Make Fee - MF

We start by changing the rebate/MF only on the primary market holding all the other fees constant at zero, $TF = mf = tf = 0$. We isolate the change in the make fee/rebate to understand the causal effects that such a change in trading fees determines on the quality of both the primary and the competing market when both markets compete for the provision of liquidity.[23] Tables 2 and 3 report results for the primary market, and Tables A6 and A7 report results for the competing market.[24] We solve our 3 and 4-period models for 3 sets of trading fees in the primary market: $MF = 0.00$ and $TF = 0.00$, $MF = -0.001$ and $TF = 0.00$, and $MF = -0.005$ and $TF = 0.00$. We hold the trading fees in the competing market constant at zero: $mf = tf = 0.00$.

Results for the 3-period model with a large support reported in columns 2, 3 and 4 of Table 2 show the effects of a change from a regime without fees, $MF = 0.00$ and $TF = 0.00$, to a regime with a rebate on MF, $MF = -0.001$ and $TF = 0.00$. Results reported in column 5 show the equilibrium order submission probabilities associated with a further increase in rebate, $MF = -0.005$ and $TF = 0.00$, and results in columns 6 and 7 show the change (Δ) and the percentage change ($\Delta\%$) of the equilibrium order submission probabilities following the change in regime from $MF = -0.001$ and $TF = 0.00$, to $MF = -0.005$ and $TF = 0.00$. The same columns in Table 3 show the results on the effects of the same change in trading fees resulting from our 4-period model.

[22] Note that even if the average order submission probability of limit orders across the trading game decreases in the 4-period model compared to the 3-period one, liquidity provision overall increases in the 4-period protocol. The reason is that as the book fills up with limit orders, over time there is less room for traders to post additional limit orders; therefore, even though in the first two periods of the trading game the average order submission probability of limit orders in the 4-period model increases compared to the 3-period model, as the book fills up with limit orders, in the additional third period, t_3, the average probability of limit order submission decreases, with the consequence that the overall average of limit order submission probability in the 4-period model decreases.

[23] Even though it may happen for short periods of time that trading platforms strategically set their pricing such that the total fee (make fee plus take fee) is negative, in general trading platforms set their fees such that the total fee is positive. We change the make fee to investigate the trade-offs that govern our model.

[24] To economize space we report the results for the competing market in Appendix 1.

The increase in rebate on MF in the primary market enhances traders' willingness to supply liquidity resulting in an increase in LO^{Prim}. The increased propensity to offer liquidity increases competition for the provision of liquidity so that as the book fills up at the inside quotes, attracted by the rebate, traders resort to post limit orders at the outside quotes and the equilibrium order submission probability of $LO^{Prim}(P_2)$ almost doubles. As a result, market quality improves with $Quoted\,Spread^{Prim}$ decreasing, $BBODepth^{Prim}$ and $Depth^{Prim}(P_2) + Depth^{Prim}(P_1)$ increasing, especially at the outside quotes. The increase in limit orders stimulates an increase in MO^{Prim} and, driven by limit orders, over the whole trading game market orders increase at the outside quotes, $MO^{Prim}(P_2)$. As the book gradually fills up, market orders increase so that despite the substantial increase in liquidity supply, $Eff.Spread^{Prim}$ improves in the first two periods of the 3-period trading game and then deteriorates, while it deteriorates outright in the 4-period trading game. As discussed further below, involving the outside quotes in the competition for the provision of liquidity stimulates market orders at the outside quotes which affect $Eff.Spread^{Prim}$, particularly at the last period of the trading game when investors only post market orders. MS^{Prim} increases substantially but some activity still survives on the competing market. When the queues on the primary market become too long, investors switch to the top of the competing market where they do not get the rebate on MF but obtain higher execution probability. As the take fee is zero both on the primary and on the competing market, liquidity takers are indifferent between taking liquidity from the primary or from the competing market.[25] The same line of reasoning would not apply if one of the two markets was cheaper in terms of take fee, as in that case liquidity takers would only take liquidity from the cheapest market.

When the rebate is further increased to $MF = -0.005$, liquidity supply and liquidity demand overall further increase with the higher rebate on MF enhancing competition for the

[25] For example, in the 3-period model with $S = [0, 2]$ considering the branches of the trading game that start at t_1 with the ask side of the primary market - the bid side of being symmetric, with $MF = TF = mf = tf = 0$ at t_1 investors post both $LO^{Prim}(S_2)$ with probability 0.0082 and $LO^{Prim}(S_1)$ with probability 0.2418; at t_2 if the book open with a $LO^{Prim}(S_2)$, investors post $LO^{Prim}(S_1)$ and $LO^{Comp}(S_1)$ with probability 0.2488, $LO^{Prim}(B_2)$ and $LO^{Comp}(B_2)$ with probability 0.0123, and $MO^{Prim}(S_2)$ with probability 0.4779; if instead at t_2 the book opens with $LO^{Prim}(S_1)$ investors post $LO^{Comp}(S_1)$ with probability 0.4959, $LO^{Prim}(B_2)$ and $LO^{Comp}(B_2)$ with probability 0.0082, and $MO^{Prim}(S_1)$ with probability 0.4878.

When all else equal ta rebate on MF is increased on the primary market, with $MF = -0.001$ and $TF = mf = tf = 0.00$, at t_1 investors post both limit order only on the primary market that now grants a rebate on MF, more precisely they post $LO^{Prim}(S_2)$ with probability 0.0159 and $LO^{Prim}(S_1)$ with probability 0.4841; at t_2 if the book open with a $LO^{Prim}(S_2)$, investors post do not post - as in the case without fees - limit orders on the competing market and therefore they post both $LO^{Prim}(S_1)$ and $LO^{Prim}(B_2)$ with a much greater probability, 0.4975 and 0.025 respectively; finally, investors post $MO^{Prim}(S_2)$ with probability 0.4775; if instead at t_2 the book opens with $LO^{Prim}(S_1)$ investors have to resort to the competing market to post aggressive limit orders at the first level of the book and therefore post $LO^{Comp}(S_1)$ with a high probability 0.4955, they finally post $LO^{Prim}(S_2)$ with probability 0.01712, and $MO^{Prim}(S_1)$ with probability 0.4873. This explains the increase in limit orders both at the inside and at the outside of the primary market, but also the reason why a good deal of activity survives at the top of the competing market. Note that when the trading frequency is higher and the suport is smaller, and the provision of liquidity at the inside quotes of the primary market. Market quality improves with the exception - as before - of the $Eff.Spread^{Prim}$ which improves in the 3-period model but deteriorates in the 4-period model. Note however that now the deterioration of $Eff.Spread^{Prim}$ is milder as limit orders increase at the inside rather than at the outside quotes. Note also that when the rebate is increased further, competition gets intense at the inside quotes of the primary market so that the probability that the book will open with an order already posted at the top of the primary market increases thus increasing the average $LO^{Comp}(S_1)$ and therefore reducing MS^{Prim}.

Columns 2 and 3 in Table A6 show the effects of the increase in the rebate on MF ($MF = -0.001$) and of its further enhancement ($MF = -0.005$) on the equilibrium limit and market order submission probabilities and market quality metrics of the competing market. Limit and market orders migrate to the primary market so LO^{Comp} - and in particular MO^{Comp} - decrease substantially. However, due to the increased competition for the provision of liquidity at the top of the two limit order books, a good proportion of limit orders ($LO^{Comp}(P_1)$) survives in the competing market at the first level of the book sustaining both $BBODepth^{Comp}$ and depth at the inside quotes, $Depth^{Comp}(P_1)$. These results are consistent throughout all of our 4 protocols.

Support

Interestingly, results reported in Tables 2 and 3 for the primary market, and in Tables A6 and A7 for the competing market show that the effects discussed above become stronger when the support of investors' valuation is smaller and hence investors are more willing to supply rather than take liquidity. Both in the 3-period and in the 4-period protocols the effects on order flows - LO^{prim} and MO^{prim} - and on market quality - $Quoted\,Spread^{Prim}$, $BBODepth^{Prim}$, $Depth^{Prim}(P_2) + Depth^{Prim}(P_1)$ and $Eff.Spread^{Prim}$ - are stronger when the support is smaller. As discussed above, when the support is smaller, investors are generally less aggressive at posting limit orders at the beginning of the trading game - at t_1 they post $LO^{Prim}(S_1)$ with a smaller probability. This explains why later on, e.g., at t_2 in the 3-period model, when the book opens with an order at the inside quote of the primary market they will undercut with a smaller probability the primary market inside quotes by posting $LO^{Comp}(S_1)$.[26] Less

[26]If at t_1 the probability of observing $LO^{Prim}(S_1)$, is smaller, also the probability that the book will open at t_2 with a $LO^{Prim}(S_1)$ will be smaller. As this is the state of the book at t_2 in which investors will have to undercut the primary inside quotes by posting orders at the inside quotes of the competing venue, this undercutting will take place with a smaller probability and therefore orders will migrate less to the competing venue, thus preserving MS^{Prim}. Note that the probability of $LO^{Prim}(S_1)$ submission at t_1 is smaller in the smaller support framework even though the average (across all periods in which investors post limit orders) probability of $LO^{Prim}(S_1)$ submission is higher when the support decreases from $S = [0, 2]$ to $S = [0.05, 1.95]$ both in the 3-period and in the 4-period model. This is due to the fact that in later periods - at t_2 in the 3-period framework and both at t_2 and t_3 in the 4-period one - the probability of $LO^{Prim}(S_1)$ submission is higher due to the increased competition for the provision of liquidity.

undercutting means less migration to the competing market resulting in a higher MS^{Prim} and symmetrically a smaller MS^{Comp} both in the 3-period and in the 4-period framework.

Trading Frequency

The same tables confirm the effects of a change in rebate on MF in markets characterized by higher trading frequency. In the 4-period framework the driving effect on liquidity supply (LO^{Prim}) is stronger. However, given that in the 4-period market investors are less aggressive when posting limit orders, the increase in limit orders is stronger at the outside quotes, $LO^{Prim}(P_2)$, than at the inside quotes, $LO^{Prim}(P_1)$, resulting in a weaker positive effect on market quality, $Quoted\,Spread^{Prim}$, $BBODepth^{Prim}$ and $Depth^{Prim}(P_2) + Depth^{Prim}(P_1)$, when we exclude the last period of the trading game, and resulting in a stronger effect on market quality when we instead include it. The reason being that at the last period of the trading game the book inherits the liquidity posted more patiently at the outside quotes - in the preceding periods - with market orders hitting a larger proportion of liquidity at those outside quotes. If in the last period liquidity is consumed more at the outside quotes, quoted spread and depth are preserved, whereas the $Eff.Spread^{Prim}$ heavily deteriorates.

Even though the primary market offers a rebate on MF, in the 4-period model investors post - overall - orders to the competing venue with a higher probability compared - all else equal - to the 3-period framework. The reason is twofold. First, there is now an additional period in which the primary book can open with a limit order posted at the inside quotes - in which case investors may find it profitable to post their orders at the inside quotes of the competing venue. Second, when the trading frequency is higher overall some activity shifts to the outside quotes, and when the primary book opens with a limit orders at the outside quotes, investors may find it profitable to post orders even at the outside quotes of the competing market. The increased limit orders posted to the competing venue explain why MS^{Prim} improves less when a rebate on the MF is introduced in a market with higher frequency both in the protocol with a larger support and in the protocol with a smaller support. The reason why this effect is weaker - hence MS^{Prim} is relatively higher - in the smaller support framework is the same as for the 3-period model explained above.

Taken together, these findings lead to our first set of main results.

Main Results 1. *All else equal, consider the introduction of a rebate on MF in one limit order book - the primary market - that competes with an identical limit order book - the competing market. Both limit order books can be characterized by either a large -* $S = [0, 2]$ *- or a small -* $S = [0.05, 1.95]$ *- support of investors' personal valuations, or by either a high -* $N = 4$ *- or a low -* $N = 3$ *- trading frequency:*

- *Liquidity supply and hence liquidity demand cluster on the primary market resulting in an improvement in quoted spread, depth at the best bid-offer and total depth.*
- *Liquidity supply and liquidity demand decrease in the competing market and migrate to the primary market but some activity survives in the competing market due to competition for the provision of liquidity at the inside quotes.*
- *When the support of the investors' personal valuation is smaller,* $S = [0.05, 1.95]$*, traders' propensity to supply liquidity increases and results are overall stronger.*
- *When trading frequency increases, competition for the provision of liquidity extends to the outside quotes:*
  - *Liquidity is preserved more at the inside quotes and consumed more at the outside quotes - market quality improves and* $Eff.Spread^{Prim}$ *deteriorates.*
  - *Migration of order flows from the primary to the competing increases - smaller increase of* MS^{Prim} *and smaller reduction of* MS^{Comp}*.*
- *When the rebate on MF is further increased on the primary market, market quality further improves but the increased competition for the provision of liquidity on the primary market induces traders to post limit orders on the competing market, resulting in a migration of order flows from the primary to the competing market and a negative effect on* MS^{Prim}*.*

Our results also lead to our first empirical prediction for which - consistently with our empirical experiment - we consider a reduction , rather than an increase of a rebate on MF:

Prediction 1. *If a primary market decreases its rebate on the make fee relative to a competing market, order flows migrate out of the primary market to the competing market, causing market quality to deteriorate and market share to decrease in the primary market, and causing market quality to improve and market share to increase in the competing market.*
The effects are generally stronger if the markets are characterized by traders with less heterogeneous gains from trade. If instead the markets are characterized by higher trading frequency the effects on market quality are overall stronger but due to the increased trading frequency there are more opportunities for investors to migrate from the primary to the competing market resulting in a smaller improvement in the primary market share.

3.2.2. Change in Make Fee and Take Fee - $MF\&TF$

We now change both the rebate/MF and the TF on the primary market, holding the fees in the competing market constant at zero, $mf = tf = 0.00$. Tables 4 and 5 report results for the primary market respectively for the 3-period and the 4-period model, and Tables A8 and A9 report results for the competing market. As for the case of a change in MF, we solve our 3-period and 4-period models for 3 sets of trading fees in the primary market: $MF = 0.00$ and $TF = 0.00$, $MF = -0.001$ and $TF = 0.001$, and $MF = -0.005$ and $TF = 0.005$. We hold the trading fees in the competing market constant at zero: $mf = tf = 0.00$.

Results for the 3-period model with a large support reported in columns 2 and 3 of Table 4 show the effects of a change from a regime without fees, $MF = 0.00$ and $TF = 0.00$, to a regime with a rebate on MF and a positive charge on TF, $MF = -0.001$ and $TF = 0.001$. Results reported in column 5 show the equilibrium order submission probabilities associated with a further increase in rebate on MF and a positive change of the same size on TF, $MF = -0.005$ and $TF = 0.005$, and results in columns 6 and 7 show the change (Δ) and the percentage change ($\Delta\%$) in the equilibrium order submission probabilities following a change in regime from $MF = -0.001$ and $TF = 0.001$, to $MF = -0.005$ and $TF = 0.005$. The same columns in Table 5 show the results on the effects of the same change in trading fees resulting from our 4-period model.

When a rebate on MF is introduced in the primary market together with a positive charge of the same size on TF, both liquidity supply LO^{Prim} and liquidity demand MO^{Prim} decrease in the primary market with the strongest effect taking place for limit and market orders at the inside quotes, so that $LO^{Prim}(P_1)$ and $MO^{Prim}(P_1)$ decrease substantially. The result is a migration of order flows from the primary to the competing market with a deterioration of all our metrics of market quality for the primary market and an improvement of the same metrics for the competing market. As discussed in Section 3.2.1, the increase in - only - a rebate on MF in the primary market generates an overall migration of order flows to the primary market with an improvement in market quality; therefore, comparing this overall positive outcome with the one generated by the increase in both a rebate on MF and a positive charge on TF, we can infer that the net effect of the increase of a positive charge on the TF reverses the overall positive effect of the introduction of a rebate/MF and depresses order flows especially on the first level of the book of the primary market. Liquidity suppliers know that even if they could potentially get a rebate by posting a limit order on the primary market, the execution probability of their limit orders would drop to zero if any limit order were available at the same time and at the same price level on the cheaper competing market, and therefore aggressive liquidity suppliers prioritize the competing market. Some less aggressive - marginal - liquidity suppliers instead post their limit orders at the second price level of the primary market as they know that when liquidity will be exhausted at the top of the competing market, liquidity takers arriving sequentially will have to resort to hitting their limit orders, in which case - that would happen with a very small probability - they would be granted a rebate on MF.

When the rebate/MF and the positive charge on TF are further increased, from $MF =$

-0.001 and $TF = 0.001$ to $MF = -0.005$ and $TF = 0.005$, the increase in rebate/MF enhances liquidity supply and hence liquidity demand at the second level of the book of the primary market thus improving market quality. The increase in the positive charge on TF prevents traders from competing at the top of the primary market as the competing market is now even cheaper than the primary market.[27] However, as now the rebate is higher in the primary market, patient investors post their limit orders with higher probability at the second price level of the primary market to attract investors with larger gains from trade willing to take liquidity.[28] The enhanced liquidity supply on the primary market stimulates an increase in liquidity demand so that overall the negative effect of the introduction of the double fee regime is attenuated when the fees are further increased, as reflected in our metrics of market quality that show a smaller deterioration. This line of reasoning and results hold across all our 4 models.

Table 4 and Table 5 show respectively how our results change when the support is smaller, $S = [0.05, 1.95]$, and when the number of trading periods increases to $N = 4$. Smaller support or higher trading frequency translates into higher willingness to supply liquidity which means that both after the increase in trading fees to $MF = -0.001$ and $TF = 0.001$ and after the further increase to $MF = -0.005$ and $TF = 0.005$, investors will be more willing to supply liquidity at the outside quotes of the primary market.[29] The enhanced trading activity translates into a positive effect on market quality. These findings lead to our second set of main results:

Main Results 2. *All else equal, consider the simultaneous increase of a rebate on MF and a positive charge on TF in one limit order book - the primary market - that competes with an identical limit order book - the competing market. Both limit order books can be characterized by either a large -* $S = [0, 2]$ *- or a small -* $S = [0.05, 1.95]$ *- support of investors' personal valuations, or by either a high -* $N = 4$ *- or a low -* $N = 3$ *- trading frequency:*

- *Liquidity supply and liquidity demand migrate from the primary market to the competing market and quoted spread, effective spread, depth at the best bid-offer, and total depth in the primary market generally deteriorates.*

[27] For the framework with $S = [0, 2]$, and $MF = -0.001$ and $TF = 0.001$ ($MF = -0.005$ and $TF = 0.005$), considering the branches of the trading game that start at t_1 with the ask side of the primary market - the bid side of being symmetric, investors will post $LO^{Prim}S_1$ with probability 0.005 (0.005) at t_2 only when they know that at t_3 liquidity takers will not have other options than taking liquidity from the primary market and this only happens when the book at t_1 opens with a $LO^{Prim}S_2$, which in turns has probability 0.0081 (0.0117).

[28] In this specific case, in which the order submission probability of $LO^{Prim}(P_1)$ is tiny, it is informative to consider not only the Δ% change in the equilibrium order submission probabilities, but also the Δ change reported in columns 6 and 12.

[29] With $S = [0, 2]$ and $MF = -0.001$ and $TF = 0.001$, at t_1 the equilibrium order submission probability of $LO^{Prim}S_2$ in the framework is 0.0081; all else equal, reducing the support to $S = [0.05, 1.95]$ the same probability of $LO^{Prim}S_2$ submission is 0.0085; and all else equal - still with $S = [0, 2]$ - increasing the trading frequency to $N = 4$ it increases to 0.0110.

- *Liquidity supply and hence liquidity demand cluster on the competing market resulting in an general improvement in quoted spread, effective spread, depth at the best bid-offer, and total depth in the competing market.*

- *The migration of orders flows to the competing market and the resulting effects on market quality of both the primary and the competing market are weaker when the markets are characterized by a smaller support* $S = [0.05, 1.95]$ *or by higher trading frequency* $N = 4$.

- *When the size of both the rebate on MF and of the positive charge on TF increases from* $MF = -0.001$ *and* $TF = 0.001$ *to* $MF = -0.005$ *and* $TF = 0.005$*, both liquidity supply and liquidity demand increase at the outside quotes of the primary market with a general positive effect on market quality.*

Taken together our results show that when a rebate/MF coupled with a positive charge on TF is increased in a primary market that competes with an identical competing market, order flows migrate to the competing market and market quality deteriorates on the primary market and improves on the competing market. Driven by competition for the provision of liquidity, the effect is stronger at the inside quotes.

When the dual fee regime is further enhanced, the activity at the inside quotes does not substantially change being still attracted by the much cheaper competing market; the activity at the outside quotes instead increases on the primary market improving market quality and market share, and this effect is stronger when the two markets in question - primary and competing - are characterized by investors with less heterogeneous private valuations - like speculative short term traders, whose trading strategies are more responsive to a change in the rebate on MF. The effects is also somewhat stronger when the two competing markets are characterized by a higher trading frequency that induces investors to mildly switch their activity at the outside quotes. We can therefore summarize our results for a reduction rather than an increase in the rebate/MF and TF in our empirical prediction 2:

Prediction 2. *If a primary market decreases both its rebate on the make fee and its positive charge on the take fee relative to a competing market, the activity at the inside quotes of the primary market increases with the result that market quality and market share improves on the primary market and deteriorates on the competing market. The improvement of market quality and market share is stronger (weaker) for stocks characterized by investors with (more) less heterogeneous gains from trade and lower (higher) trading frequency.*

4. Data Description and Methodology

4.1. Market Structure and Intermarket Competition

We study the January 1, 2013, changes in BATS make-take fees. During our sample period, November 2012 - February 2013, BATS operated two European lit venues, BXE and CXE, and each platform featured a continuous order book executing orders based on price, display, and time priority, and both offered very similar maker-taker pricing at the end of 2012. Table 6 illustrates the trading fee schedules in basis points (bps) that apply for LSE listed firms in each BATS venue as of December, 2012. It shows that the take fee was 0.28 bps (0.30 bps) and the rebate was 0.18 bps (0.20 bps) on BXE (CXE).

[Insert Table 6 about here]

BXE and CXE in each market faced competition from the exchange where firms are listed. The LSE operates a transparent, continuous order book, executing orders based on price, display, and time priority. LSE charged trading fees based on the value-traded using a scale ranging from 0.45 bps to 0.20 bps for orders beyond ₤10bn of value traded (Table 6).[30] Value-tiers are typically determined based on monthly value traded, and rebates are distributed and fees collected ex post on a monthly basis. Furthermore, BATS venues also faced competition from the transparent MTF Turquoise (TQ) which also operated a continuous order book executing orders based on price, display, and time priority.[31] TQ charged takers 0.30 bps and used a value-based rebate ranging from 0.14 bps to 0.28 bps for monthly value traded above €2.5bn.[32]

Several dark venues were also actively trading European stocks during our sample period, including: two venues operated by BATS - BXE-Dark and CXE-Dark - both operated as dark midpoint order books; a venue operated by the LSE - TQ-Dark - a dark midpoint order book with both continuous and uncross trading which executed orders based on size followed by time priority; and a venue operated by the broker UBS - UBS-MTF which operates as a continuous midpoint order book with price followed by time priority.[33] BXE-Dark charged 0.15 bps for executed orders, while CXE-Dark charged 0.30 bps for executed Immediate or Cancel (IOC) orders and 0.15 bps for executed Non IOC orders. TQ-Dark charged 0.30 bps for executed orders. The UBS-MTF charged 0.10 bps for executed orders.

To illustrate the degree of intermarket competition in our sample of stocks, we manually

[30] The LSE used maker-taker pricing up to 2009.

[31] TQ was originally launched by a consortium of investment banks on August 15, 2008, but was acquired by the LSE on December 21, 2009. See Gresse (2017) for a discussion of the fragmentation of European equity trading.

[32] For reference, the average December 2012 exchange rate was ₤0.813/€.

[33] BXE Dark, CXE Dark, and TQ Dark all use the midpoint from the LSE market as their reference price.

collect daily data from Fidessa (Fragulator) on share volume reported by each venue, and use it to compute the distribution of market shares across our covered venues. Figure 1, (Figure 1a) reports the distribution of market share for November and December, 2012.[34] It shows that LSE trades (continuous and auction) represent 67.0% of share volume, while lit MTFs capture 27.8%, and dark MTFs capture 5.2% of share volume for UK stocks. BATS lit venues' market share is 21.6% and BATS overall market share is 24.5%.

[Insert Figure 1 about here]

4.2. Data and Sample

We rely on a sample consisting of 120 LSE-listed stocks, to study the effect of BATS' January 2013 fee changes on market share and market quality. The sample is constructed using the following stratification methodology. We begin with a sample of all publicly traded companies listed on the LSE that are also traded on either BXE or CXE (using information provided on the BATS website). The reason we screen on existing BATS trading activity is that we cannot measure changes in market quality and market share at the venue-level unless the stock was traded on BATS both before and after the fee change. For these firms we acquire information on daily average market capitalization and daily price for the month of January 2012 using COMPUSTAT Global and Bloomberg. This initial sample consists of 355 firms. We then only focus on firms where market capitalization is greater than £500m in order to have sufficient liquidity when we calculate our measures of market quality. From this set of 258 firms, we sample 12 firms (with 6 firms above the median price and six below) within each market capitalization decile and end up with a representative final sample of 120 LSE firms that also traded on BATS.

For each of our sample stock-venue combinations, we calculate our daily market quality measures and market share using Thompson Reuters Tick History (TRTH) cash equities market data. The data includes all intraday best bid and ask prices and associated depth, as well as all trades (price and size) for each covered venue (exchanges and transparent MTFs), time-stamped to the microsecond. We also use TRTH end-of-day data to obtain volume, high, low and closing prices.

To capture the effect of BATS fee changes on measure of market quality, we employ a difference-in-difference specification (described in detail in Section 4.4) where we use a similar size sample of Australian firms as a control group. We follow the same stratification methodology used for the LSE sample, to choose the 120 firms of this control sample from the population of Australian firms listed in the Austalian stock exchange (ASX).

[34]We exclude off-market trades when we calculate market share, which represented 56.5% of share volume for LSE listed firms during November and December 2012.

4.3. Descriptive Statistics

Our model speaks to the effect of a change in maker-taker fees on market quality at the venue level. Therefore, we calculate market quality measures both for the venues that are changing fees, BXE and CXE, and for the competing venues, the listing exchange and TQ. We calculate five different measures of market quality for each venue as follows: Volume is the daily number of shares (in 000s) traded using the end-of-day files from TRTH; Depth is the daily average of the intraday quoted BBO depth in shares at the ask-side and the bid-side of each quote respectively; Spread is the time-weighted average of the intraday difference between the ask price and the bid price of each quote in units of currency (₤); %Spread is the time-weighted average of the intraday ask price minus the bid price of each quote divided by the midquote (average of the ask and bid prices); Volatility is the difference between the high and low trading price each trading day (using the end-of-day files from TRTH) divided by the high price. Market share is the daily number of shares traded divided by the total number of shares traded across all venues (CXE, BXE, TQ and LSE).

Table 7 reports summary statistics across stocks based on average daily values for each market quality measure at the listing exchange during December 2012. We also report summary statistics for the distribution of market capitalization in millions as well as price levels in British pounds (₤). We report summary statistics for the overall sample (Overall) and for the subsamples of the highest (Large) and lowest (Small) market capitalization terciles.

[Insert Table 7 about here]

As can be seen in Table 7, the average (median) market capitalization of our LSE sample firms is ₤7.62bn (₤1.68bn) and the stratified sampling generates a wide distribution of firms along the size dimension (interquartile range is ₤3.36bn). Similarly, the average (median) stock price is ₤6.91 (₤4.12) and the distribution across stocks in terms of price is significant (interquartile range is £7.56). In terms of market quality measures, the average (median) share volume is 4.5mn (0.93mn), depth 7,421 (3,172) shares, spread 1.667 (0.889) pence, %spread 0.228% (0.146%), and volatility is 1.886% (1.575%). Hence, our sampling methodology ensures that we have a significant dispersion in market quality measures across firms. As expected, size and price are higher and market quality better for large than for small firms.

We compare market quality measures at each MTF venue (BXE, CXE, and TQ) to LSE for our sample and sub-samples by size in Figure 2. At each venue, we report the average market quality measure for the pre-event period, December 2013. We examine whether the venue mean is significantly different from the listing exchange mean based on a simple differences in group means test and find that all differences are statistically significant with the exception of BXE %spread and CXE volatility, both for the large size sub-sample. As we already highlighted in

Section 4.1, Figure 2 demonstrates that the listing exchange is the dominant venue in terms of share of volume and this is true both overall, and for large and small stocks. CXE captures the second largest fraction of share of volume, and its share of average volume is higher for large than for small stocks. By comparison, both TQ and BXE are smaller players in terms of market share. The distribution of average depth is also skewed towards the listing exchange but much less so than share volume. MTFs depth relative to the listing exchange depth is higher for large stocks than for small stocks.

[Insert Figure 2 about here]

By comparison, the differences in average relative spreads across venues trading is smaller. Quoted spreads are on average lowest on the listing exchange, followed by CXE and TQ, while BXE has the widest quoted spreads. For large stocks, the MTFs are much more competitive relative to the listing exchange. By contrast, for small stocks, the MTFs all have at least fifty percent wider spreads than the listing exchange.

Finally, the differences in volatility measured as (high-low)/high for each venue for each sub-sample. Volatility is significantly lower on the MTFs compared to the listing exchange overall. Volatility is also more muted on the MTFs for small than for large stocks.

4.4. Methodology

In order to examine whether the fee changes have a significant effect on market quality and market share for BATS' and its competitors, we conduct an event study using an event window of two months centered on the fee-change event.[35] We face the usual trade-off when selecting the event window. Using a longer time series would enable us to more precisely measure variables pre- and post-event and also capture longer term effects of the pricing changes. However, a narrower window allows us to reduce the potential effects of confounding factors.[36]

We start by studying time-series of average daily market quality measures. Specifically, we compute equal-weighted daily means across stocks for each venue both for the overall sample (120 firms) and for sub-samples based on size terciles. Firms are classified into size terciles based on market capitalization of the firms one year before the first month of the event (i.e., January 2012).[37] The result is four time-series (overall, large, medium, and small) of roughly forty daily observations (trading days) for each venue (BXE, CXE, TQ and LSE).[38]

[35] We exclude the week of Christmas in December, and instead add the last week of November for the January 2013 fee event.

[36] Our results are qualitatively robust for longer windows (four months before and four months after the fee changes), but the statistical significance is, as expected, lower.

[37] Similarly, in unreported results we examine sub-samples based on the median price level (low and high priced stocks).

[38] We winsorize extreme values of the dependent variable at the 1% level for the overall sample to reduce the influence of extreme observations. We also exclude option expiration dates, i.e., for the January 2013 fee change

We evaluate the change in volume (natural logarithm), quoted depth (natural logarithm), quoted spread, and market share for each venue and sample following the fee changes based on a time-series regression:

$$y_t^V = \mu + \delta \cdot Post_t + \varepsilon_t \quad (2)$$

where y_t^V is the measure of market quality for venue V and $Post_t$ is a dummy variable that takes on a value of one for days in the post-event period and zero otherwise. Standard errors are computed using the Newey-West correction for autocorrelation with ten lags.

Recall from the model that the fee changes affect traders' order choice and order routing decisions, and this in equilibrium produces market outcomes that we can measure such as venue market share, volume, depth and spreads. In our empirical setting, all orders routed to a particular venue experience the same fee change so we do not have any within-venue variation across stocks in terms of the fees to exploit for the creation of a control sample (e.g., matching stocks on pre-event characteristics). By contrast, we do have variation in terms of fees across venues trading the same stocks - e.g., BATS changes its fees but fees on the listing exchange and other MTFs remain unchanged. It is therefore tempting to use market quality on competing platforms as a control sample. However, our model shows that traders' response to fee changes affects not just their order choice on the venue which changes its fees, but also affects order inflow from, and order outflow to, competing venues. As a result, market quality on competing venues are likely to be indirectly affected by the BATS fee changes which suggests that we need to investigate both a direct and an indirect effect of the fee changes (Boehmer, Jones, and Zhang (2020)).

Therefore, to establish the causal effect of fee changes on measures of market quality, and to address exogenous market trends, we employ a difference-in-difference methodology using Australian firms' market quality measures as a control (control venue ASX). The Australian market is similar to Europe, both in terms of the degree of fragmentation and HFT activity.[39] Moreover, there are no trading fee changes in either one of our event windows for the venues trading Australian stocks, making this an advantageous control group. We rely on a sample of Australian stocks that is stratified based on market capitalization and price.[40] Specifically, we estimate the following panel regression specification:

we exclude the 21st of December 2012 and the 18th of January 2013.

[39] HFT activity for European markets for 2013 and 2014 are roughly 25% according to TABB Group, and the level of HFT trading is reasonably steady at 27% of total turnover according to the Australian Securities and Investments Commission report (2015).

[40] Descriptive statistics of the ASX sample are shown in Appendix 2. They are based on average daily values of each marker quality measure at the ASX during December 2012, similarly to Table 7 for the LSE sample. We also report summary statistics of market capitalization in millions as well as price levels, both measured in Australian Dollars (AUD) for the same period as for the LSE sample. For reference, the exchange rate was AUD 1.5/£1

$$y_{i,t}^{V,ASX} = \mu + \beta_1 \cdot Treatment_i^V + \beta_2 \cdot Post_t + \beta_3 \cdot Treatment_i^V * Post_t + \eta_{i,t} \tag{3}$$

where $y_{i,t}^{V,ASX}$ is the measure of market quality (either market share, volume (log), spread, or quoted depth (log)) for stocks in venue V and the control venue ASX, subscript i indicates an individual stock, subscript t denotes time in days, $Treatment_i^V$ is a dummy variable that takes on a value of one for stocks in the venue V and zero for stocks in the control venue ASX, and $Post_t$ is a dummy variable that takes on a value of one for days in the post-event period and zero otherwise. Standard errors are clustered by firm and date. The estimated coefficient $\hat{\beta}_3$ measures the change in market quality in venue V associated with the change in trading fees over and above time series changes in market quality that are unrelated to fee changes (captured by the estimated coefficient $\hat{\beta}_2$ of the control venue ASX) and the cross-sectional differences between the market quality measures across venues V and ASX (in the period before the fee changes) captured by the estimated coefficient $\hat{\beta}_1$ of the venue V.

We also estimate a similar difference-in-difference panel version of the relationship between market quality in venue V and the fee changes controlling for market quality on the listing exchange LSE, to evaluate the robustness of our results. Specifically, we estimate the following regression specification:

$$y_{i,t}^{V,LSE} = \mu + \beta_1 \cdot Treatment_i^V + \beta_2 \cdot Post_t + \beta_3 \cdot Treatment_i^V * Post_t + \eta_{i,t} \tag{4}$$

where $y_{i,t}^{V,LSE}$ is the measure of market quality for stocks in venue V and the control venue is now the listing exchange LSE. For this analysis, we also use standard errors that are clustered by firm and date. We acknowledge that we cannot claim that LSE can be used as proper control since it can also be affected by the fee changes –following our theory we expect such indirect effects since we are in an environment with significant intermarket competition. Nevertheless, and following Boehmer et al. (2020) we believe that we can learn from capturing these indirect effects. In particular, whereas in equation 4, the estimated coefficient $\hat{\beta}_3$ measures the direct change in market quality in venue V associated with the change in trading fees, we note that the estimated coefficient $\hat{\beta}_2$ absorbs any indirect effect caused by spillover from the listing exchange's response to the fee changes in venue V. Hence, we focus on the joint direct and indirect effect of fee changes ($\hat{\beta}_3$ $+\hat{\beta}_2$).

5. Empirical Results

In this section, we estimate the changes in volume, market quality, and market shares on CXE, BXE, TQ, and LSE associated with the BATS fee changes overall and for each sub-sample. We start by discussing the results based on the time-series event-study methodology for the listing exchange LSE, and for each MTF: BXE, CXE, and TQ. We then report the results using difference-in-difference panel regressions with a control group of Australian firms, to properly control for exogenous market trends. We then estimate changes in revenues associated with the BATS fee changes. Finally, to confirm that our results are robust, we report the results based on difference-in-difference panel regressions using trading on the LSE as a control.

5.1. Fee Changes and Mapping with the Theory

In late 2012, BATS announced a plan to change its pricing effective January 1, 2013, of its two transparent trading venues. Specifically, as reported in the second sets of columns in Table 6, BATS eliminated the liquidity rebate from its BXE venue completely (from 0.18 bps to zero), and reduced the take fee from 0.28 bps to 0.15 bps. Furthermore, BATS reduced the CXE liquidity rebate from 0.20 bps to 0.15 bps while leaving the take fee at 0.30 bps. As TQ did not change its pricing, the relative changes in fees/competitiveness across the three European trading venues are the following:[41]

$\downarrow$ **rebate MF** : CXE had the rebate on MF reduced ($\Delta MF = 5bsp$) with respect to TQ;

$\downarrow$ **rebate MF** & **TF** : BXE had the rebate on MF and the positive charge on the TF reduced ($\Delta MF = 18bsp$ and $\Delta TF = -13bsp$) with respect to TQ;

$\downarrow$ **rebate MF** & **TF** : BXE had the rebate on MF and the the positive charge on the TF moderately reduced ($\Delta MF = 13bsp$ and $\Delta TF = -13bsp$) with respect to CXE.

We now face 3 relative changes in fees, a first one involving a reduction in rebate on MF only, a second one involving a reduction in rebate on MF and a positive charge on TF, and a third one involving a somewhat milder reduction in rebate on MF and TF. Our model predicts that the effects of a change in the rebate on MF and of a simultaneous change in the rebate on MF and of the positive charge on TF differ depending on the stocks being characterized by investors with a larger or a smaller support of traders' personal valuations and by a higher or a lower trading frequency, proxied by the length of the trading game.

Our dataset includes stocks classified by market capitalization as large or small. If we consider large stocks as populated by traders with a more pronounced speculative attitude than small stocks - in the language of the model HFTs being traders with an extreme speculative attitude and personal evaluation equal to the asset value ($\gamma = AV$) - we can then map large (small) stocks with the stocks that in the model are characterized by a small (large) support

[41] LSE has to large extent a captive order flow. It offers a flat fee for all order types and therefore it is not directly affected by the change in rebates. It is also substantially more expensive in terms of take fee, hence it is not directly much affected by the change in take fee either.

of investors personal evaluation. In addition, if we consider large (small) stocks as being characterized by a higher (lower) trading frequency, we can also map large (small) stocks with the stocks that in the model are characterized by a higher (lower) trading frequency.

Given the proposed mapping, our model predicts that - all else equal - the CXE reduction in the rebate on MF with respect to TQ should deteriorate market quality - measured by quoted spread and BBODepth - of CXE stocks, and improve market quality for TQ stocks; it should also induce a migration of order flow from CXE to TQ. In addition, the model predicts that the deterioration of quoted spread and BBODepth for CXE and the improvement of quoted spread and BBODepth for TQ should be stronger for large stocks than for small stocks, and the migration of stock from CXE to TQ should be somewhat stronger for large stocks. Our model also predicts that - all else equal - the BXE reduction in the rebate on MF and in the positive charge on TF with respect to TQ, should generate a migration of order flows from TQ to BXE and an improvement (deterioration) of market quality for BXE (TQ) stock, stronger for small stocks. Finally, our model predicts that - all else equal - the BXE milder reduction in rebate on MF and the reduction in the positive charge on TF with respect to CXE, should generate a migration of order flows from CXE to BXE and an improvement (deterioration) of market quality for BXE (CXE) stock, stronger for small stocks. Considering all the relative changes in fees, the net effects of the overall BATS change in pricing should be:

BXE: an improvement in market quality stronger for small stocks as BXE experienced a reduction in rebate on MF and TF both with respect to CXE and with respect to TQ;

CXE: a deterioration of market quality and market share, with respect to TQ - for the reduction in rebate on MF only; and a further deterioration in market quality and market share with respect to BXE - for the *relatively milder* increase in rebate on MF and TF;

TQ: an improvement in market quality and inflow of order flow for large stocks and a reduction in market quality and an outflow of order flow for small stocks. This should be the net effect of the improvement in market quality and market share (stronger for large stocks) generated by the reduction in CXE rebate on MF, and of the reduction in market quality and market share (stronger for small stocks) resulting from the BXE reduction in both rebate on MF and TF;

5.2. Collapsed Time-Series Regressions

We first evaluate the effect of BATS' fee changes on volume (log), quoted spreads, quoted depth (log), and market share for each venue for the overall sample and for the two sub-samples based on a collapsed time-series regression following equation 2. The results in Table 8 show that for stocks overall, volume increased in all venues and the magnitude of the change is much larger for BXE and TQ than for the other two venues. By contrast, we find no significant change for stocks overall in market share for CXE. Spreads for stocks overall decline on BXE and increase on LSE but both changes are only marginally significant, while we find that depth declines significantly on BXE and increases significantly on TQ.

[Insert Table 8 about here]

The results for stocks overall mask significant cross-sectional differences. Consider first small stocks where volume increased significantly only on BXE and LSE. The BXE take fee reduction appears to have been successful in attracting order flow for small stocks as its market share increases significantly. Comparing the magnitudes of the fall in market shares for CXE and TQ we conclude that marketable orders primarily came from CXE but also from TQ. Small stock spreads are unchanged in all venues except for BXE, where the significant reduction of spreads suggests that the competition for the incoming order flow intensifies following the BATS' fee changes. At the same time, depth does not deteriorate on BXE suggesting that the venue did experience sufficient inflow of limit orders attracted by the increased execution probability. Depth for small stocks increases significantly only for LSE, as well as volume but market share does not change significantly.

For large stocks, volume increases in both BATS venues - BXE and CXE, and in TQ following BATS' fee changes, and the increase on TQ is almost three times larger than the increase on BATS trading platforms. By contrast, spread increases for both BATS markets and depth decreases for BXE. For TQ depth increases significantly with no change in spreads.

5.3. Panel Regressions

We next analyze the effects of the BATS fee changes in a difference-in-difference panel regression specification with Australian stocks as controls, following equation 3. Note that in this case, the market share regressions compare each venue's market share of trading LSE-listed stock , e.g. BXE/(BXE+CXE+TQ+LSE), to the market share of ASX of trading ASX-listed stocks, ASX/(ASX+Australian Chi-X). Recall that in this specification, we are interested in the interaction coefficient $Post * Treatment$.[42]

Table 9, Panel A reports the results for BXE. Overall, we find that volume increases, spreads decline, and market share increases significantly following the BXE fee changes. By contrast, there is no effect on depth for the overall sample. The results for stocks overall are consistent with our model Prediction 2 that the make and take fee reductions encourage order flow to migrate to BXE and market quality improves. The results for sub-samples of large and small stocks also support our model Prediction 2. Small stocks - proxied in the model by

[42]For completeness, we also report in Table 9 the joint effect of $Post{+}Post * Treatment$ (following Boehmer et al. (2020)), but we focus on that only when we run a difference-in-difference panel regression specification using LSE as a control in the robustness Section 5.5.

stocks characterized by investors with more heterogeneous gains from trade - benefit the most from the BXE fee reduction and attract both limit and marketable orders with the result of improving market quality and market share. Following the model prediction 2 we expect torder flow to come either from CXE or TQ or from both markets and we see evidence of this. Large stocks instead do not benefit from the reduction in the fees and experience a deterioration of spread. This is also consistent with the model prediction 2 that in a stylized way predicts a much smaller improvement for BXE large stock.

[Insert Table 9 about here]

Results reported in Panel B for CXE show that after we control for market developments on our control market, ASX, spread increases signficantly both for the overall sample and for the sub-sample of stocks. In addition market share deteriorates for small stocks. Consistent with our model, this negative effects can be the result of both the CXE reduction in rebate on MF with respect to TQ (stronger effect on large stocks) and of BXE reduction in rebate on MF and TF (stronger effect on small stocks).

Taken together our results show that the reduction in BATS fees only benefited small stocks in their venues. The negative externality of BATS strategic change in pricing resulted in an improvement of market quality and market share for large TQ stocks.

The results for TQ - reported in Panel C - show that for the overall sample, depth and market share increase significantly without any significant change in spread or volume. For large stocks we find a significant decrease in spreads, a significant increase in depth and also in market share. This significant improvement in market quality and market share is the outcome of the CXE reduction in rebate and the resulting migration of order from CXE. Note that according to our model the predicted outflow of order flow from TQ to BXE following the BXE reduction in rebate on MF and TF, should mainly come from small stocks. This is evident from the reduction in market share for TQ small stocks.

5.4. Trading Revenues

While outside the scope of our model, a venue operator is likely to consider anticipated changes in market share when setting its maker-taker pricing. Revenues related to trading fees are the lion's share of revenues for many markets (Harty (2018)) and changes to maker-taker pricing can have potentially devastating effects on the bottom line. Table 8 shows that BATS fee changes were associated with significant shifts in markets shares across venues and that these changes were different for small stocks compared to large stocks. This begs the questions: Did the fee changes succeed in raising BATS' overall fee revenues? And, were the effects of the fee changes different for small compared to large stocks?

We calculate a proxy for trading-fee revenues (hereafter trading revenues) that relies on the total fee charged by each venue and its volume traded each day. In particular, for each venue, we define revenues to be equal to the nominal volume traded each day times the total fee for that venue. We run the same event study analysis and look at the period of one month pre- to one month post- January 1st, 2013. We calculate daily trading revenues for both the BXE and CXE markets, where the total fee increased from 10 bps in the pre-period to 15 bps in the post-period. We also calculate trading revenues for the rival market TQ and the listing exchange. Unlike the BATS markets, in the TQ market and the listing exchange, the total fee charged remained constant during our event period. As shown in Table 6, however, since both the TQ and listing exchanges follow a value-traded based trading fee schedule, we calculate revenues for these markets based on both the lower (0.20 bps for listing exchange and 0.02 bps for TQ) and upper (0.45 bps for listing exchange and 0.16 bps for TQ) total fees, which represent the lower and upper bound of the trading revenues in each market.

We first calculate actual trading revenues in British pounds for BXE and CXE. Specifically, for BXE we find daily average (median) trading revenues of £1,575 (£357) in the pre-period and £2,768 (£662) in the post-period. Similarly, for the CXE market, we find daily average (median) revenues of £5,614 (£1,268) in the pre-period versus £9,627 (£2,186) in the post-period. These results show a significant increase in revenues for both markets driven primarily by the increase in total fees and less so by changes in volume. Indeed, when we calculate trading revenues for our sub-samples of large and small capitalization firms, we find increases in both sub-samples for both markets. Specifically, for the CXE market we find daily average (median) trading revenues of £14,890 (£8,146) in the pre-period and £25,640 (£13,750) in the post period for large firms and £345 (£152) in the pre-period and £595 (£220) in the post period for small firms. This indicates that even though the change in make-take fees for the CXE market results in a decrease in market share for small stocks documented in Table 8 above, the CXE market more than compensates for this with increases in revenue through the increase in total fee.[43] BXE also shows large increases in trading revenues for both large and small firms after the fee changes, even though we find no increase in market share for large firms in our earlier analysis.

To provide a more representative picture of trading revenue changes across all markets (CXE, BXE, TQ, and LSE), we run similar collapsed time-series regressions as in Section 5.2. We run these regressions on the market share of trading revenues for each venue. Thus for each stock, each day, we divide revenues in each venue by that stock's total revenues measured across all venues for that day. The results are reported in Table 10.

[Insert Table 10 about here]

[43] This suggests an inelastic relationship between total fee and trading volume.

Table 10, (Columns 1-3) shows the results based on an upper bound of revenues in TQ and the LSE. For both BXE and CXE markets, we find an increase in the market share of trading revenues in the post-period. In particular, for the BXE market we find an increase in the market share of revenues of 1.2% overall, 1.3% for small capitalization firms and 0.99% for large capitalization. The larger increase for small capitalization stocks is consistent with the evidence we present in Section 5.2 which shows that BXE market share increases significantly for small stocks while market share for large stocks does not change significantly. The CXE shows increases of 2.54% overall, 3.73% for the large firms, and 1.07% for the small firms. Thus, despite the fact that CXE market share falls for small stocks, the increase in total fee outweighs the market share loss resulting in higher trading revenues. For the rival market TQ the results show an increase in the market share of revenues of 0.24% overall, with a 0.64% increase for large firms, but a 0.32% decrease for small firms. This is consistent with Section 5.2 finding of an increase in TQ market share for large firms but a decrease for small firms. Interestingly, the LSE experiences a decrease in the market share of trading revenues by 4.01% overall, 5.36% for large firms, and 2.05% for small firms as they lose business to BXE. The results appear similar both when we use the lower bound of revenues for the TQ and LSE (Table 10, Columns 4-6). We conclude that the fee changes were successful in terms of increasing the BATS' market share of fee revenues for LSE-listed stocks, and that the bulk of the market share gains happened at the expense of the LSE.

5.5. Robustness

We run one more panel difference-in-difference regression specification in order to verify the robustness of our results. Specifically, instead of using a sample of ASX-listed stocks as controls we use trading of the same stocks on the LSE as a control for trading on BXE, CXE, and TQ, following equation 4. The results are reported in Table 11 for each of the lit venues that compete with the LSE; BXE, CXE, and TQ. In this specification, the coefficient on *Post* captures the effect on LSE trading of BATS' fee changes, while the interaction term $Post * Treatment$ captures the differential effect on the three venues BXE, CXE, and TQ respectively relative to LSE. Virtually no coefficient on *Post* is statistically significant for volume, spreads, and depth. This is consistent with the results in Table 9, Panel D, which showed that there were no significant changes in volume or market quality for LSE. However, as expected since we have already documented large shifts in LSE market share following BATS' fee changes, the coefficient on *Post* is highly significant for the market share results in the last three columns. Recognizing the effect of BATS fee changes on LSE, and following Boehmer et al. (2020), we report the sum of the direct and the indirect treatment effects at the bottom of each panel.

[Insert Table 11 about here]

Starting with the market share results, LSE market share as captured by the coefficient on *Post* falls by roughly 2.2 percentage points for large stocks and about 1.4 percentage points overall with no change for small stocks. Adding these indirect effects to the interaction coefficient, the results for BXE in Panel A show that the total effect on market share for large stocks is insignificant while market share for small stocks and stocks overall increase of 1.5 and 0.9 percentage points respectively. A similar calculation shows that the total effect on market shares for CXE is a significant increase for large stocks of 0.5 percentage points and a decline for small stocks of 0.9 percentage points, but does not affect overall sample market share on this venue. Similarly, for TQ we find a significant total effect on market share for large stocks and overall of 1.7 and 0.8 percentage points respectively, and a marginally significant reduction in market share for small stocks of 0.4 percentage points. The magnitude and significance of the shifts in market share are similar to those we observed in Table 8. Using LSE as control results provide similar support to our model as section 5.3.

We also investigate the effect of the fee change on cum-fee spreads (quoted spread plus twice the take fee), following Malinova and Park (2015). We run univariate (time-series) regressions, as shown in equation 2, for each of our trading venues (BXE, CXE, TQ and LSE). Since the listing exchange (LSE) follows a take fee schedule, we calculate cum-fee spreads for this market based on both the lower (e.g., 0.20 bps for LSE) and upper (e.g., 0.45 bps for LSE) take fees. In contrast to Malinova and Park (2015)—who base their model on Colliard and Foucault (2012) without a tick size—but in support of our model, we find that cum-fee spreads are affected by fee changes. In particular, for the 2013 fee change event, our cum-fee results show: (1) an overall increase in CXE cum-fee spreads driven by large firms, and (2) a decrease (increase) in BXE cum-fee spreads in small (large) firms. These results are similar to our quoted spread time-series results in Section 5.2, though the economic significance appears to be smaller.[44]

6. Conclusions and Policy Implications

Maker-taker pricing is actively debated among academics, practitioners, market operators, and is currently under review by U.S. and European regulators. The SEC in March 2018, proposed a Transactions Fee Pilot for NMS stocks that would mandate a reduction or elimination of rebates (make fees) and a significant reduction in the cap for take fees. We shed light on this debate by studying the effects on venue market quality and market shares of a reduction of liquidity rebates and take fees in fragmented markets in which intermarket competition plays an important role.

We first develop a theoretical model of a primary market and a competing venue, both

[44]Due to space considerations, these results are not reported but are available from the authors upon request.

operating limit order books with price and time priority. It shows that order flow between venues is key to understanding what will happen to the venue's market quality and market share when it changes its maker-taker pricing structure. We then empirically examine the effects on market quality and market shares of changes in make-take fees implemented by BATS on its two lit European venues - BXE and CXE - in 2013 and compare the outcomes to the model's predictions. The model emphasizes that the fee changes will likely also affect competing venues, and we therefore analyze what happens to market shares and market quality not only on BXE and CXE, but also on the competing lit venue TQ.

BXE eliminated its rebates entirely, and significantly reduced the take-fee. These fee reductions attracted order flow to BXE thus improving market quality and market share. The results are stronger for small capitalization stocks. CXE lowered only its rebate and we find that this reduction had a detrimental effect on market quality with spread increasing.

To further highlight that intermarket competition affect other markets, we also study TQ which did not change any of its fees. We find that market quality and market share improves significantly for large stocks on TQ following BATS' fee changes.

Based on our empirical results, we conclude that the effects on market quality and the distribution of volume of a proposal such as the one put forth by ICE and SIFMA are likely to differ across stocks. Specifically, our evidence suggests that an elimination of the make fee and a reduced take fee cap would result in worse market quality for large capitalization stocks but better market quality for small capitalization stocks. This suggests that the elimination of make-fees are going to be particularly detrimental for liquid stocks. In light of our findings, BATS' proposal to eliminate rebates and reduce take fees for the most liquid stocks, while allowing higher rebates and take fees for less liquid stocks, may be ill advised.

We caution that our empirical setting is one where fees are changed by a subset of the market operators, and hence traders can shop across venues for the combination of fees that best fit their trading strategies. If the fee structure is mandated to be the same for all venues trading a particular stock, traders will likely substitute across stocks focusing their rebate strategies in stocks with the most attractive rebates and their more aggressive strategies in those with low take fees. This means that it is going to be challenging to use the proposed SEC Transaction Fee Pilot to infer what would happen to market quality following a universally lower cap on fees.

Documenting cross-sectional differences of the effect of fee changes on market quality and volume leads naturally to the following question: was the BATS fee fight successful? This is a challenging question to answer as we are unable to observe the counterfactual, what would have happened had BATS not changed their fees. In order to evaluate the success of the BATS fee changes we have to both take into account what happened to market share and estimate changes in fee revenues due to the now higher fees. Figure 1 shows that BATS combined market share in LSE listed firms declined from 24.6% in November and December 2012 (Figure 1a) to 22.4% in February and March 2015 (Figure 1b).[45] The distribution across BATS venues also shows that the loss of market share was primarily caused by traders leaving CXE which is where the bulk of the fee experimentation took place. By contrast, BXE actually gained market share suggesting that there is a role for a venue without liquidity rebates and low take fees. Nevertheless, our analysis shows that BATS' total fee increases were large enough to imply that trading revenues rise significantly. For LSE stocks, we conservatively estimate a revenue increase of 1.20% for BXE and 2.54% for CXE. Moreover, the revenues for BATS rise at the expense of the listing exchange which experiences a concomitant decline in revenues. Thus, our results suggest that the BATS fee changes were successful.

We close by highlighting our contributions to the literature. We take intermarket competition between two limit order books into account in both our theoretical and empirical analyses of maker-taker fee changes. Given the significant fragmentation of today's equity markets, this is clearly an important consideration. We show empirically that the spillover effects on competing venues are significant. Our evidence is corroborated by recent fee experiments conducted by both the Nasdaq and the TSX which lost market share after reducing liquidity rebates.

We also study a multi-platform reduction in rebates which are only partially subsidized by reductions in take fee, hence leading to an increase in total fees. The previous literature has mainly studied the elimination of a charge for liquidity provision (Lutat (2010)) and increases in the make and take fees (Malinova and Park (2015)). The current policy debate is focused on reducing rather than increasing make-take fees, and our evidence is therefore directly relevant to the SEC Transactions Fee Pilot proposal.

Furthermore, we document significant cross-sectional differences in the response to changes in maker-taker fees. Specifically, our evidence suggests that traders in large (small) capitalization stocks are relatively more (less) attracted by changes in rebates on make fees.

Lastly, we study changes in fees that took place in 2013 while the previous empirical work on the topic of maker-taker pricing has evaluated this type of pricing based on data from 2008-2010. Given how fast market structure and the ecosystem of traders are changing, it is important to evaluate fee changes in recent years when regulators consider mandating a reduction in liquidity rebates.

[45] We also examine-though not report-introductions by BATS CXE market of value-tiers which imply that HFTs that execute significant volume on BATS venues enjoy a higher rebate (April 1st 2014, CXE) and a lower take fee (January 1st 2015, CXE). BATS was hoping to create a virtuous cycle where both limit and market orders from HFTs were attracted to their venues. Our results show that their experimentation was unsuccessful. Nevertheless, we account for these two events and therefore report market share across venues in the post period (February and March 2015) after the last BATS event in Figure 1b.

References

Anand, A., Hua, J., McCormick, T., 2016. Make-take structure and market quality: Evidence from the US options markets. Management Science 62, 3271–3290.

Angel, J. J., Harris, L. E., Spatt, C. S., 2015. Equity trading in the 21st century: An update. The Quarterly Journal of Finance 5, 1550002.

Battalio, R., Corwin, S. A., Jennings, R., 2016. Can brokers have it all? on the relation between make-take fees and limit order execution quality. The Journal of Finance 71, 2193–2238.

Black, J., 2018. The impact of make-take fees on market efficiency, working Paper University of Memphis.

Boehmer, E., Jones, C. M., Zhang, X., 2020. Potential pilot problems: Treatment spillovers in financial regulatory experiments. Journal of Financial Economics 135, 68–87.

Brogaard, J., 2010. High frequency trading and its impact on market quality, working paper Northwestern University.

Brolley, M., Malinova, K., 2013. Informed trading and maker-taker fees in a low-latency limit order market, working paper University of Toronto.

Buti, S., Rindi, B., Werner, I. M., 2017. Dark pool trading strategies, market quality and welfare. Journal of Financial Economics 124, 244–265.

Cardella, L., Hao, J., Kalcheva, I., 2017. Make and take fees in the US equity market, working paper Rawls College of Business.

Chao, Y., Yao, C., Ye, M., 2018. Why discrete price fragments us stock exchanges and disperses their fee structures. The Review of Financial Studies 32, 1068–1101.

Clapham, B., Gomber, P., Lausen, J., Panz, S., 2017. Liquidity Provider Incentives in Fragmented Securities Markets, sAFE Working Paper No. 231.

Colliard, J.-E., Foucault, T., 2012. Trading fees and efficiency in limit order markets. The Review of Financial Studies 25, 3389–3421.

Comerton-Forde, C., Grégoire, V., Zhong, Z., 2019. Inverted fee structures, tick size, and market quality. Journal of Financial Economics .

Foucault, T., 2012. Pricing liquidity in electronic markets. United Kingdom Government Office of Science, Foresight Projects .

Foucault, T., Kadan, O., Kandel, E., 2005. Limit order book as a market for liquidity. Review of Financial Studies 18, 1171–1217.

Foucault, T., Kadan, O., Kandel, E., 2013. Liquidity cycles and make/take fees in electronic markets. The Journal of Finance 68, 299–341.

Harris, L., 2013. Maker-taker pricing effects on market quotations, working Paper USC Marshall School of Business.

Harty, D., 2018. New stock exchanges could appear if sec pilot cuts fee revenues for cboe, others. Tech. rep., S&P Global Market Intelligence. Reprinted by Tabb Forum.

He, P. W., Jarnecic, E., Liu, Y., 2015. The determinants of alternative trading venue market share: Global evidence from the introduction of Chi-X. Journal of Financial Markets 22, 27–49.

Hendershott, T., Riordan, R., 2013. Algorithmic trading and the market for liquidity. Journal of Financial and Quantitative Analysis 48, 1001–1024.

Jarnecic, E., Snape, M., 2011. An analysis of trades by high frequency participants on the London Stock Exchange, working Paper University of Sydney.

Lin, Y., Swan, P. L., et al., 2017. Why Maker-Taker Fees Improve Exchange Quality: Theory and Natural Experimental Evidence, working Paper University of New South Wales.

Lutat, M., 2010. The effect of maker-taker pricing on market liquidity in electronic trading systems–empirical evidence from European equity trading, working Paper Goethe University.

Malinova, K., Park, A., 2015. Subsidizing liquidity: The impact of make/take fees on market quality. The Journal of Finance 70, 509–536.

Malinova, K., Park, A., Riordan, R., 2018. Do retail investors suffer from high frequency traders?, working Paper University of Toronto.

Menkveld, A. J., 2013. High frequency trading and the new market makers. Journal of Financial Markets 16, 712–740.

O'Donoghue, S. M., 2015. The effect of maker-taker fees on investor order choice and execution quality in us stock markets, kelley School of Business Research Paper No. 15-44.

OICV-IOSCO, 2013. Trading fee models and their impact on trading behaviour. Tech. rep., The Board of the International Organization of Securities Commissions, FR 12/13.

Riccó, R., Rindi, B., Seppi, D. J., 2020. Information, Liquidity, and Dynamic Limit Order Markets, working Paper Carnegie Mellon University.

Tham, W. W., Sojli, E., Skjeltorp, J. A., 2018. Cross-sided liquidity externalities. Management Science 64, 2901–2929.

Table 1: **Order Submission Strategies**

In this table column 1 reports the payoffs of traders' order submission strategies, $\pi^{j}_{t_z}$. Column 2 reports the payoff of orders posted on the primary market $\pi^{Prim}_{t_z}$ and column 3 the payoffs of orders posted on the competing market $\pi^{Comp}_{t_z}$ where $j = Prim$ for the primary market and $j = Comp$ for the competing market. Market orders to sell $(MO^{j}_{t_z}(B^{j,b}_{i}))$ and market orders to buy $(MO^{j}_{t_z}(S^{j,b}_{i}))$ execute against the best bid price, $B^{j,b}_{t_z} = max\left\{B^{j}_{t_z,i}|l^{B^{Prim}}_{t_z,i}, l^{B^{Comp}}_{t_z,i}, \Omega^{Prim}, \Omega^{Comp}, N, S\right\}$, or the best ask price, $S^{j,b}_{t_z,i} = min\left\{S^{j}_{t_z,i}|l^{B^{Prim}}_{t_z,i}, l^{B^{Comp}}_{t_z,i}, \Omega^{Prim}, \Omega^{Comp}, N, S\right\}$ respectively, where $l^{B^{j}}_{t_z,i}$ ($l^{S^{j}}_{t_z,i}$) is the number of shares available at the $i-th$ price level of the bid side (ask side) of the $j-th$ market at time t_z. Traders have a personal evaluation of the asset which is, $\gamma \sim U[\underline{\gamma}, \overline{\gamma})$. MF (mf) is the make fee and TF (tf) is the take fee for the Primary (Competing) market. Limit orders to sell, $LO^{j}_{t_z}(S^{j}_{i})$, and limit orders to buy, $LO^{j}_{t_z}(B^{j}_{i})$, posted at time t_1, t_2 or t_3 may execute at the limit price, S^{j}_{i} and B^{j}_{i}, respectively. Limit buy and sell orders execution probabilities are respectively $Pr_{t_z}(S^{j}_{i}|lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S)$ and $Pr_{t_z}(B^{j}_{i}|lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S$); The payoff of no-trade, NT_{t_z}, is 0 in both markets.

Strategy	Payoffs: Primary Market (Prim) $\pi^{Prim}_{t_z}$	Payoffs: Competing Market (Comp) $\pi^{Comp}_{t_z}$
Market Order to Sell: $MO^{j}_{t_z}(B^{j,b}_{i})$	$B^{Prim,b}_{i} - \gamma_{t_z} - TF$	$B^{Comp,b}_{i} - \gamma_{t_z} - tf$
Limit Order to Sell: $LO^{j}_{t_z}(S^{j}_{i})$	$(S^{Prim}_{i} - \gamma_{t_z} - MF)\times$ $Pr_{t_z}(S^{Prim}_{i}|lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S)$	$(S^{Comp}_{i} - \gamma_{t_z} - mf)\times$ $Pr_{t_z}(S^{Comp}_{i}|lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S)$
No Trade: NT_{t_z}	0	0
Limit Order to Buy: $LO^{j}_{t_z}(B^{j}_{i})$ Limit Order to Buy: $LO^{j}_{t_z}(B^{j}_{i})$	$(\gamma_{t_z} - B^{Prim}_{i} - MF)\times$ $Pr_{t_z}(B^{Prim}_{i}|lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S)$	$(\gamma_{t_z} - B^{Comp}_{i} - mf)\times$ $Pr_{t_z}(B^{Comp}_{i}|lob^{Prim}_{t_z}, lob^{Comp}_{t_z}, \Omega^{Prim}, \Omega^{Comp}, N, S)$
Market Order to Buy: $MO^{j}_{t_z}(S^{j,b}_{i})$	$\gamma_{t_z} - S^{Prim,b}_{i} - TF$	$\gamma_{t_z} - S^{Comp,b}_{i} - tf$

Table 2: **Equilibrium Order Submission Strategies and Market Quality in the Primary Market. Change in MF only. 3-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.05, 1.95]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF, holding $TF = tf = mf = 0.00$, specifically: for $MF = 0.00$ (columns 2 and 7), for $MF = -0.001$ (columns 3 and 8), and for $MF = -0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001$ and $MF = -0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_3) and across all the periods of the trading game (With Period t_3). $Av = 1$ and $\tau = 0.01$.

Primary			$\boldsymbol{S = [0, 2]}$ **3 Periods**						$\boldsymbol{S = [0.05, 1.95]}$ **3 Periods**			
TF	**0.0000**	**0.0000**		**0.0000**			**0.0000**	**0.0000**		**0.0000**		
MF	**0.0000**	**-0.0010**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0.0000**	**-0.0010**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Prim}	0.3781	0.5166	0.3663	0.5172	0.0006	0.0010	0.3783	0.5175	0.3679	0.5181	0.0006	0.0011
$LO^{Prim}(S_2)$ $(LO^{Prim}(B_2))$	0.0062	0.0123	0.9901	0.0121	-0.0002	-0.0198	0.0065	0.0129	0.9899	0.0127	-0.0003	-0.0202
$LO^{Prim}(S_1)$ $(LO^{Prim}(B_1))$	0.1829	0.2460	0.3452	0.2465	0.0005	0.0021	0.1826	0.2458	0.3458	0.2464	0.0006	0.0023
Without Period t_3												
MO^{Prim}	0.1219	0.2435	0.9980	0.2425	-0.0009	-0.0039	0.1217	0.2432	0.9980	0.2422	-0.0010	-0.0041
$MO^{Prim}(S_2)$ $(MO^{Prim}(B_2))$	0.0020	0.0038	0.9346	0.0033	-0.0005	-0.1346	0.0021	0.0040	0.9341	0.0034	-0.0005	-0.1355
$MO^{Prim}(S_1)$ $(MO^{Prim}(B_1))$	0.0590	0.1179	1.0002	0.1180	0.0000	0.0003	0.0588	0.1176	1.0002	0.1176	0.0000	0.0003
$No\ Trade$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$Eff.\ Spread^{Prim}$	0.0027	0.0027	-0.0019	0.0026	0.0000	-0.0077	0.0027	0.0027	-0.0020	0.0026	0.0000	-0.0081
$Quoted\,Spread^{Prim}$	0.0401	0.0349	-0.1277	0.0349	-0.0001	-0.0016	0.0401	0.0349	-0.1278	0.0349	-0.0001	-0.0017
$BBODepth^{Prim}$	0.5042	0.7652	0.5176	0.7678	0.0025	0.0033	0.5044	0.7660	0.5185	0.7687	0.0027	0.0035
$Depth^{Prim}(S_2)$ $(Depth^{Prim}(B_2))$	0.0083	0.0165	0.9767	0.0157	-0.0008	-0.0471	0.0088	0.0173	0.9765	0.0165	-0.0008	-0.0475
$Depth^{Prim}(S_1)$ $(Depth^{Prim}(B_1))$	0.2448	0.3701	0.5118	0.3716	0.0015	0.0041	0.2445	0.3698	0.5124	0.3715	0.0016	0.0044
$Depth^{Prim}(S_2)(B_2) + Depth^{Prim}(S_1)(B_1)$	0.2531	0.3866	0.5271	0.3873	0.0008	0.0020	0.2533	0.3872	0.5285	0.3880	0.0008	0.0020
MS^{Prim}	0.5000	1.0000	1.0000	1.0000	0.0000	0.0000	0.5000	1.0000	1.0000	1.0000	0.0000	0.0000
With Period t_3												
MO^{Prim}	0.1251	0.2105	0.6825	0.2106	0.0001	0.0006	0.1251	0.2106	0.6832	0.2107	0.0001	0.0007
$MO^{Prim}(S_2)$ $(MO^{Prim}(B_2))$	0.0020	0.0040	0.9896	0.0039	-0.0001	-0.0206	0.0021	0.0042	0.9894	0.0041	-0.0001	-0.0210
$MO^{Prim}(S_1)$ $(MO^{Prim}(B_1))$	0.0605	0.1012	0.6722	0.1014	0.0002	0.0015	0.0604	0.1011	0.6725	0.1012	0.0002	0.0016
$No\ Trade$	0.2456	0.2454	-0.0009	0.2446	-0.0008	-0.0034	0.2454	0.2452	-0.0009	0.2443	-0.0009	-0.0036
$Eff.\ Spread^{Prim}$	0.0026	0.0027	0.0100	0.0027	0.0000	-0.0020	0.0026	0.0027	0.0105	0.0027	0.0000	-0.0021
$Quoted\,Spread^{Prim}$	0.0409	0.0374	-0.0853	0.0373	0.0000	-0.0013	0.0409	0.0374	-0.0855	0.0373	0.0000	-0.0013
$BBODepth^{Prim}$	0.4624	0.6414	0.3870	0.6437	0.0023	0.0036	0.4627	0.6423	0.3882	0.6447	0.0024	0.0037
$Depth^{Prim}(S_2)$ $(Depth^{Prim}(B_2))$	0.0070	0.0137	0.9620	0.0128	-0.0009	-0.0629	0.0073	0.0144	0.9612	0.0134	-0.0009	-0.0633
$Depth^{Prim}(S_1)$ $(Depth^{Prim}(B_1))$	0.2239	0.3081	0.3761	0.3091	0.0010	0.0031	0.2237	0.3079	0.3767	0.3089	0.0010	0.0033
$Depth^{Prim}(S_2)(B_2) + Depth^{Prim}(S_1)(B_1)$	0.2309	0.3218	0.3938	0.3219	0.0001	0.0003	0.2310	0.3223	0.3953	0.3224	0.0001	0.0003
MS^{Prim}	0.5000	0.8411	0.6821	0.8409	-0.0001	-0.0001	0.5000	0.8414	0.6829	0.8413	-0.0001	-0.0002

Table 3: **Equilibrium Order Submission Strategies and Market Quality in the Primary Market. Change in MF only. 4-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.05, 1.95]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF, holding $TF = tf = mf = 0.00$, specifically: for $MF = 0.00$ (columns 2 and 7), for $MF = -0.001$ (columns 3 and 8), and for $MF = -0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001$ and $MF = -0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 4 periods, $t_z = t_1, t_2, t_3, t_4$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_4) and across all the periods of the trading game (With Period t_4). $AV = 1$ and $\tau = 0.01$.

Primary			$S = [0, 2]$ **4 Periods**						$S = [0.05, 1.95]$ **4 Periods**			
TF	**0.000**	**0.000**		**0.000**			**0.000**	**0.000**		**0.000**		
MF	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Prim}	0.3368	0.5115	0.5187	0.5119	0.0004	0.0008	0.3369	0.5120	0.5196	0.5125	0.0004	0.0009
$LO^{Prim}(S_2)$ $(LO^{Prim}(B_2))$	0.0455	0.0908	0.9964	0.0903	-0.0005	-0.0053	0.0457	0.0911	0.9961	0.0906	-0.0005	-0.0056
$LO^{Prim}(S_1)$ $(LO^{Prim}(B_1))$	0.1229	0.1650	0.3420	0.1657	0.0007	0.0042	0.1228	0.1649	0.3424	0.1656	0.0007	0.0044
Without Period t_4												
MO^{Prim}	0.1242	0.2096	0.6882	0.2095	-0.0001	-0.0005	0.1241	0.2097	0.6892	0.2095	-0.0001	-0.0006
$MO^{Prim}(S_2)$ $(MO^{Prim}(B_2))$	0.0031	0.0062	1.0117	0.0063	0.0002	0.0263	0.0032	0.0065	1.0113	0.0066	0.0002	0.0257
$MO^{Prim}(S_1)$ $(MO^{Prim}(B_1))$	0.0590	0.0986	0.6714	0.0984	-0.0002	-0.0022	0.0588	0.0984	0.6716	0.0981	-0.0002	-0.0023
$No\ Trade$	0.0781	0.0781	-0.0005	0.0779	-0.0002	-0.0021	0.0779	0.0778	-0.0005	0.0777	-0.0002	-0.0022
$Eff.\ Spread^{Prim}$	0.0037	0.0039	0.0454	0.0039	0.0000	0.0093	0.0037	0.0039	0.0466	0.0039	0.0000	0.0094
$Quoted\,Spread^{Prim}$	0.0399	0.0355	-0.1109	0.0354	-0.0001	-0.0027	0.0399	0.0355	-0.1112	0.0354	-0.0001	-0.0028
$BBODepth^{Prim}$	0.5529	0.8213	0.4854	0.8259	0.0046	0.0056	0.5535	0.8228	0.4865	0.8276	0.0048	0.0059
$Depth^{Prim}(S_2)$ $(Depth^{Prim}(B_2))$	0.0507	0.1011	0.9957	0.1004	-0.0007	-0.0065	0.0511	0.1020	0.9954	0.1013	-0.0007	-0.0069
$Depth^{Prim}(S_1)$ $(Depth^{Prim}(B_1))$	0.2275	0.3146	0.3829	0.3171	0.0025	0.0079	0.2274	0.3147	0.3839	0.3174	0.0026	0.0083
$Depth^{Prim}(S_2)(B_2) + Depth^{Prim}(S_1)(B_1)$	0.2782	0.4157	0.4945	0.4176	0.0018	0.0044	0.2786	0.4167	0.4961	0.4187	0.0019	0.0046
MS^{Prim}	0.5000	0.8442	0.6885	0.8444	0.0002	0.0002	0.5000	0.8448	0.6895	0.8450	0.0002	0.0003
With Period t_4												
MO^{Prim}	0.1556	0.2521	0.6195	0.2523	0.0002	0.0007	0.1556	0.2522	0.6204	0.2524	0.0002	0.0008
$MO^{Prim}(S_2)$ $(MO^{Prim}(B_2))$	0.0176	0.0352	0.9985	0.0352	-0.0001	-0.0019	0.0177	0.0354	0.9984	0.0353	-0.0001	-0.0020
$MO^{Prim}(S_1)$ $(MO^{Prim}(B_1))$	0.0602	0.0908	0.5085	0.0910	0.0002	0.0018	0.0601	0.0907	0.5090	0.0908	0.0002	0.0019
$No\ Trade$	0.1835	0.1835	-0.0005	0.1831	-0.0004	-0.0021	0.1834	0.1833	-0.0005	0.1828	-0.0004	-0.0022
$Eff.\ Spread^{Prim}$	0.0042	0.0052	0.2548	0.0052	0.0000	0.0034	0.0042	0.0052	0.2550	0.0053	0.0000	0.0034
$Quoted\,Spread^{Prim}$	0.0408	0.0372	-0.0900	0.0371	-0.0001	-0.0022	0.0408	0.0372	-0.0903	0.0371	-0.0001	-0.0023
$BBODepth^{Prim}$	0.5106	0.7455	0.4600	0.7493	0.0037	0.0050	0.5112	0.7469	0.4611	0.7508	0.0039	0.0052
$Depth^{Prim}(S_2)$ $(Depth^{Prim}(B_2))$	0.0543	0.1083	0.9955	0.1075	-0.0008	-0.0078	0.0547	0.1091	0.9952	0.1082	-0.0009	-0.0082
$Depth^{Prim}(S_1)$ $(Depth^{Prim}(B_1))$	0.2023	0.2682	0.3257	0.2703	0.0021	0.0077	0.2023	0.2683	0.3266	0.2705	0.0022	0.0081
$Depth^{Prim}(S_2)(B_2) + Depth^{Prim}(S_1)(B_1)$	0.2566	0.3765	0.4675	0.3778	0.0012	0.0033	0.2569	0.3774	0.4689	0.3787	0.0013	0.0034
MS^{Prim}	0.5000	0.6705	0.3410	0.6703	-0.0002	-0.0003	0.5000	0.6707	0.3414	0.6705	-0.0002	-0.0004

Table 4: **Equilibrium Order Submission Strategies and Market Quality in the Primary Market. Change in MF and in TF. 3-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.05, 1.95]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF and TF, specifically: for $MF = 0.00$ and $TF = 0.00$ (columns 2 and 7), for $MF = -0.001$ and $TF = 0.001$ (columns 3 and 8), and for $MF = -0.005$ and $TF = 0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001\,\&\,TF = 0.001$ and $MF = -0.005\,\&\,TF = 0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_3) and across all the periods of the trading game (With Period t_3). $AV = 1$ and $\tau = 0.01$.

Primary	**$S = [0, 2]$ 3 Periods**						**$S = [0.05, 1.95]$ 3 Periods**					
TF	**0.000**	**0.001**		**0.005**			**0.000**	**0.001**		**0.005**		
MF	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Prim}	0.3781	0.0185	-0.9512	0.0241	0.0057	0.3068	0.3783	0.0194	-0.9487	0.0253	0.0059	0.3063
$LO^{Prim}(S_2)$ $(LO^{Prim}(B_2))$	0.0062	0.0092	0.4877	0.0120	0.0028	0.3065	0.0065	0.0097	0.4886	0.0126	0.0030	0.3060
$LO^{Prim}(S_1)$ $(LO^{Prim}(B_1))$	0.1829	0.0000	-0.9999	0.0000	0.0000	0.4565	0.1826	0.0000	-0.9999	0.0000	0.0000	0.4557
Without Period t_3												
MO^{Prim}	0.1219	0.0038	-0.9685	0.0055	0.0017	0.4390	0.1217	0.0040	-0.9669	0.0058	0.0018	0.4373
$MO^{Prim}(S_2)$ $(MO^{Prim}(B_2))$	0.0020	0.0019	-0.0231	0.0028	0.0008	0.4390	0.0021	0.0020	-0.0228	0.0029	0.0009	0.4373
$MO^{Prim}(S_1)$ $(MO^{Prim}(B_1))$	0.0590	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0588	0.0000	-1.0000	0.0000	0.0000	0.0000
$No\ Trade$	0.0000	0.2420	0.0000	0.2392	-0.0028	-0.0115	0.0000	0.2416	0.0000	0.2387	-0.0029	-0.0121
$Eff.\ Spread^{Prim}$	0.0027	0.0075	1.8181	0.0075	0.0000	0.0000	0.0027	0.0075	1.8099	0.0075	0.0000	0.0000
$Quoted\,Spread^{Prim}$	0.0401	0.0498	0.2424	0.0497	-0.0001	-0.0015	0.0401	0.0498	0.2420	0.0497	-0.0001	-0.0016
$BBODepth^{Prim}$	0.5042	0.0226	-0.9551	0.0303	0.0076	0.3370	0.5044	0.0238	-0.9528	0.0318	0.0080	0.3370
$Depth^{Prim}(S_2)$ $(Depth^{Prim}(B_2))$	0.0083	0.0113	0.3576	0.0151	0.0038	0.3370	0.0088	0.0119	0.3583	0.0159	0.0040	0.3370
$Depth^{Prim}(S_1)$ $(Depth^{Prim}(B_1))$	0.2448	0.0000	-0.9999	0.0000	0.0000	0.4565	0.2445	0.0000	-0.9999	0.0000	0.0000	0.4557
$Depth^{Prim}(S_2)(B_2) + Depth^{Prim}(S_1)(B_1)$	0.2531	0.0113	-0.9552	0.0152	0.0038	0.3376	0.2533	0.0119	-0.9529	0.0159	0.0040	0.3372
MS^{Prim}	0.5000	0.0158	-0.9685	0.0228	0.0070	0.4450	0.5000	0.0165	-0.9669	0.0239	0.0073	0.4436
With Period t_3												
MO^{Prim}	0.1251	0.0060	-0.9518	0.0078	0.0018	0.3003	0.1251	0.0063	-0.9494	0.0082	0.0019	0.2995
$MO^{Prim}(S_2)$ $(MO^{Prim}(B_2))$	0.0020	0.0030	0.4861	0.0039	0.0009	0.3000	0.0021	0.0032	0.4869	0.0041	0.0009	0.2991
$MO^{Prim}(S_1)$ $(MO^{Prim}(B_1))$	0.0605	0.0000	-0.9999	0.0000	0.0000	0.4506	0.0604	0.0000	-0.9999	0.0000	0.0000	0.4495
$No\ Trade$	0.2456	0.4063	0.6541	0.4034	-0.0028	-0.0069	0.2454	0.4057	0.6534	0.4028	-0.0030	-0.0073
$Eff.\ Spread^{Prim}$	0.0026	0.0051	0.9409	0.0051	0.0000	0.0040	0.0026	0.0051	0.9382	0.0051	0.0000	0.0040
$Quoted\,Spread^{Prim}$	0.0409	0.0498	0.2177	0.0497	-0.0001	-0.0014	0.0409	0.0498	0.2174	0.0497	-0.0001	-0.0015
$BBODepth^{Prim}$	0.4624	0.0214	-0.9538	0.0284	0.0071	0.3300	0.4627	0.0225	-0.9515	0.0299	0.0074	0.3300
$Depth^{Prim}(S_2)$ $(Depth^{Prim}(B_2))$	0.0070	0.0106	0.5235	0.0141	0.0035	0.3277	0.0073	0.0112	0.5239	0.0148	0.0036	0.3272
$Depth^{Prim}(S_1)$ $(Depth^{Prim}(B_1))$	0.2239	0.0000	-0.9999	0.0000	0.0000	0.4584	0.2237	0.0000	-0.9999	0.0000	0.0000	0.4578
$Depth^{Prim}(S_2)(B_2) + Depth^{Prim}(S_1)(B_1)$	0.2309	0.0106	-0.9540	0.0141	0.0035	0.3279	0.2310	0.0112	-0.9516	0.0148	0.0037	0.3275
MS^{Prim}	0.5000	0.0241	-0.9519	0.0313	0.0072	0.2988	0.5000	0.0253	-0.9495	0.0328	0.0075	0.2980

Table 5: **Equilibrium Order Submission Strategies and Market Quality in the Primary Market. Change in MF and in TF. 4-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.5, 1.5]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF and TF, specifically: for $MF = 0.00$ and $TF = 0.00$ (columns 2 and 7), for $MF = -0.001$ and $TF = 0.001$ (columns 3 and 8), and for $MF = -0.005$ and $TF = 0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001\,\&\,TF = 0.001$ and $MF = -0.005\,\&\,TF = 0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3, t_4$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_4) and across all the periods of the trading game (With Period t_4). $AV = 1$ and $\tau = 0.01$.

Primary	**$S = [0, 2]$ 4 Periods**						**$S = [0.05, 1.95]$ 4 Periods**					
TF	**0.000**	**0.001**		**0.005**			**0.000**	**0.001**		**0.005**		
MF	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Prim}	0.3368	0.3336	-0.0095	0.3345	0.0009	0.0028	0.3369	0.3336	-0.0099	0.3346	0.0010	0.0030
$LO^{Prim}(S_2)$ $(LO^{Prim}(B_2))$	0.0455	0.1652	2.6331	0.1657	0.0005	0.0030	0.0457	0.1651	2.6166	0.1656	0.0005	0.0031
$LO^{Prim}(S_1)$ $(LO^{Prim}(B_1))$	0.1229	0.0016	-0.9869	0.0016	0.0000	-0.0097	0.1228	0.0017	-0.9863	0.0017	0.0000	-0.0102
Without Period t_4												
MO^{Prim}	0.1242	0.0092	-0.9262	0.0116	0.0024	0.2614	0.1241	0.0096	-0.9226	0.0121	0.0025	0.2604
$MO^{Prim}(S_2)$ $(MO^{Prim}(B_2))$	0.0031	0.0046	0.4943	0.0058	0.0012	0.2614	0.0032	0.0048	0.4944	0.0061	0.0012	0.2604
$MO^{Prim}(S_1)$ $(MO^{Prim}(B_1))$	0.0590	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0588	0.0000	-1.0000	0.0000	0.0000	0.0000
$No\ Trade$	0.0781	0.0813	0.0411	0.0809	-0.0005	-0.0058	0.0779	0.0812	0.0431	0.0807	-0.0005	-0.0061
$Eff.\ Spread^{Prim}$	0.0037	0.0100	1.7139	0.0100	0.0000	0.0000	0.0037	0.0100	1.7019	0.0100	0.0000	0.0000
$Quoted\,Spread^{Prim}$	0.0399	0.0449	0.1247	0.0449	0.0000	-0.0007	0.0399	0.0449	0.1246	0.0449	0.0000	-0.0007
$BBODepth^{Prim}$	0.5529	0.5056	-0.0860	0.5086	0.0030	0.0060	0.5535	0.5058	-0.0860	0.5090	0.0032	0.0063
$Depth^{Prim}(S_2)$ $(Depth^{Prim}(B_2))$	0.0507	0.2504	3.9420	0.2519	0.0015	0.0061	0.0511	0.2504	3.8984	0.2520	0.0016	0.0065
$Depth^{Prim}(S_1)$ $(Depth^{Prim}(B_1))$	0.2275	0.0024	-0.9894	0.0024	0.0000	-0.0095	0.2274	0.0025	-0.9888	0.0025	0.0000	-0.0100
$Depth^{Prim}(S_2)(B_2) + Depth^{Prim}(S_1)(B_1)$	0.2782	0.2528	-0.0913	0.2543	0.0015	0.0060	0.2786	0.2529	-0.0920	0.2545	0.0016	0.0063
MS^{Prim}	0.5000	0.0369	-0.9262	0.0466	0.0097	0.2625	0.5000	0.0387	-0.9226	0.0488	0.0101	0.2615
With Period t_4												
MO^{Prim}	0.1556	0.0959	-0.3840	0.0968	0.0010	0.0099	0.1556	0.0960	-0.3833	0.0970	0.0010	0.0104
$MO^{Prim}(S_2)$ $(MO^{Prim}(B_2))$	0.0176	0.0475	1.6952	0.0480	0.0005	0.0102	0.0177	0.0475	1.6822	0.0480	0.0005	0.0106
$MO^{Prim}(S_1)$ $(MO^{Prim}(B_1))$	0.0602	0.0004	-0.9926	0.0004	0.0000	-0.0151	0.0601	0.0005	-0.9923	0.0005	0.0000	-0.0159
$No\ Trade$	0.1835	0.1863	0.0147	0.1860	-0.0003	-0.0014	0.1834	0.1862	0.0154	0.1859	-0.0003	-0.0015
$Eff.\ Spread^{Prim}$	0.0042	0.0102	1.4474	0.0102	0.0000	-0.0014	0.0042	0.0102	1.4389	0.0102	0.0000	-0.0015
$Quoted\,Spread^{Prim}$	0.0408	0.0446	0.0924	0.0446	0.0000	-0.0004	0.0408	0.0446	0.0924	0.0446	0.0000	-0.0005
$BBODepth^{Prim}$	0.5106	0.5335	0.0448	0.5355	0.0020	0.0038	0.5112	0.5336	0.0439	0.5358	0.0021	0.0040
$Depth^{Prim}(S_2)$ $(Depth^{Prim}(B_2))$	0.0543	0.2478	3.5643	0.2488	0.0010	0.0040	0.0547	0.2477	3.5311	0.2487	0.0010	0.0042
$Depth^{Prim}(S_1)$ $(Depth^{Prim}(B_1))$	0.2023	0.0026	-0.9873	0.0025	0.0000	-0.0090	0.2023	0.0027	-0.9867	0.0027	0.0000	-0.0094
$Depth^{Prim}(S_2)(B_2) + Depth^{Prim}(S_1)(B_1)$	0.2566	0.2504	-0.0243	0.2513	0.0010	0.0038	0.2569	0.2504	-0.0254	0.2514	0.0010	0.0041
MS^{Prim}	0.5000	0.2632	-0.4736	0.2672	0.0040	0.0151	0.5000	0.2639	-0.4723	0.2680	0.0042	0.0158

Table 6: **Trading Fee Schedules for UK and Irish listed firms.**
This table reports the trading fee schedules that apply for the LSE-listed firms during our sample period right before December 31st, 2012 to the period right after January 1st, 2013. We look at both transparent (lit) venues and dark pools. In particular, the venue that we examine are: BXE-Lit, CXE-Lit, TQ-Lit, LSE-Lit and BXE-Dark, CXE-Dark, TQ-Dark, and UBS-Dark. Our study focuses on the fee changes for the BXE-Lit and CXE-Lit markets implemented on January 1st, 2013. No other venue incurred any changes in fees.

	Effective December 31, 2012				Effective January 1, 2013		
	Tiers/Order Type	Maker fee (bps)	Taker Fee (bps)	Total Fee (bps)	Maker fee (bps)	Taker Fee (bps)	Total Fee (bps)
A. Transparent MTFs							
BXE-Lit		-0.18	0.28	0.10	0.00	0.15	0.15
CXE-Lit		-0.20	0.30	0.10	-0.15	0.30	0.15
TQ-Lit	< €1.5bn	-0.14	0.30	0.16	-0.14	0.30	0.16
	€1.5 - €2.5bn	-0.24	0.30	0.06	-0.24	0.30	0.06
	> €2.5bn	-0.28	0.30	0.02	-0.28	0.30	0.02
B. Primary/Listing Exchange							
LSE-Lit*	< £2.5bn	0.00	0.45	0.45	0.00	0.45	0.45
	£2.5 - £5.0bn	0.00	0.40	0.40	0.00	0.40	0.40
	£5.0 - £10.0bn	0.00	0.30	0.30	0.00	0.30	0.30
	> £10.0bn	0.00	0.20	0.20	0.00	0.20	0.20
C. Dark Venues							
BXE-Dark		0.15	0.15	0.30	0.15	0.15	0.30
CXE-Dark	Non-IOC Orders	0.15	0.15	0.30	0.15	0.15	0.30
	IOC Orders	0.30	0.30	0.60	0.30	0.30	0.60
TQ-Dark		0.30	0.30	0.60	0.30	0.30	0.60
UBS-Dark		0.10	0.10	0.20	0.10	0.10	0.20

Notes: * The 0.00 make fee only applies to passive executions qualifying under Liquidity Provider Scheme for FTSE 350 securities. LSE enforced a minimum per order charge of £0.10. Furthermore, LSE offered two Liquidity Taker Scheme Packages for Equities: 1) for a monthly fee of £50,000 the taker fee is 0.15 bps; 2) for a monthly fee of £5,000 the taker fee is 0.28 bps. Effective June 3, 2013, the hurdles for these packages were reduced to £40,000 and £4,000 respectively.

Table 7: **Descriptive Statistics for 2013 Event, LSE Sample.**
This table reports summary statistics for our main variables. Our 120 LSE listed stocks sample is stratified by price and market capitalization, based on daily averages for the month of January 2012. All variables reported in the tables, daily measures at the stock level, are for the listing exchange only. *Volume* is defined as the daily number of shares (in 000s) at the end-of-day files from Thomson Reuters Tick History (TRTH). *Depth* is defined as the daily average of the intraday quoted depth at the ask-side and the bid-side of each quote respectively. *Spread* is defined as the time-weighted daily average of the intraday difference between the ask price and the bid price of each quote. *%Spread* is defined as the time weighted daily average of the intraday ask price minus the bid price divided by the midquote of each quote. *Volatility* is defined as the difference between the high and low trading priced of each trading day divided by the high price of that day (using the end-of-day files from TRTH). The descriptive statistics for the five measures of market quality are based on daily numbers for each stock in the one-month pre-period (December 2012). We also report *market capitalization* (in £millions) and *price* levels (in £) both variables are daily measures for the month of January 2012. In addition to the overall samples, for all of our variables we also report summary statistics for the subsamples of the highest (*Large*) and lowest (*Small*) market capitalization terciles.

Market Quality Measures		**Mean**	**Median**	**ST dev**	**Q1**	**Q3**
	Large	10,980	3,352	23,692	1,478	7,718
Volume (000s)	Small	767	329	1,140	119	910
	Overall	4,457	931	14,560	307	2,854
	Large	11,500	7,082	16,730	4,094	11,080
Depth	Small	6,211	1,922	14,336	867	4,882
	Overall	7,421	3,172	13,899	1,403	7,271
	Large	0.898	0.722	0.812	0.215	1.486
Spread	Small	2.050	0.891	2.748	0.369	2.658
	Overall	1.667	0.889	3.576	0.310	1.717
	Large	0.092%	0.096%	0.038%	0.060%	0.120%
% Spread	Small	0.357%	0.264%	0.330%	0.182%	0.435%
	Overall	0.228%	0.146%	0.276%	0.108%	0.246%
	Large	1.602%	1.402%	0.819%	1.101%	1.899%
Volatility (High-Low)/High	Small	2.068%	1.706%	1.387%	1.207%	2.552%
	Overall	1.886%	1.575%	1.284%	1.163%	2.211%
	Large	20,290	8,896	24,684	4,373	25,200
Market Capitalization (£Mill)	Small	789	792	169	634	926
	Overall	7,622	1,676	16,835	931	4,289
	Large	9.280	5.620	8.633	2.502	14.180
Price	Small	4.970	2.910	4.994	1.195	5.768
	Overall	6.909	4.115	6.932	2.148	9.705

Table 8: **Measures of Market Quality. Time-Series Changes for the 2013 Event.**
This table reports the changes in market quality measures (Volume (Log), Quoted Spread, Depth (Log), and Market Share) for the 2013 event using a one-month pre- and one-month post-event window. We investigate four market venues: BATS (BXE), Chi-X (CXE), Turquoise (TQ), and the primary market (LSE). Our post minus pre (differences) estimation methodology is based on running daily time-series regressions of the mean values of each measure of market quality on a dummy variable *Event* to indicate post-event period as shown in equation 2. We run regressions for the overall sample and two subsamples of the highest (*Large*) and lowest (*Small*) market capitalization terciles. The table reports estimated coefficients and t-statistics (in parentheses) for the LSE sample. For all specifications, we employ the Newey-West correction for autocorrelation in the error terms using 10 day lags. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively

	Volume (Log)			Spread			Depth (Log)			Market Share		
	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall
BXE												
Event	0.0914**	0.4975***	0.2558***	0.0327**	-0.5563**	-0.1829*	-0.1050***	0.0188	-0.0437***	0.0008	0.0134***	0.0075***
(t-statistic)	(2.75)	(4.08)	(3.75)	(2.54)	(-2.46)	(-1.83)	(-4.35)	(0.56)	(-3.84)	(0.70)	(3.13)	(2.94)
CXE												
Event	0.0895***	0.0424	0.0724***	0.0147***	0.1702	0.0423	-0.0309	0.0097	-0.0102	0.0040**	-0.0113***	-0.0017
(t-statistic)	(3.23)	(1.43)	(3.31)	(3.33)	(0.70)	(0.97)	(-0.77)	(0.45)	(-0.62)	(2.34)	(-5.51)	(-0.74)
TQ												
Event	0.2643***	-0.0035	0.1916**	-0.0179	-0.0505	-0.0123	0.2350***	-0.0358	0.0785***	0.0162***	-0.0054**	0.0067***
(t-statistic)	(4.42)	(-0.06)	(2.62)	(-1.17)	(-0.65)	(-0.30)	(4.62)	(-1.11)	(3.82)	(6.19)	(-2.21)	(2.62)
LSE												
Event	0.0380	0.1271***	0.0595**	0.0084	0.0666	0.0544*	0.0074	0.0576***	0.0158*	-0.0210***	0.0033	-0.0129***
(t-statistic)	(1.39)	(3.28)	(2.04)	(0.76)	(1.61)	(1.82)	(0.40)	(2.88)	(1.81)	(5.75)	(0.64)	(-3.54)

Table 9: **Measures of Market Quality - Panel Regressions of the 2013 Event using ASX Sample as Control.**
The table reports the changes in market quality (Volume (log), Spread, Depth (log), and Market Share) using panel difference-in-difference regressions for the 2013 event using a one-month pre- and one-month post-event window. We investigate four market venues (treatment group): BATS (BXE), Chi-X (CXE), Turquoise (TQ), and the primary market (LSE). For our control group we use a stratified sample of 120 Australian firms listed in the Australian Stock Exchange. To measure the change in market quality for each of the market venues, we follow the standard difference-in-difference specification as shown in equation 3. The interaction variable event*treatment indicates the post-event period effect for our treatment group. We run regressions for the overall sample and two subsamples of the highest (Large) and lowest (Small) market capitalization terciles. Each Panel reports estimated coefficients and t-statistics (in parentheses) for each for the four venues. For all specifications, we employ clustered standard errors by firm and date. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively

Panel A: Panel Difference-in-difference Regressions for BXE (using ASX market as control)

	Volume (Log)			Spread			Depth (Log)			Market Share		
	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall
Intercept	14.7353***	13.7542***	14.2493***	0.0084**	0.0220*	0.0124***	9.2607***	9.6809***	9.5454***	0.9047***	0.9192***	0.9122***
(t-statistic)	(74.50)	(64.89)	(118.12)	(2.57)	(1.85)	(7.15)	(33.65)	(31.94)	(56.76)	(119.92)	(141.35)	(208.96)
Post	0.0784	0.0416	0.0084	0.0005	-0.0143	-0.0075	-0.0348	0.0353	-0.0437	-0.0067	-0.0160**	-0.0128**
(t-statistic)	(0.50)	(0.24)	(0.09)	(0.14)	(-1.18)	(-1.16)	(-0.50)	(0.22)	(-0.82)	(-1.02)	(-2.17)	(-2.29)
Treatment	-1.8564***	-4.2969***	-3.1792***	0.9582***	3.9609***	2.7605***	-1.7956***	-2.9689***	-2.6045***	-0.8375***	-0.8634***	-0.8496***
(t-statistic)	(-6.73)	(-11.34)	(-14.19)	(7.00)	(4.53)	(4.19)	(-5.75)	(-8.66)	(-13.62)	(-100.73)	(-98.93)	(-152.22)
Post*Treatment	0.0364	0.4568**	0.2714***	0.0325***	-0.5222***	-0.1612***	-0.0745	-0.0251	-0.0038	0.0092	0.0305***	0.0217***
(t-statistic)	(0.25)	(2.52)	(3.33)	(12.80)	(-2.69)	(-16.86)	(-1.29)	(-0.16)	(-0.08)	(1.26)	(3.66)	(3.47)
Option Exp. Date Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Nobs	3200	3200	9600	3192	3180	9570	3200	3200	9600	3193	3189	9581
Adj R^2	0.32	0.53	0.40	0.38	0.18	0.06	0.27	0.44	0.40	0.98	0.98	0.98
Adding the indirect and direct treatment effects:												
Post+Post*Treatment	0.1147*	0.4984***	0.2798***	0.0331	-0.5365***	-0.1688	-0.1093	0.0102	-0.0474	0.0025	0.0145***	0.0088***
(t-statistic)	(1.68)	(5.07)	(5.14)	(1.04)	(-2.63)	(-1.08)	(-1.43)	(0.12)	(-1.02)	(0.86)	(4.29)	(4.87)

Panel B: Panel Difference-in-difference Regressions for CXE (using ASX market as control)

	Volume (Log)			Spread			Depth (Log)			Market Share		
	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall
Intercept	14.7322***	13.7706***	14.2545***	0.0101***	0.0137***	0.0105***	9.2595***	9.6815***	9.5456***	0.9054***	0.9201***	0.9129***
(t-statistic)	(74.59)	(65.01)	(118.24)	(6.54)	(3.28)	(19.84)	(33.64)	(31.94)	(56.76)	(117.03)	(137.77)	(198.94)
Post	0.0805	0.0331	0.0060	0.0005	0.0030	-0.0040	-0.0332	0.0342	-0.0434	-0.0068	-0.0164**	-0.0131**
(t-statistic)	(0.52)	(0.19)	(0.07)	(0.28)	(0.23)	(-0.84)	(-0.48)	(0.22)	(-0.81)	(-1.01)	(-2.18)	(-2.26)
Treatment	-0.5130*	-3.4882***	-2.0943***	0.7567***	3.6290***	2.3365***	-0.7743**	-2.8654***	-2.0481***	-0.6534***	-0.8056***	-0.7282***
(t-statistic)	(-1.91)	(-8.97)	(-8.78)	(7.41)	(3.45)	(3.83)	(-2.53)	(-8.25)	(-10.26)	(-64.41)	(-64.97)	(-80.99)
Post*Treatment	0.0328	0.0154	0.0751	0.0142**	0.2038***	0.1116***	-0.0032	-0.0334	0.0256	0.0132	0.0062	0.0130*
(t-statistic)	(0.23)	(0.10)	(1.07)	(2.50)	(51.21)	(2.87)	(-0.06)	(-0.22)	(0.56)	(1.46)	(0.75)	(1.92)
Option Exp. Date Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Nobs	3200	3200	9600	2192	3180	9570	3200	3200	9600	3193	3189	9581
Adj R^2	0.04	0.43	0.21	0.40	0.10	0.05	0.06	0.42	0.27	0.96	0.96	0.95
Adding the indirect and direct treatment effects:												
Post+Post*Treatment	0.1133*	0.0486	0.0811	0.0147	0.2067	0.1076	-0.0364	0.0008	-0.0177	0.0063*	-0.0102**	-0.0001
(t-statistic)	(1.71)	(0.48)	(1.39)	(0.61)	(0.75)	(0.70)	(-0.48)	(0.01)	(-0.36)	(1.95)	(-2.56)	(-0.04)

Panel C: Panel Difference-in-difference Regressions for TQ (using ASX market as control)

	Volume (Log)			Spread			Depth (Log)			Market Share		
	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall
Intercept	14.7357***	13.7683***	14.2553***	0.0086***	0.0016	0.0049	9.2606***	9.6817***	9.5459***	0.9046***	0.9197***	0.9123***
(t-statistic)	(74.45)	(65.04)	(118.09)	(2.80)	(0.20)	(0.86)	(33.65)	(31.94)	(56.77)	(119.98)	(140.46)	(206.88)
Post	0.0782	0.0360	0.0056	0.0012	-0.0053	-0.0024	-0.0342	0.0335	-0.0437	-0.0066	-0.0160**	-0.0127**
(t-statistic)	(0.50)	(0.21)	(0.06)	(0.33)	(-0.34)	(-0.24)	(-0.50)	(0.21)	(-0.83)	(-1.00)	(-2.16)	(-2.26)
Treatment	-2.0256***	-3.9284***	-3.0343***	0.8976***	3.3707***	2.3792***	-1.8392***	-3.0579***	-2.6297***	-0.8470***	-0.8538***	-0.8442***
(t-statistic)	(-7.27)	(-11.09)	(-14.70)	(7.41)	(4.96)	(4.11)	(-5.89)	(-8.95)	(-13.80)	(-98.30)	(-100.99)	(-145.72)
Post*Treatment	0.2235	-0.0266	0.1204	-0.0206***	-0.0172	0.0325	0.2659***	-0.0794	0.1147**	0.0243***	0.0111	0.0200***
(t-statistic)	(1.50)	(-0.15)	(1.30)	(-23.98)	(-0.59)	(0.60)	(4.91)	(-0.52)	(2.40)	(3.26)	(1.38)	(3.09)
Option Exp. Date Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Nobs	3200	3200	9600	3192	3180	9568	3200	3200	9600	3193	3189	9581
Adj R^2	0.32	0.52	0.39	0.40	0.20	0.06	0.24	0.46	0.39	0.98	0.98	0.98
Adding the indirect and direct treatment effects:												
Post+Post*Treatment	0.3017***	0.0094	0.1261**	-0.0194	-0.0225	0.0301	0.2317***	-0.0459	0.0709	0.0177***	-0.0049	0.0073***
(t-statistic)	(4.22)	(0.10)	(2.33)	(-0.70)	(-0.13)	(0.20)	(3.04)	(-0.54)	(1.51)	(6.09)	(-1.47)	(3.98)

Panel D: Panel Difference-in-difference Regressions for LSE (using ASX market as control)

	Volume (Log)			Spread			Depth (Log)			Market Share		
	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall
Intercept	14.7233***	13.7561***	14.2442***	0.0096***	-0.0115	-0.0038	9.2560***	9.6773***	9.5425***	0.9020***	0.9173***	0.9100***
(t-statistic)	(74.71)	(64.97)	(118.40)	(4.76)	(-0.48)	(-0.27)	(33.62)	(31.90)	(56.70)	(120.49)	(135.65)	(199.31)
Post	0.0833	0.0430	0.0114	0.0018	0.0193	0.0152	-0.0289	0.0366	-0.0410	-0.0059	-0.0144*	-0.0117**
(t-statistic)	(0.54)	(0.25)	(0.13)	(0.89)	(0.81)	(1.10)	(-0.42)	(0.23)	(-0.76)	(-0.86)	(-1.89)	(-2.01)
Treatment	0.4036	-1.0956***	-0.5287***	0.8860***	2.0407***	1.6562***	-0.4282	-1.9507***	-1.4325***	-0.2833***	-0.1547***	-0.2277***
(t-statistic)	(1.46)	(-3.76)	(-2.80)	(7.20)	(5.16)	(5.52)	(-1.39)	(-5.37)	(-7.20)	(-29.60)	(-8.53)	(-22.35)
Post*Treatment	-0.0274	0.0724	0.0535	0.0051	0.0326*	-0.0000	0.0260	0.0054	0.0508	-0.0149*	0.0158**	-0.0021
(t-statistic)	(-0.20)	(0.45)	(0.77)	(1.19)	(1.76)	(-0.00)	(0.46)	(0.04)	(1.07)	(-1.69)	(2.07)	(-0.30)
Option Exp. Date Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Nobs	3200	3200	9600	3190	3180	9567	3200	3200	9600	3193	3189	9581
Adj R^2	0.02	0.10	0.03	0.38	0.22	0.09	0.02	0.24	0.15	0.82	0.31	0.55
Adding the indirect and direct treatment effects:												
Post+Post*Treatment	0.0559	0.1155	0.065	0.0069	0.0519	0.0152	-0.0029	0.042	0.0098	-0.0208***	0.0014	-0.0138***
(t-statistic)	(0.82)	(1.45)	(1.37)	(0.24)	(0.53)	(0.19)	(-0.04)	(0.47)	(0.20)	(-5.90)	(0.25)	(-4.51)

Table 10: **Trading Revenues.**
This table reports the changes in trading revenues for the 2013 event using a one-month pre- and one-month post-event window. WE investigate all four market venues in our analysis: Chi-X (CXE), BATS (BXE), Turquoise (TQ), and the listing exchange (LSE). Trading revenues are defined to be equal to the nominal volume traded each day times the total fee for that venue. To better capture the effect of the changes across markets we standardize trading revenues as follows: we divide venue-stock-day trading revenues by total trading revenues taken over all fours venues (BXE, CXE, TQ, and LSE) for that stock that day. Our post- minus pre-event (difference) estimation methodology is based on running daily time-series regressions of the mean values of trading revenues that day on a dummy variable *Event* to indicate post-event period. We run regressions for the overall sample and two subsamples of the highest (Large) and lowest (Small) market capitalization terciles. Since both the TQ and LSE follow a trading fee schedule, we calculate revenues for these markets based on both the lower (0.20 bps for LSE and 0.02 bps for TQ) and upper (0.45 bps for LSE and 0.16 bps for TQ) total fees. The latter is reported in columns 1-3 and the former in columns 4-6. The table reports estimated coefficients and t-statistics (in parentheses). For all specifications we employ the Newey-West correction for auto correlation in the error terms using 10 day lags. ** and *** indicate significance at the 5% and 1% levels, respectively.

2013 Event for LSE Sample. Time Series (Post Minus Pre) Differences of Revenues.

	Revenues Highest LSE Total Fees Used: 0.45 bps Highest TQ Total Fees Used: 0.16 bps			Revenues Lowest LSE Total Fees Used: 0.20 bps Lowest TQ Total Fees Used: 0.02 bps		
	Large	Small	Overall	Large	Small	Overall
BXE						
Event	0.0099***	0.0130***	0.0120***	0.0173***	0.0253***	0.0221***
(t-statistic)	(12.42)	(9.48)	(14.11)	(12.30)	(9.21)	(13.15)
CXE						
Event	0.0373***	0.0107***	0.0254***	0.0645***	0.0189***	0.0445***
(t-statistic)	(22.53)	(7.66)	(14.17)	(22.72)	(6.94)	(13.63)
TQ						
Event	0.0064***	-0.0032***	0.0024**	0.0012***	-0.0011***	0.0002
(t-statistic)	(4.47)	(-3.09)	(2.09)	(3.59)	(-4.03)	(0.70)
LSE						
Event	-0.0536***	-0.0205***	-0.0401***	-0.0823***	-0.0431***	-0.0674***
(t-statistic)	(-16.93)	(-8.36)	(-15.76)	(-19.93)	(-11.16)	(-17.99)

Table 11: **Measures of Market Quality - Panel Regressions of the 2013 Event using LSE Sample as Control.**
The table reports the changes in market quality (Volume (log), Spread, Depth (log), and Market Share) using panel difference-in-difference regressions for the 2013 event using a one-month pre- and one-month post-event window. We investigate four market venues (treatment group): BATS (BXE), Chi-X (CXE) and Turquoise (TQ). For our control group we use the LSE. To measure the change in market quality for each of the market venues, we follow the standard difference-in-difference specification as shown in equation 4. The interaction variable event*treatment indicates the post-event period effect for our treatment group. Since we expect indirect effects on the LSE market due to intermarket competition, and following Boehmer et al. (2020) we also report the joint direct and indirect effects (event+event*treatment). We run regressions for the overall sample and two subsamples of the highest (Large) and lowest (Small) market capitalization terciles. Each Panel reports estimated coefficients and t-statistics (in parentheses) for each for the three venues (BXE, CXE, and TQ). For all specifications, we employ clustered standard errors by firm times date. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Panel A: 2013 Event for LSE sample – Panel Difference-in-difference Regressions for BXE (using LSE market as control)

	Volume (Log)			Spread			Depth (Log)			Market Share		
	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall
Intercept	15.1447***	12.6536***	13.7196***	0.8924***	2.0417***	1.6542***	8.8244***	7.7179***	8.1044***	0.6202***	0.7630***	0.6832***
(t-statistic)	(317.50)	(243.73)	(376.07)	(30.23)	(20.42)	(21.43)	(230.59)	(163.17)	(309.20)	(272.41)	(157.56)	(271.04)
Post	0.0327	0.1256*	0.0604	0.0074	0.0333	0.0025	0.0016	0.0559	0.0164	-0.0219***	0.0016	-0.0136***
(t-statistic)	(0.49)	(1.67)	(1.18)	(0.18)	(0.24)	(0.02)	(0.03)	(0.86)	(0.45)	(-7.34)	(0.25)	(-3.83)
Treatment	-2.2600***	-3.2014***	-2.6506***	0.0722***	1.9201***	1.0744***	-1.3674***	-1.0182***	-1.1719***	-0.5541***	-0.7086***	-0.6219***
(t-statistic)	(-159.12)	(-47.25)	(-99.28)	(6.36)	(12.64)	(11.45)	(-57.55)	(-50.07)	(-92.51)	(-194.17)	(-117.98)	(-206.37)
Post*Treatment	0.0639***	0.3743***	0.2105***	0.0264*	-0.5563***	-0.1530	-0.1009	-0.0356	-0.0560***	0.0236***	0.0134	0.0225***
(t-statistic)	(3.46)	(4.29)	(6.18)	(1.78)	(-2.98)	(-1.04)	(-3.37)	(-1.27)	(-2.82)	(6.63)	(1.59)	(5.33)
Option Exp. Date Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Adding the indirect and direct treatment effects:												
Post+Post*Treatment	0.0966	0.4990***	0.2709***	0.0338	-0.5230*	-0.1505	-0.0993**	0.0203	-0.0396	0.0017	0.0151***	0.0089***
(t-statistic)	(1.44)	(4.49)	(4.25)	(0.76)	(-1.85)	(-0.69)	(-1.99)	(0.37)	(-1.30)	(1.54)	(6.47)	(8.35)

Panel B: 2013 Event for LSE sample – Panel Difference-in-difference Regressions for CXE (using LSE market as control)

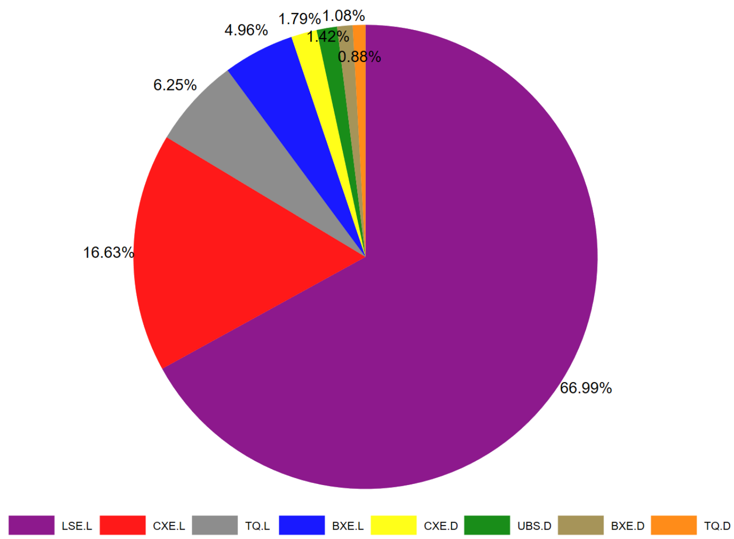
	Volume (Log)			Spread			Depth (Log)			Market Share		
	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall
Intercept	15.1416***	12.6700***	13.7249***	0.8941***	2.0334***	1.6523***	8.8231***	7.7184***	8.1046***	0.6210***	0.7639***	0.6839***
(t-statistic)	(318.01)	(241.83)	(374.38)	(30.50)	(20.20)	(21.61)	(230.88)	(163.03)	(308.13)	(270.40)	(158.15)	(271.67)
Post	0.0349	0.1168	0.0579	0.0073	0.0493	0.0059	0.0031	0.0550	0.0167	-0.0221***	0.0013	-0.0139***
(t-statistic)	(0.52)	(1.54)	(1.13)	(0.18)	(0.35)	(0.11)	(0.06)	(0.85)	(0.46)	(-7.37)	(0.19)	(-3.92)
Treatment	-0.9166***	-2.3926***	-1.5656***	-0.1293***	1.5882***	0.6804***	-0.3461***	-0.9147***	-0.6156***	-0.3700***	-0.6508***	-0.5005***
(t-statistic)	(-88.53)	(-44.23)	(-65.01)	(-14.51)	(7.87)	(7.27)	(-17.08)	(-43.66)	(-49.87)	(-96.24)	(-88.61)	(-119.22)
Post*Treatment	0.0578***	-0.0640	0.0153	0.0086	0.1384	0.1161	-0.0299	-0.0427	-0.0269	0.0272***	-0.0106	0.0136**
(t-statistic)	(4.22)	(-0.85)	(0.45)	(0.71)	(0.46)	(0.75)	(-1.05)	(-1.41)	(-1.57)	(5.37)	(-1.05)	(2.30)
Option Exp. Date Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Adding the indirect and direct treatment effects:												
Post+Post*Treatment	0.0927	0.0527	0.0732	0.0159	0.1876	0.1219	-0.0267	0.0123	-0.0102	0.0051**	-0.0093**	-0.0003
(t-statistic)	(1.46)	(0.46)	(1.05)	(0.47)	(0.49)	(0.57)	(-0.57)	(0.22)	(-0.28)	(2.22)	(-2.52)	(-0.10)

Panel C: 2013 Event for LSE sample – Panel Difference-in-difference Regressions for TQ (using LSE market as control)

	Volume (Log)			Spread			Depth (Log)			Market Share		
	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall	Large	Small	Overall
Intercept	15.1451***	12.6677***	13.7257***	0.8926***	2.0215***	1.6468***	8.8243***	7.7187***	8.1049***	0.6202***	0.7634***	0.6834***
(t-statistic)	(317.31)	(243.60)	(376.99)	(30.32)	(20.44)	(21.48)	(230.55)	(163.22)	(309.08)	(272.60)	(157.63)	(270.86)
Post	0.0322	0.1194	0.0571	0.0080	0.0423	0.0077	0.0021	0.0543	0.0164	-0.0218***	0.0016	-0.0135***
(t-statistic)	(0.48)	(1.58)	(1.12)	(0.20)	(0.30)	(0.07)	(0.04)	(0.84)	(0.45)	(-7.31)	(0.25)	(-3.81)
Treatment	-2.4293***	-2.8329***	-2.5056***	0.0116	1.3300***	0.7231***	-1.4109***	-1.1073***	-1.1972***	-0.5636***	-0.6990***	-0.6165***
(t-statistic)	(-154.99)	(-55.62)	(-119.48)	(1.56)	(13.38)	(9.28)	(-60.95)	(-56.61)	(-102.85)	(-197.27)	(-113.87)	(-203.06)
Post*Treatment	0.2379***	-0.1152	0.0439	-0.0254**	-0.0686	0.0410	0.2382***	-0.0869***	0.0633***	0.0389***	-0.0053	0.0211***
(t-statistic)	(6.30)	(-1.55)	(1.24)	(-2.44)	(-0.49)	(0.30)	(7.71)	(-3.04)	(3.91)	(10.28)	(-0.63)	(4.90)
Option Exp. Date Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Adding the indirect and direct treatment effects:												
Post+Post*Treatment	0.2701***	0.0042	0.1010	-0.0174	-0.0262	0.0487	0.2403***	-0.0326	0.0797**	0.0170***	-0.0037*	0.0075***
(t-statistic)	(3.60)	(0.04)	(1.60)	(-0.45)	(0.23)	(0.24)	(4.82)	(-0.61)	(2.55)	(13.09)	(-1.68)	(6.55)

Figure 1: **Market Share Pie-Charts of the LSE sample in 2012 (Pre-Event) and 2015 (Post-Event)** The pie-chart figures show average daily market share of each market venue used in the analysis for the LSE sample in the pre-period of the 2013 event (November and December 2012) and in the period after fee change in January 2015 (February and March 2015). In particular, we look at both lit markets (LSE.L, CXE.L, BXE.L, and TQ.L) and dark pool venues (CXE.D, BXE.D, TQ.D, and UBS.D) market share. We exclude other trading venues and off-market trades for the pie-charts. Market share data were collected from Fidessa (Fragulator).

(a) 2013 Event Pre-Period (November and December 2012)



(b) 2015 Event Post-Period (February and March 2015)

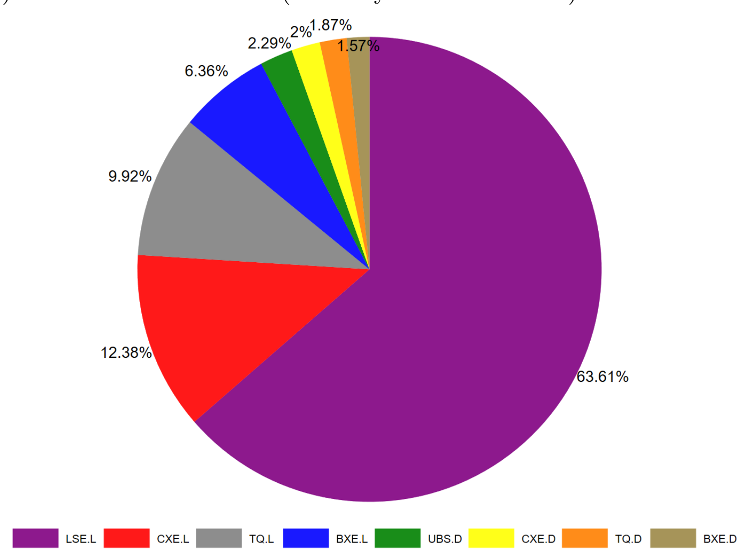
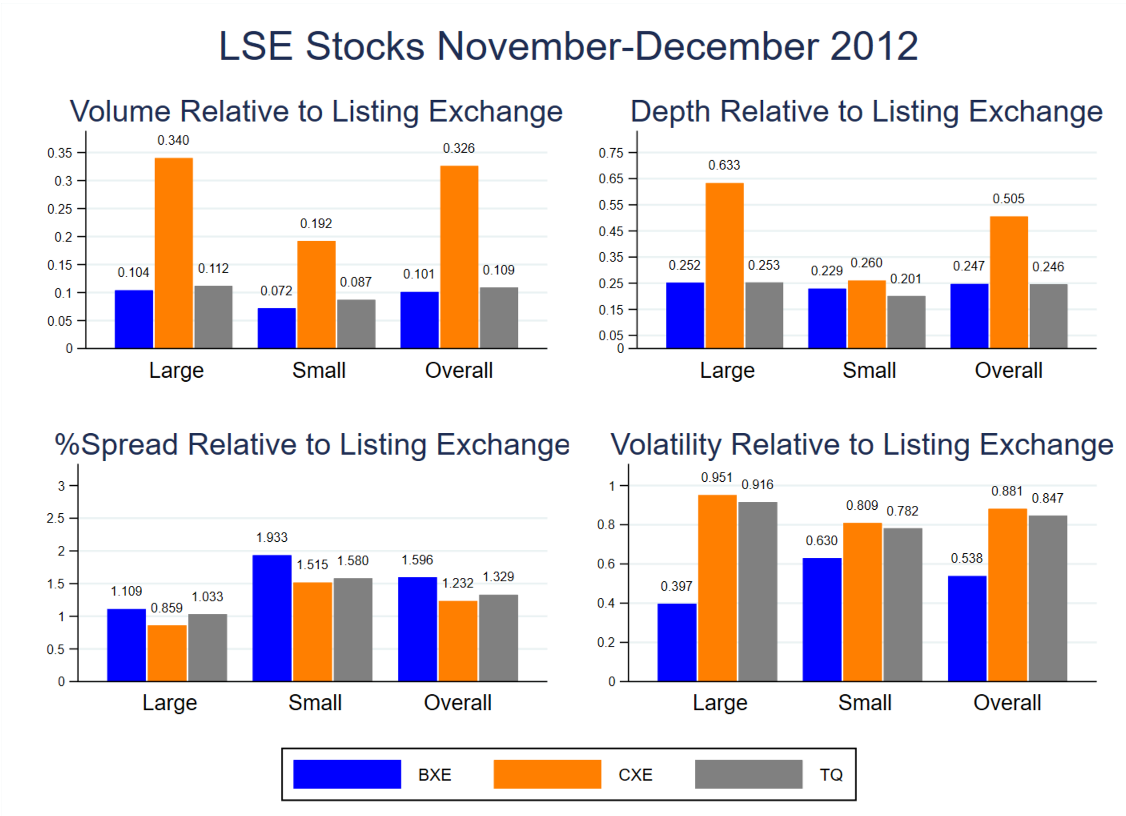


Figure 2: **Market Quality Measures across Markets**
The figure show average daily market quality measures (Volume, Depth, %Spread, and Volatility) of the three market venues (BXE, CXE, TQ) relative to the listing exchange (LSE) in the pre-period (Nov/Dec 2012) of the 2013 Event. It depicts relative market quality measures for the overall sample and two sub-samples of the highest (Large) and lowest (Small) market capitalization terciles. Filled bars indicate that a venue mean is significantly different from the listing exchange mean based on a simple differences-in-group-means test.



Internet Appendix

Model Solution

At each period t_z, a trader uses the information from the state of the book of both the primary and the competing market to rationally compute and compare the payoffs from the available strategies (Table 1). However, to compare the payoffs across these strategies, the trader has to compute the execution probabilities of limit orders, which are uncertain as they depend on the probability of the t_{z+1} (and possibly t_{z+2}) market order submissions. To overcome this issue, the model is solved by backward induction starting from the last period of the trading game, t_3. At t_3 the execution probabilities of limit orders, $LO_{t_3}(P_i^j)$, are equal to zero and therefore to choose the order submission strategy ($ST^*_{t_3}$) that maximizes the expected payoff ($\pi^e_{t_3}$) conditional on their personal evaluation of the asset, γ, traders solve problem (5) by choosing between market orders, $MO_{t_3}(P_i^{j,b})$, and no-trade $NT_{t_3}(0))$:

$$max_{ST^*_{t_3}} \pi^e_{t_3} \left\{ MO_{t_3}(P_i^{j,b}),\, NT_{t_3}(0) \mid \gamma,\, lob^j_{t_3} \right\} \tag{5}$$

Table 1 shows that the non-zero traders' payoffs are a function of $\gamma \in (\overline{\gamma}, \underline{\gamma})$. We can therefore rank the payoffs of adjacent optimal strategies in terms of γ and equate them to determine the t_3 equilibrium γ thresholds in the following way:

$$\gamma_{t_3}^{ST^*_n, ST^*_{n-1}} = \left\{ \gamma \in \mathbb{R} \,:\, \pi^e_{t_3}\left(ST^*_n \,|\, lob^j_{t_3}\right) - \pi^e_{t_3}\left(ST^*_{n-1} \,|\, lob^j_{t_3}\right) = 0 \right\} \tag{6}$$

By using the γ thresholds together with the cumulative distribution function (CDF) of γ, $F(\cdot)$, we can now derive the probability of each equilibrium order submission strategy, $ST^*_{\cdot}$, conditional on all the possible combinations of the t_3 states of the book:

$$Pr[ST^*_n \,|\, lob^j_{t_3}] = F(\gamma_{t_3}^{ST^*_{n+1}, ST^*_n} \,|\, lob^j_{t_3}) - F(\gamma_{t_3}^{ST^*_n, ST^*_{n-1}} \,|\, lob^j_{t_3}) \tag{7}$$

Clearly, the probability to observe a $MO_{t_3}(P_i^{j,b})$ at t_3 is the execution probability of a $LO_{t_2}(P_i^j)$ at t_2, therefore, we can now compute and compare the t_2 payoffs to determine the equilibrium γ thresholds and therefore the equilibrium order submission probabilities conditional on each possible combination of the states of the book in the two markets at t_2. The t_1 equilibrium order submission strategies can then be recursively obtained, as the t_2 market orders' equilibrium probabilities are the execution probabilities of the limit orders posted at t_1.

As a general example, consider a case at t_3 with the book that opens empty and with one sell order standing on the first level of the competing market and one buy order standing on the second level of the primary market. This means that the payoffs from the t_3 strategies are:

$$\begin{aligned}\pi^e_{t_3}(MO_{t_3}(S^C_1)\,|\,lob^j_{t_3}) &= \gamma AV - S^C_1 - tf\\ \pi^e_{t_3}(NT_{t_3}(0)\,|\,lob^j_{t_3}) &= 0\\ \pi^e_{t_3}(MO_{t_3}(B^P_2)\,|\,lob^j_{t_3}) &= B^P_2 - \gamma AV - TF\end{aligned} \tag{8}$$

Hence the t_3 equilibrium strategies are:

$$ST^*_{(\cdot)} = \begin{cases} MO_{t_3}(S^C_1) & \text{if } \gamma \in [\underline{\gamma},\, \frac{S^C_1 - tf}{AV}) \\ NT_{t_3}(0) & \text{if } \gamma \in [\frac{S^C_1 - tf}{AV},\, \frac{B^P_2 + TF}{AV}) \\ MO_{t_3}(B^P_2) & \text{if } \gamma \in (\frac{B^P_2 + TF}{AV},\, \overline{\gamma}] \end{cases} \tag{9}$$

and the t_3 equilibrium order submission probabilities are:

$$Pr[ST^*_{(\cdot)}\,|\,lob^j_{t_3}] = \begin{cases} \int_{\gamma \in \left\{\gamma\,:\,ST^*_{(\cdot)} = MO_{t_3}(1, S^C_1)\right\}} g(\gamma)\, d\gamma \\ \int_{\gamma \in \left\{\gamma\,:\,ST^*_{(\cdot)} = NT_{t_3}(0)\right\}} g(\gamma)\, d\gamma \\ \int_{\gamma \in \left\{\gamma\,:\,ST^*_{(\cdot)} = MO_{t_3}(1, B^P_2)\right\}} g(\gamma)\, d\gamma \end{cases} \tag{10}$$

where $g(\gamma)$ is the probability density function (PDF) of γ.
Note that $Pr[MO_{t_3}(S^C_1)\,|\,lob^j_{t_3}]$ and $Pr[MO_{t_3}(B^P_2)\,|\,lob^j_{t_3}]$ correspond to the execution probabilities of the previous period (t_2) limit orders respectively posted to the competing and to the primary market, i.e., $[LO_{t_2}(S^C_1)\,|\,lob^j_{t_2}]$ and $[LO_{t_2}(B^P_2)\,|\,lob^j_{t_2}]$, which are the dynamic link between periods t_3 and t_2.

As an example, we now solve the model to obtain the results shown in Table 4 for one set of trading fees: $MF = -0.001$ and $TF = 0.001$ and $mf = tf = 0.0$. Results for the other sets of fees can be obtained in a similar way. Tables A1, A2 and A3 show the equilibrium strategies (column 1) at t_3, t_2 and t_1 respectively for all the possible states of the book starting from an empty book at t_1. Each table also shows the payoff associated to each equilibrium strategy (column 2), the γ thresholds indicating the corresponding support of the TN distribution for each equilibrium strategy (column 3), and the resulting submission probabilities (column 4).[46]

The model is solved by backward induction, so as an example, following the branch of the trading game that starts at t_1 with $LO_{t_1}(S^C_1)$, the book opens at t_2 as [0000-0100].[47] Given the three equilibrium strategies that result when we condition to this opening book at t_2, $[NT_{t_2}(0)$, $LO_{t_2}(B^P_2)$ and $MO(S^C_1)]$, at t_3 the book may open with three different states, [0000-0100], [0001-0100], and [0000-0000], respectively. The last column of each table shows the submission probability of the equilibrium orders which are then used to compute both the metrics of order flows (average limit orders, LO^j, and average market share MS^j), and

[46] The γ thresholds indicate the optimal trading strategies that result from comparing the payoffs of all the possible orders a trader can choose conditional on each state of the book in any trading period (equation 6).

[47] [0000-0100] indicates the state of the primary and of the competing market respectively, $[l^{S^P_2}\, l^{S^P_1}\, l^{B^P_1}\, l^{B^P_2} - l^{S^C_2}\, l^{S^C_1}\, l^{B^C_1}\, l^{B^C_2}]$.

the metrics of market quality, (average quoted spread, $Spread^j$ and average depth at the best bid-offer, $BBODepth^j$), shown in Table 4 for the above mentioned set of trading fees: $MF = -0.001$ and $TF = 0.001$ and $mf = tf = 0.0$. Finally, Tables A4 and A5 show how to obtain both the order flows and the market quality metrics for this set of fees, starting from the equilibrium order submission strategies. Therefore, Tables A4 and A5 link Tables A1, A2 and A3 with Table 2.[48] Results for different sets of fees can be obtained in a similar way.

[Insert Tables A1, A2, A3, A4 and A5 about here]

Figures Competing Market

[Insert Tables A6, A7, A8 and A9 about here]

Appendix 2: ASX Sample Descriptive Statistics

[Insert Table A10 about here]

[48]Results for average values reported in Tables A4 and A5 have been obtained by rounding at the fourth decimal value and they may slightly differ from the results reported in column 3 of Table 4 which have been obtained without any rounding.

Table A1: **Equilibrium Strategies at t_3** This table shows how to derive the equilibrium order submission strategies at t_3 of the 3-period model - for the following set of trading fees: $MF = -0.001$ and $TF = 0.001$ and $mf = tf = 0.0$ and for $\gamma \in ([0.0, 2.0]$. At t_1 both the primary and the competing markets open with an empty book, [0000-0000], where each element in the square bracket, $l_{t_z}^{S_i^j}$, corresponds to the depth of the book at each price level of both the primary and the competing market at time t_z, $[l^{S_2^{Prim}} l^{S_1^{Prim}} l^{B_1^{Prim}} l^{B_2^{Prm}} - l^{S_2^{Comp}} l^{S_1^{Comp}} l^{B_1^{Comp}} l^{B_2^{Comp}}]_{t_z}$. Given the chosen set of fees, four are the equilibrium strategies at t_1, $LO_{t_1}(S_1^{Comp})$, $LO_{t_1}(S_2^{Prim})$, $LO_{t_1}(B_1^{Comp})$ and $LO_{t_1}(B_2^{Prim})$. We only consider the sell side of the market, the buy side being symmetrical. Given the equilibrium limit sell orders, the possible states of the books at the beginning of t_2 are: [0000-0100] and [1000-0000]. Given the equilibrium strategies at t_2 and therefore the possible states of the books at the beginning of t_3, this table shows the equilibrium Strategies at t_3 (column 1), their payoffs (column 2), the γ thresholds (column 3) and the order submission probabilities (column 4).

Equilibrium Strategy	Payoff	γ Threshold	Order Submission Probability
at t_1 Prim and Comp books open empty [0000-0000]: equilibrium strategy $LO_{t_1}(S_1^{Comp})$			
at t_2 Prim and Comp books open [0000-0100]			
	t_2 **equilibrium strategy** NT_{t_2}		
at t_3 Prim and Comp books open [0000-0100]			
$NT_{t_3}(0)$	0	$\{0.0000, 1.0050\}$	0.5025
$MO_{t_3}(S_1^{Comp})$	$\gamma AV - S_1^{Comp} - tf = \gamma - 1.0050$	$\{1.0050, 2.0000\}$	0.4975
	t_2 **equilibrium strategy** $LO_{t_2}(B_2^{Prim})$		
at t_3 Prim and Comp books open [0001-0100]			
$MO_{t_3}(B_2^{Prim})$	$B_2^{Prim} - \gamma AV - TF = 0.9840 - \gamma$	$\{0.0000, 0.9840\}$	0.4920
$NT_{t_3}(0)$	0	$\{0.9840, 1.0050\}$	0.0105
$MO_{t_3}(S_1^{Comp})$	$\gamma AV - S_1^{Comp} - tf = \gamma - 1.0050$	$\{1.0050, 2.0000\}$	0.4975
	t_2 **equilibrium strategy** $MO_{t_2}(S_1^{Comp})$		
at t_3 Prim and Comp books open [0000-0000]			
$NT_{t_3}(0)$	0	$\{0.0000, 2.0000\}$	1.0000
at t_1 Prim and Comp books open empty [0000-0000]: equilibrium strategy $LO_{t_1}(S_2^{Prim})$			
at t_2 Prim and Comp books open [1000-0000]			
	t_2 **equilibrium strategy** $LO_{t_2}(S_1^{Comp})$		
at t_3 Prim and Comp books open [1000-0100]			
$NT_{t_3}(0)$	0	$\{0.0000, 1.0050\}$	0.5025
$MO_{t_3}(S_1^{Comp})$	$\gamma AV - S_1^{Comp} - tf = \gamma - 1.0050$	$\{1.0050, 2.0000\}$	0.4975
	at t_2 equilibrium strategy $LO_{t_2}(S_1^{Prim})$		
at t_3 Prim and Comp books open [1100-0000]			
$NT_{t_3}(0)$	0	$\{0.0000, 1.0060\}$	0.5030
$MO_{t_3}(S_1^{Prim})$	$\gamma AV - S_1^{Prim} - TF = \gamma - 1.0060$	$\{1.0060, 2.0000\}$	0.4970
	at t_2 equilibrium strategy $LO_{t_2}(S_2^{Comp})$		
at t_3 Prim and Comp books open [1000-1000]			
$NT_{t_3}(0)$	0	$\{0.0000, 1.0150\}$	0.5075
$MO_{t_3}(S_2^{Comp})$	$\gamma AV - S_2^{Comp} - tf = \gamma - 1.0150$	$\{1.0150, 2.0000\}$	0.4925
	at t_2 equilibrium strategy $LO_{t_2}(B_2^{Prim})$		
at t_3 Prim and Comp books open [1001-0000]			
$MO_{t_3}(B_2^{Prim})$	$B_2^{Prim} - \gamma AV - TF = 0.9840 - \gamma$	$\{0.0000, 0.9840\}$	0.4920
$NT_{t_3}(0)$	0	$\{0.9840, 1.0160\}$	0.0160
$MO_{t_3}(S_2^{Prim})$	$\gamma AV - S_2^{Prim} - TF = \gamma - 1.0160$	$\{1.0160, 2.0000\}$	0.4920
	at t_2 equilibrium strategy $MO_{t_2}(S_2^{Prim})$		
at t_3 Prim and Comp books open [0000-0000]			
$NT_{t_3}(0)$	0	$\{0.0000, 2.0000\}$	1.0000

Table A2: **Equilibrium Strategies at** t_2 This table shows how to derive the equilibrium order submission strategies at t_2 of the 3-period model - for the following set of trading fees: $MF = -0.001, TF = 0.001$ and $mf = tf = 0.0$ and for $\gamma \in [0.0, 2.0]$. At t_1 both the primary and the competing markets open with an empty book, [0000-0000], where each element in the square bracket, $l_{t_z}^{S_i^j}$, corresponds to the depth of the book at each price level of both the primary and the competing market at time t_z, $[l^{S_2^{Prim}} l^{S_1^{Prim}} l^{B_1^{Prim}} l^{B_2^{rim}} - l^{S_2^{Comp}} l^{S_1^{Comp}} l^{B_1^{Comp}} l^{B_2^{Comp}}]_{t_z}$. Given the chosen set of fees, four are the equilibrium strategies at t_1, $LO_{t_1}(S_1^{Comp})$, $LO_{t_1}(S_2^{Prim})$,$LO_{t_1}(B_1^{Comp})$ and $LO_{t_1}(B_2^{Prim})$. We only consider the sell side of the market, the buy side being symmetrical. Given the equilibrium limit sell orders, the possible states of the books at the beginning of t_2 are: [0000-0100] and [1000-0000]. Column 1 shows the Equilibrium strategies at t_2, column 2 shows their payoffs, and columns 3 and 4 shows the γ thresholds and the order submission probabilities respectively.

Equilibrium Strategy	**Payoff**	**γ Threshold**	**Order Submission Probability**
	at t_1 Prim and Comp books open empty [0000-0000]: equilibrium strategy $LO_{t_1}(S_1^{Comp})$		
at t_2 Prim and Comp books open [0000-0100]			
$NT_{t_2}(0)$	0	$\{0.0000, 0.9840\}$	0.4920
$LO_{t_2}(B_2^{Prim})$	$(\gamma AV - B_2^{Prim} - MF) \times Pr(MO_{t_3}(B_2^{Prim}) \mid [0001-0100]) = -0.4841 + 0.4920\gamma$	$\{0.9840, 1.0253\}$	0.0207
$MO_{t_2}(S_1^{Comp})$	$\gamma AV - S_1^{Comp} - tf = -1.005 + \gamma$	$\{1.0253, 2.0000\}$	0.4873
	at t_1 Prim and Comp books open empty [0000-0000]: equilibrium strategy $LO_{t_1}(S_2^{Prim})$		
at t_2 Prim and Comp books open [1000-0000]			
$LO_{t_2}(S_1^{Comp})$	$(S_1^{Comp} - \gamma AV - mf) \times Pr(MO_{t_3}(S_1^{Comp}) \mid [1000-0100]) = 0.49998 - 0.4975\gamma$	$\{0.0000, 0.0110\}$	0.0055
$LO_{t_2}(S_1^{Prim})$	$(S_1^{Prim} - \gamma AV - MF) \times Pr(MO_{t_3}(S_1^{Prim}) \mid [1100-0000]) = 0.49998 - 0.4970\gamma$	$\{0.0110, 0.0210\}$	0.0050
$LO_{t_2}(S_2^{Comp})$	$(S_2^{Comp} - \gamma AV - mf) \times Pr(MO_{t_3}(S_2^{Comp}) \mid [1000-1000]) = 0.49989 - 0.4925\gamma$	$\{0.0210, 0.9995\}$	0.4893
$LO_{t_2}(B_2^{Prim})$	$(\gamma AV - B_2^{Comp} - MF) \times Pr(MO_{t_3}(B_2^{Prim}) \mid [1001-0000]) = -0.48413 + 0.4920\gamma$	$\{0.9995, 1.0470\}$	0.0237
$MO_{t_2}(S_2^{Prim})$	$\gamma AV - S_2^{Prim} - TF = -1.016 + \gamma$	$\{1.0470, 2.0000\}$	0.4765

Table A3: **Equilibrium Strategies at** t_1 This table shows how to derive the equilibrium order submission strategies at t_1 - of the 3-period model - for the following set of trading fees: $MF = -0.001, TF = 0.001$ and $mf = tf = 0.0$ and for $\gamma \in [0.0, 2.0]$. At t_1 both the primary and the competing markets open with an empty book, [0000-0000], where each element in the square bracket, $l_t^{S_i^j}$, corresponds to the depth of the book at each price level of both the primary and the competing market at time t_z, $[l^{S_2^{Prim}} l^{S_1^{Prim}} l^{B_1^{Prim}} l^{B_2^{Prim}} - l^{S_2^{Comp}} l^{S_1^{Comp}} l^{B_1^{Comp}} l^{B_2^{Comp}}]_{t_z}$. Given the chosen set of fees, four are the equilibrium strategies at t_1, $LO_{t_1}(S_1^{Comp})$, $LO_{t_1}(S_2^{Prim})$, $LO_{t_1}(B_1^{Comp})$ and $LO_{t_1}(B_2^{Prim})$ which are shown in column 1. Column 2 shows their payoffs, and column 3 and 4 shows the γ thresholds and the order submission probabilities respectively.

Equilibrium Strategy	**Payoff**	**γ Threshold**	**Order Submission Probability**
	at t_1 Prim and Comp books open empty [0000-0000]		
$LO_{t_1}(S_1^{Comp})$	$(S_1^{Comp} - \gamma AV - mf) \times [(Pr(MO_{t_2}(S_1^{Comp}) \mid [0000-0100]) + +(1 - Pr(MO_{t_2}(S_1^{Comp}) \mid [0000-0100])) \times Pr(MO_{t_3}(S_1^{Comp}) \mid [0000-0100]))] = 0.7461 - 0.7424\gamma$	$\{0.0000, 0.9839\}$	0.4919
$LO_{t_1}(S_2^{Prim})$	$(S_2^{Prim} - \gamma AV - MF) \times [(Pr(MO_{t_2}(S_2^{Prim}) \mid [1000-0000]) + (1 - Pr(MO_{t_2}(S_2^{Prim}) \mid [1000-0000]) - Pr(LO_{t_2}(S_1^{Prim}) \mid [1000-0000]) - Pr(LO_{t_2}(S_1^{Comp}) \mid [1000-0000])) \times Pr(MO_{t_3}(S_2^{Prim}) \mid [1000-0000]))] = 0.4960 - 0.4882\gamma$	$\{0.9839, 1.0000\}$	0.0081
$LO_{t_1}(B_2^{Prim})$	$(\gamma AV - B_2^{Prim} - MF) \times [(Pr(MO_{t_2}(B_2^{Prim}) \mid [0001-0000]) + (1 - Pr(MO_{t_2}(B_2^{Prim}) \mid [0001-0000]) - Pr(LO_{t_2}(B_1^{Prim}) \mid [0001-0000]) - Pr(LO_{t_2}(B_1^{Comp}) \mid [0001-0000])) \times Pr(MO_{t_3}(B_2^{Prim}) \mid [0001-0000]))] = -0.4804 + 0.4882\gamma$	$\{1.0000, 1.0161\}$	0.0081
$LO_{t_1}(B_1^{Comp})$	$(\gamma AV - B_1^{Comp} - mf) \times [(Pr(MO_{t_2}(B_1^{Comp}) \mid [0000-0010]) + +(1 - Pr(MO_{t_2}(B_1^{Comp}) \mid [0000-0010])) \times Pr(MO_{t_3}(B_1^{Comp}) \mid [0000-0010]))] = -0.7387 + 0.7424\gamma$	$\{1.0161, 2.0000\}$	0.4919

Table A4: **Equilibrium Order Submission Strategies, Order Flows and Market Quality** This Table shows how to obtain the metrics on order flows and market quality (column 1) presented in Tables 2 and A6 for the following set of trading fees: $MF = -0.001, TF = 0.001$ and $mf = tf = 0.0$. Column 2 reports the equilibrium order submission probability of limit and market orders in the primary and in the competing market in each period t_z, $LO^j_{t_z}$ and $MO^j_{t_z}$, and the equilibrium average of limit orders, market orders and market share, LO^j, MO^j and MS^j. Column 3 shows how the values reported in column 2 are computed from the equilibrium strategies. Results are reported for both the primary (Prim) and the competing (Comp) market. Traders have a personal evaluation of the asset which is a Uniform distribution, $\gamma \sim U[\overline{\gamma}, \underline{\gamma}]$ with $S = [0, 2]$ and $AV = 1$.

Metric	Value	Analytical Computation
$LO^{Prim}_{t_1}$	0.0162	$Pr(LO_{t_1}(S^{Prim}_2)\|.)) + Pr(LO_{t_1}(B^{Prim}_2)\|.)) = 0.0081 + 0.0081$
$LO^{Prim}_{t_2}$	0.0208	$(2 \times Pr(LO_{t_1}(S^{Comp}_1)\|.)) \times Pr(LO_{t_2}(B^{Prim}_2)\|0000-0100) + (2 \times Pr(LO_{t_1}(S^{Prim}_2)\|.)) \times (Pr(LO_{t_2}(S^{Prim}_1)\|1000-0000) + Pr(LO_{t_2}(B^{Prim}_2)\|1000-0000)$ $= (2 \times 0.4919) \times 0.0207 + (2 \times 0.0081) \times (0.0050 + 0.0237)$
LO^{Prim}	0.0185	$(LO^{Prim}t_1 + LO^{Prim}t_2)/2 = (0.0162 + 0.0208)/2$
$MO^{Prim}_{t_2}$	0.0077	$2 \times Pr(LO_{t_1}(S^{Prim}_2)\|.) \times Pr(MO_{t_2}(S^{Prim}_2)\|1000-0000) = 2 \times 0.0081 \times 0.4765$
$MO^{Prim}_{t_3}$	0.0104	$(2 \times Pr(LO_{t_1}(S^{Prim}_2)\|.) \times (Pr(LO_{t_2}(S^{Prim}_1)\|1000-0000) \times Pr(MO_{t_3}(S^{Prim}_1)\|1100-0000) + Pr(LO_{t_2}(B^{Prim}_2)\|1001-0000)$ $\times(Pr(MO_{t_3}(S^{Prim}_2)\|1001-0000) + Pr(MO_{t_3}(B^{Prim}_2)\|1001-0000))) + (2 \times Pr(LO_{t_1}(S^{Comp}_1)\|.))$ $\times Pr(LO_{t_2}(B^{Prim}_2)\|0000-0100) \times Pr(MO_{t_3}(B^{Prim}_2)\|0001-0100))$ $= 2 \times 0.0081 \times (0.0050 \times 0.4970 + 0.0237 \times (0.492 + 0.492)) + 2 \times 0.4919 \times 0.0207 \times 0.4920$
MO^{Prim}	0.0091	$(MO^{Prim}_{t_2} + MO^{Prim}_{t_3})/2 = (0.0077 + 0.0104)/2$
MS^{Prim}	0.0242	$MO^{Prim}/(MO^{Prim} + MO^{Comp}) = 0.0091/(0.0091 + 0.3671)$
$LO^{Comp}_{t_1}$	0.9838	$(Pr(LO_{t_1}(S^{Comp}_1)\|.) + Pr(LO_{t_1}(B^{Comp}_1)\|.)) = (0.4919 + 0.4919)$
$LO^{Comp}_{t_2}$	0.0080	$(2 \times Pr(LO_{t_1}(S^{Comp}_1)\|.)) \times 0 + (2 \times Pr(LO_{t_1}(S^{Prim}_2)\|.)) \times (Pr(LO_{t_2}(S^{Comp}_1)\|0000-0100) + Pr(LO_{t_2}(S^{Comp}_2)\|0000-0100)) =$ $= (2 \times 0.4919) \times 0 + (2 \times 0.0081) \times (0.0055 + 0.4893)$
LO^{Comp}	0.4959	$(LO^{Comp}_{t_1} + LO^{Comp}_{t_2})/2 = (0.9838 + 0.0080)/2$
$MO^{Comp}_{t_2}$	0.4794	$(2 \times Pr(LO_{t_1}(S^{Comp}_1)\|.)) \times Pr(MO_{t_2}(S^{Comp}_1)\|0000-0100) + (2 \times Pr(LO_{t_1}(S^{Prim}_2)\|.)) \times 0=$ $= (2 \times 0.4919) \times 0.4873 + (2 \times 0.0081) \times 0$
$MO^{Comp}_{t_3}$	0.2548	$(2 \times Pr(LO_{t_1}(S^{Comp}_1)\|.))\times[(Pr(NT_{t_2}(0)\|0000-0100) + Pr(LO_{t_2}(S^{Prim}_2)\|0000-0100)) \times Pr(MO_{t_3}(S^{Comp}_1)\|0000-0100)] + 2 \times Pr(LO_{t_1}(S^{Prim}_2)\|.)$ $\times(Pr(LO_{t_2}(S^{Comp}_1)\|1000-0000) \times Pr(MO_{t_3}(S^{Comp}_1)\|1000-0100) + Pr(LO_{t_2}(S^{Comp}_2)\|1000-0000) \times Pr(MO_{t_3}(S^{Comp}_2)\|1000-1000) =$ $= 2 \times 0.4919 \times [(0.4920 + 0.0207) \times 0.4975] + (2 \times 0.0081) \times (0.0055 \times 0.4975 + 0.4893 \times 0.4925)$
MO^{Comp}	0.3671	$(MO^{Comp}_{t_2} + MO^{Comp}_{t_3})/2 = (0.4794 + 0.2548)/2$
MS^{Comp}	0.9758	$MO^{Comp}/(MO^{Prim} + MO^{Comp}) = 0.3671/(0.0091 + 0.3671)$

Table A5: **Equilibrium Order Submission Strategies, Order Flows and Market Quality**

This Table shows how to obtain the metrics on order flows and market quality (column 1) presented in in Tables 2 and A6 for the following set of trading fees: $MF = -0.001$, $TF = 0.001$ and $mf = tf = 0.0$. Column 2 reports both the equilibrium market quality metrics for periods t_1 and t_2, $Spread^j_{t_z}$ and $BBODepth^j_{t_z}$, and the equilibrium average market quality metrics, $Spread^j$ and $BBODepth^j$. Column 3 shows how the values reported in column 2 are computed from the equilibrium strategies. Results are reported for both the primary (Prim) and the competing (Comp) markets. Traders have a personal evaluation of the asset $\gamma \sim U[\underline{\gamma}, \overline{\gamma}]$, $S = [0, 2]$ and $AV = 1$. We assume that when the book is empty the quoted spread is equal to 5 ticks, i.e., 0.05. To economize space we indicate the empty book, $0000 - 0000$, as '|.'

Metric	Value	Analytical Computation
$Spread^{Prim}_{t_1}$	0.0498	$(2 \times Pr(LO_{t_1}(S_2^{Prim})\vert.)) \times 0.04 + (1 - 2 \times Pr(LO_{t_1}(S_2^{Prim})\vert.)) \times 0.05 = (2 \times 0.0081) \times 0.04 + (1 - 2 \times 0.0081) \times 0.05$
$Spread^{P}_{t_2}$	0.0497	$(2 \times Pr(LO_{t_1}(S_2^{Prim})\vert.)) \times [Pr(LO_{t_2}(S_1^{Prim}\vert 1000 - 0000) \times 0.03 + Pr(LO_{t_2}(B_2^{Prim}\vert 1000 - 0000) \times 0.03 + Pr(MO_{t_2}(S_2^{Prim}\vert 1000 - 0000) \times 0.05 + (1 - (Pr(LO_{t_2}(S_1^{Prim}\vert 1000 - 0000)+$
		$Pr(LO_{t_2}(B_2^{Prim}\vert 1000 - 0000) + Pr(MO_{t_2}(S_2^{Prim}\vert 1000 - 0000))) \times 0.04] + 2 \times Pr(LO_{t_2}(S_1^{Comp}\vert.) \times [Pr(LO_{t_2}(B_2^{Prim}\vert 0000 - 0100) \times 0.04 + (1 - Pr(LO_{t_2}(B_2^{Prim}\vert 0000 - 0100)) \times 0.05]$
		$= (2 \times 0.0081) \times [0.005 \times 0.03 + 0.0237 \times 0.03 + 0.4765 \times 0.05 + (1 - 0.005 - 0.0237 - 0.4765) \times 0.04] + (2 \times 0.4919) \times [0.0207 \times 0.04 + (1 - 0.0207) \times 0.05]$
$Spread^{Prim}$	0.0497	$(Spread^{Prim}_{t_1} + Spread^{Prim}_{t_2})/2 = (0.0498 + 0.0497)/2$
$Spread^{Comp}_{t_1}$	0.0303	$(2 \times Pr(LO_{t_1}(S_1^{Comp})\vert.)) \times 0.03 + (1 - 2 \times Pr(LO_{t_1}(S_1^{Comp})\vert.)) \times 0.05 = 2 \times 0.4919 \times 0.03 + (1 - 2 \times 0.4919) \times 0.05$
$Spread^{Comp}_{t_2}$	0.0398	$(2 \times Pr(LO_{t_1}(S_1^{Comp})\vert.)) \times [Pr(MO_{t_2}(S_1^{Comp})\vert 0000 - 0100) \times 0.05 + (1 - Pr(MO_{t_2}(S_1^{Comp})\vert 0000 - 0100)) \times 0.03] + (2 \times Pr(LO_{t_1}(S_2^{Prim})\vert.) \times [Pr(LO_{t_2}(S_1^{Comp})\vert 1000 - 0000) \times 0.03+$
		$Pr(LO_{t_2}(S_2^{Comp})\vert 1000 - 0000) \times 0.04 + (1 - Pr(LO_{t_2}(S_1^{Comp})\vert 1000 - 0000) - Pr(LO_{t_2}(S_2^{Comp})\vert 1000 - 0000)) \times 0.05]$
		$= (2 \times 0.4919) \times [0.4873 \times 0.05 + (1 - 0.4873) \times 0.03] + (2 \times 0.0081) \times [0.0055 \times 0.03 + 0.4893 \times 0.04 + (1 - 0.0055 - 0.4893) \times 0.05]$
$Spread^{Comp}$	0.0351	$(Spread^{Comp}_{t_1} + Spread^{Comp}_{t_2})/2 = (0.0303 + 0.0398)/2$
$BBODepth^{Prim}_{t_1}$	0.0162	$(2 \times Pr(LO_{t_1}(S_2^{Prim})\vert.)) \times 1 + (2 \times Pr(LO_{t_1}(S_1^{Comp})\vert.)) \times 0 = (2 \times 0.0081) \times 1 + (2 \times 0.4919) \times 0$
$BBODepth^{Prim}_{t_2}$	0.0292	$(2 \times Pr(LO_{t_1}(S_2^{Prim})\vert.)) \times [Pr(LO_{t_2}(S_1^{Prim}\vert 1000 - 0000) \times 1 + Pr(LO_{t_2}(B_2^{Prim}\vert 1000 - 0000) \times 2 + Pr(MO_{t_2}(S_2^{Prim}\vert 1000 - 0000) \times 0 + (1 - (Pr(LO_{t_2}(S_1^{Prim}\vert 1000 - 0000)+$
		$Pr(LO_{t_2}(B_2^{Prim}\vert 1000 - 0000) + Pr(MO_{t_2}(S_2^{Prim}\vert 1000 - 0000))) \times 1] + 2 \times Pr(LO_{t_2}(S_1^{Comp}\vert.) \times [Pr(LO_{t_2}(B_2^{Prim}\vert 0000 - 0100) \times 1 + (1 - Pr(LO_{t_2}(B_2^{Prim}\vert 0000 - 0100)) \times 0]$
		$= (2 \times 0.0081) \times [0.005 \times 1 + 0.0237 \times 2 + 0.4765 \times 0 + (1 - 0.005 - 0.0237 - 0.4765) \times 1] + (2 \times 0.4919) \times [0.0207 \times 1 + (1 - 0.0207) \times 0]$
$BBODepth^{Prim}$	0.0227	$(BBODepth^{Prim}_{t_1} + BBODepth^{Prim}_{t_2})/2 = (0.0162 + 0.0292)/2$
$BBODepth^{Comp}_{t_1}$	0.9838	$(2 \times Pr(LO_{t_1}(S_2^{Prim})\vert.)) \times 0 + (2 \times Pr(LO_{t_1}(S_1^{Comp})\vert.)) \times 1 = (2 \times 0.0081) \times 0 + (2 \times 0.4919) \times 1$
$BBODepth^{Comp}_{t_2}$	0.5124	$(2 \times Pr(LO_{t_1}(S_1^{Comp})\vert.)) \times [Pr(MO_{t_2}(S_1^{Comp})\vert 0000 - 0100) \times 0 + (1 - Pr(MO_{t_2}(S_1^{Comp})\vert 0000 - 0100)) \times 1] + (2 \times Pr(LO_{t_1}(S_2^{Prim})\vert.) \times [Pr(LO_{t_2}(S_1^{Comp})\vert 1000 - 0000) \times 1+$
		$Pr(LO_{t_2}(S_2^{Comp})\vert 1000 - 0000) \times 1 + (1 - Pr(LO_{t_2}(S_1^{Comp})\vert 1000 - 0000) - Pr(LO_{t_2}(S_2^{Comp})\vert 1000 - 0000)) \times 0]$
		$= (2 \times 0.4919) \times [0.4873 \times 0 + (1 - 0.4873) \times 1] + (2 \times 0.0081) \times [0.0055 \times 1 + 0.4893 \times 1 + (1 - 0.0055 - 0.4893) \times 0]$
$BBODepth^{Comp}$	0.7481	$(BBODepth^{Comp}_{t_1} + BBODepth^{Comp}_{t_2})/2 = (0.9838 + 0.5124)/2$

Table A6: **Equilibrium Order Submission Strategies and Market Quality in the Competing Market. Change in MF only - 3-period Model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the competing venue ($Comp$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.05, 1.95]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF, holding $TF = tf = mf = 0.00$, specifically: for $MF = 0.00$ (columns 2 and 7), for $MF = -0.001$ (columns 3 and 8), and for $MF = -0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001$ and $MF = -0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_3) and across all the periods of the trading game (With Period t_3). $AV = 1$ and $\tau = 0.01$.

Competing	**$S = [0, 2]$ 3 Periods**						**$S = [0.05, 1.95]$ 3 Periods**					
TF	**0.000**	**0.000**		**0.000**			**0.000**	**0.000**		**0.000**		
MF	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Comp}	0.3781	0.2399	-0.3657	0.2403	0.0004	0.0016	0.3783	0.2394	-0.3673	0.2398	0.0004	0.0017
$LO^{Comp}(S_2)$ $(LO^{Comp}(B_2))$	0.0062	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0065	0.0000	-1.0000	0.0000	0.0000	0.0000
$LO^{Comp}(S_1)$ $(LO^{Comp}(B_1))$	0.1829	0.1199	-0.3442	0.1201	0.0002	0.0016	0.1826	0.1197	-0.3447	0.1199	0.0002	0.0017
Without Period t_3												
MO^{Comp}	0.1219	0.0000	-1.0000	0.0000	0.0000	0.0000	0.1217	0.0000	-1.0000	0.0000	0.0000	0.0000
$MO^{Comp}(S_2)$ $(MO^{Comp}(B_2))$	0.0020	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0021	0.0000	-1.0000	0.0000	0.0000	0.0000
$MO^{Comp}(S_1)$ $(MO^{Comp}(B_1))$	0.0590	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0588	0.0000	-1.0000	0.0000	0.0000	0.0000
$Eff.\ Spread^{Comp}$	0.0027	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0027	0.0000	-1.0000	0.0000	0.0000	0.0000
$Quoted\,Spread^{Comp}$	0.0401	0.0452	0.1283	0.0452	0.0000	-0.0002	0.0401	0.0452	0.1285	0.0452	0.0000	-0.0002
$BBODepth^{Comp}$	0.5042	0.2399	-0.5243	0.2403	0.0004	0.0016	0.5044	0.2394	-0.5255	0.2398	0.0004	0.0017
$Depth^{Comp}(S_2)$ $(Depth^{Comp}(B_2))$	0.0083	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0088	0.0000	-1.0000	0.0000	0.0000	0.0000
$Depth^{Comp}(S_1)$ $(Depth^{Comp}(B_1))$	0.2448	0.1199	-0.5101	0.1201	0.0002	0.0016	0.2445	0.1197	-0.5106	0.1199	0.0002	0.0017
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2531	0.1199	-0.5262	0.1201	0.0002	0.0016	0.2533	0.1197	-0.5275	0.1199	0.0002	0.0017
MS^{Comp}	0.5000	0.0000	-1.0000	0.0000	0.0000	0.0000	0.5000	0.0000	-1.0000	0.0000	0.0000	0.0000
With Period t_3												
MO^{Comp}	0.1251	0.0398	-0.6820	0.0398	0.0001	0.0016	0.1251	0.0397	-0.6828	0.0398	0.0001	0.0017
$MO^{Comp}(S_2)$ $(MO^{Comp}(B_2))$	0.0020	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0021	0.0000	-1.0000	0.0000	0.0000	0.0000
$MO^{Comp}(S_1)$ $(MO^{Comp}(B_1))$	0.0605	0.0199	-0.6714	0.0199	0.0000	0.0016	0.0604	0.0198	-0.6716	0.0199	0.0000	0.0017
$Eff.\ Spread^{Comp}$	0.0026	0.0008	-0.6959	0.0008	0.0000	0.0016	0.0026	0.0008	-0.6973	0.0008	0.0000	0.0017
$Quoted\,Spread^{Comp}$	0.0409	0.0444	0.0860	0.0444	0.0000	-0.0002	0.0409	0.0444	0.0862	0.0444	0.0000	-0.0002
$BBODepth^{Comp}$	0.4624	0.2800	-0.3944	0.2805	0.0005	0.0016	0.4627	0.2795	-0.3960	0.2800	0.0005	0.0017
$Depth^{Comp}(S_2)$ $(Depth^{Comp}(B_2))$	0.0070	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0073	0.0000	-1.0000	0.0000	0.0000	0.0000
$Depth^{Comp}(S_1)$ $(Depth^{Comp}(B_1))$	0.2239	0.1400	-0.3747	0.1402	0.0002	0.0016	0.2237	0.1397	-0.3753	0.1400	0.0002	0.0017
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2309	0.1400	-0.3936	0.1402	0.0002	0.0016	0.2310	0.1397	-0.3950	0.1400	0.0002	0.0017
MS^{Comp}	0.5000	0.1589	-0.6821	0.1591	0.0001	0.0008	0.5000	0.1586	-0.6829	0.1587	0.0001	0.0009

Table A7: **Equilibrium Order Submission Strategies and Market Quality in the Competing Market. Change in MF only. 4-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.05, 1.95]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF, holding $TF = tf = mf = 0.00$, specifically: for $MF = 0.00$ (columns 2 and 7), for $MF = -0.001$ (columns 3 and 8), and for $MF = -0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001$ and $MF = -0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 4 periods, $t_z = t_1, t_2, t_3, t_4$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_4) and across all the periods of the trading game (With Period t_4). $AV = 1$ and $\tau = 0.01$.

Competing			**$S = [0, 2]$ 4 Periods**						**$S = [0.05, 1.95]$ 4 Periods**			
TF	**0.000**	**0.000**		**0.000**			**0.000**	**0.000**		**0.000**		
MF	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Comp}	0.3368	0.1622	-0.5184	0.1621	-0.0001	-0.0005	0.3369	0.1620	-0.5193	0.1619	-0.0001	-0.0005
$LO^{Comp}(S_2)$ ($LO^{Comp}(B_2)$)	0.0455	0.0000	-0.9994	0.0000	0.0000	0.0000	0.0457	0.0000	-0.9994	0.0000	0.0000	0.0000
$LO^{Comp}(S_1)$ ($LO^{Comp}(B_1)$)	0.1229	0.0811	-0.3405	0.0811	0.0000	-0.0001	0.1228	0.0810	-0.3409	0.0809	0.0000	-0.0001
Without Period t_4												
MO^{Comp}	0.1242	0.0387	-0.6886	0.0386	-0.0001	-0.0020	0.1241	0.0385	-0.6896	0.0384	-0.0001	-0.0021
$MO^{Comp}(S_2)$ ($MO^{Comp}(B_2)$)	0.0031	0.0000	-0.9997	0.0000	0.0000	0.0000	0.0032	0.0000	-0.9997	0.0000	0.0000	0.0000
$MO^{Comp}(S_1)$ ($MO^{Comp}(B_1)$)	0.0590	0.0193	-0.6724	0.0193	0.0000	-0.0020	0.0588	0.0193	-0.6727	0.0192	0.0000	-0.0021
$Eff.\ Spread^{Comp}$	0.0037	0.0017	-0.5476	0.0017	0.0000	-0.0001	0.0037	0.0017	-0.5497	0.0017	0.0000	-0.0001
$Quoted\,Spread^{Comp}$	0.0399	0.0444	0.1111	0.0443	0.0000	-0.0002	0.0399	0.0444	0.1115	0.0444	0.0000	-0.0002
$BBODepth^{Comp}$	0.5529	0.2822	-0.4896	0.2825	0.0003	0.0011	0.5535	0.2818	-0.4909	0.2821	0.0003	0.0012
$Depth^{Comp}(S_2)$ ($Depth^{Comp}(B_2)$)	0.0507	0.0000	-0.9994	0.0000	0.0000	0.0000	0.0511	0.0000	-0.9994	0.0000	0.0000	0.0000
$Depth^{Comp}(S_1)$ ($Depth^{Comp}(B_1)$)	0.2275	0.1411	-0.3799	0.1413	0.0002	0.0013	0.2274	0.1409	-0.3807	0.1410	0.0002	0.0014
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2782	0.1411	-0.4927	0.1413	0.0002	0.0011	0.2786	0.1409	-0.4942	0.1410	0.0002	0.0012
MS^{Comp}	0.5000	0.1558	-0.6885	0.1556	-0.0002	-0.0013	0.5000	0.1552	-0.6895	0.1550	-0.0002	-0.0013
With Period t_4												
MO^{Comp}	0.1556	0.1239	-0.2042	0.1241	0.0002	0.0018	0.1556	0.1238	-0.2044	0.1240	0.0002	0.0019
$MO^{Comp}(S_2)$ ($MO^{Comp}(B_2)$)	0.0602	0.0296	-0.5079	0.0296	0.0000	-0.0010	0.0177	0.0000	-0.9997	0.0000	0.0000	0.0000
$MO^{Comp}(S_1)$ ($MO^{Comp}(B_1)$)	0.0602	0.0296	-0.5079	0.0296	0.0000	-0.0010	0.0601	0.0295	-0.5083	0.0295	0.0000	-0.0011
$Eff.\ Spread^{Comp}$	0.0034	0.0014	-0.5857	0.0014	0.0000	-0.0002	0.0034	0.0014	-0.5872	0.0014	0.0000	-0.0002
$Quoted\,Spread^{Comp}$	0.0408	0.0431	0.0563	0.0431	0.0000	-0.0006	0.0408	0.0445	0.0904	0.0445	0.0000	-0.0001
$BBODepth^{Comp}$	0.0543	0.0000	-0.9993	0.0000	0.0000	0.0000	0.5112	0.2737	-0.4646	0.2740	0.0003	0.0010
$Depth^{Comp}(S_2)$ ($Depth^{Comp}(B_2)$)	0.2023	0.1370	-0.3229	0.1371	0.0002	0.0012	0.0547	0.0000	-0.9993	0.0000	0.0000	0.0000
$Depth^{Comp}(S_1)$ ($Depth^{Comp}(B_1)$)	0.2023	0.1370	-0.3229	0.1371	0.0002	0.0012	0.2023	0.1368	-0.3236	0.1370	0.0002	0.0013
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2566	0.1370	-0.4660	0.1371	0.0001	0.0009	0.2569	0.1368	-0.4674	0.1370	0.0001	0.0010
MS^{Comp}	0.5000	0.3295	-0.3410	0.3297	0.0002	0.0006	0.5000	0.3293	-0.3414	0.3295	0.0002	0.0007

Table A8: **Equilibrium Order Submission Strategies and Market Quality in the Competing Market. Change in MF and in TF. 3-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.05, 1.95]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF and TF, specifically: for $MF = 0.00$ and $TF = 0.00$ (columns 2 and 7), for $MF = -0.001$ and $TF = 0.001$ (columns 3 and 8), and for $MF = -0.005$ and $TF = 0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001\,\&\,TF = 0.001$ and $MF = -0.005\,\&\,TF = 0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_3) and across all the periods of the trading game (With Period t_3). $AV = 1$ and $\tau = 0.01$.

Competing	$S = [0, 2]$ **3 Periods**						$S = [0.05, 1.95]$ **3 Periods**					
TF	**0.000**	**0.001**		**0.005**			**0.000**	**0.001**		**0.005**		
MF	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Comp}	0.3781	0.4959	0.3115	0.4941	-0.0019	-0.0038	0.3783	0.4957	0.3104	0.4938	-0.0020	-0.0040
$LO^{Comp}(S_2)$ ($LO^{Comp}(B_2)$)	0.0062	0.0020	-0.6814	0.0029	0.0009	0.4476	0.0065	0.0021	-0.6820	0.0030	0.0009	0.4464
$LO^{Comp}(S_1)$ ($LO^{Comp}(B_1)$)	0.1829	0.2460	0.3451	0.2442	-0.0018	-0.0074	0.1826	0.2458	0.3457	0.2439	-0.0019	-0.0077
Without Period t_3												
MO^{Comp}	0.1219	0.2397	0.9672	0.2370	-0.0027	-0.0112	0.1217	0.2392	0.9656	0.2364	-0.0028	-0.0118
$MO^{Comp}(S_2)$ ($MO^{Comp}(B_2)$)	0.0020	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0021	0.0000	-1.0000	0.0000	0.0000	0.0000
$MO^{Comp}(S_1)$ ($MO^{Comp}(B_1)$)	0.0590	0.1199	1.0328	0.1185	-0.0013	-0.0112	0.0588	0.1196	1.0344	0.1182	-0.0014	-0.0118
$Eff.\ Spread^{Comp}$	0.0027	0.0025	-0.0606	0.0025	0.0000	0.0000	0.0027	0.0025	-0.0634	0.0025	0.0000	0.0000
$Quoted\,Spread^{Comp}$	0.0401	0.0351	-0.1244	0.0352	0.0001	0.0021	0.0401	0.0351	-0.1244	0.0352	0.0001	0.0022
$BBODepth^{Comp}$	0.5042	0.7481	0.4837	0.7453	-0.0029	-0.0038	0.5044	0.7480	0.4829	0.7450	-0.0030	-0.0040
$Depth^{Comp}(S_2)$ ($Depth^{Comp}(B_2)$)	0.0083	0.0020	-0.7635	0.0029	0.0009	0.4476	0.0088	0.0021	-0.7640	0.0030	0.0009	0.4464
$Depth^{Comp}(S_1)$ ($Depth^{Comp}(B_1)$)	0.2448	0.3721	0.5200	0.3698	-0.0023	-0.0062	0.2445	0.3720	0.5210	0.3695	-0.0024	-0.0065
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2531	0.3741	0.4777	0.3726	-0.0014	-0.0038	0.2533	0.3740	0.4766	0.3725	-0.0015	-0.0040
MS^{Comp}	0.5000	0.9842	0.9685	0.9772	-0.0070	-0.0071	0.5000	0.9835	0.9669	0.9761	-0.0073	-0.0075
With Period t_3												
MO^{Comp}	0.1251	0.2448	0.9566	0.2433	-0.0015	-0.0062	0.1251	0.2445	0.9544	0.2429	-0.0016	-0.0065
$MO^{Comp}(S_2)$ ($MO^{Comp}(B_2)$)	0.0020	0.0006	-0.6804	0.0009	0.0003	0.4476	0.0021	0.0007	-0.6809	0.0010	0.0003	0.4464
$MO^{Comp}(S_1)$ ($MO^{Comp}(B_1)$)	0.0605	0.1217	1.0114	0.1207	-0.0011	-0.0087	0.0604	0.1216	1.0120	0.1205	-0.0011	-0.0091
$Eff.\ Spread^{Comp}$	0.0026	0.0025	-0.0314	0.0026	0.0000	0.0057	0.0026	0.0025	-0.0329	0.0026	0.0000	0.0059
$Quoted\,Spread^{Comp}$	0.0409	0.0383	-0.0620	0.0384	0.0001	0.0013	0.0409	0.0383	-0.0621	0.0384	0.0001	0.0014
$BBODepth^{Comp}$	0.4624	0.5846	0.2641	0.5830	-0.0016	-0.0028	0.4627	0.5847	0.2637	0.5829	-0.0017	-0.0029
$Depth^{Comp}(S_2)$ ($Depth^{Comp}(B_2)$)	0.0070	0.0020	-0.7153	0.0029	0.0009	0.4495	0.0073	0.0021	-0.7158	0.0030	0.0009	0.4484
$Depth^{Comp}(S_1)$ ($Depth^{Comp}(B_1)$)	0.2239	0.2903	0.2966	0.2888	-0.0015	-0.0053	0.2237	0.2903	0.2978	0.2887	-0.0016	-0.0056
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2309	0.2923	0.2661	0.2917	-0.0006	-0.0022	0.2310	0.2924	0.2657	0.2917	-0.0007	-0.0023
MS^{Comp}	0.5000	0.9759	0.9519	0.9687	-0.0072	-0.0074	0.5000	0.9747	0.9495	0.9672	-0.0075	-0.0077

Table A9: **Equilibrium Order Submission Strategies and Market Quality in the Competing Market. Change in MF and in TF. 4-period model: $S = [0, 2]$ and $S = [0.05, 1.95]$**

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.5, 1.5]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF and TF, specifically: for $MF = 0.00$ and $TF = 0.00$ (columns 2 and 7), for $MF = -0.001$ and $TF = 0.001$ (columns 3 and 8), and for $MF = -0.005$ and $TF = 0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001\,\&\,TF = 0.001$ and $MF = -0.005\ \&\,TF = 0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3, t_4$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_4) and across all the periods of the trading game (With Period t_4). $AV = 1$ and $\tau = 0.01$.

Competing			**$S = [0, 2]$ 4 Periods**						**$S = [0.05, 1.95]$ 4 Periods**			
TF	**0.000**	**0.001**		**0.005**			**0.000**	**0.001**		**0.005**		
MF	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0.000**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Comp}	0.3368	0.3368	0.0000	0.3365	-0.0003	-0.0008	0.3369	0.3370	0.0000	0.3367	-0.0003	-0.0008
$LO^{Comp}(S_2)$ ($LO^{Comp}(B_2)$)	0.0455	0.0017	-0.9618	0.0018	0.0000	0.0075	0.0457	0.0018	-0.9599	0.0018	0.0000	0.0080
$LO^{Comp}(S_1)$ ($LO^{Comp}(B_1)$)	0.1229	0.1666	0.3557	0.1665	-0.0001	-0.0009	0.1228	0.1666	0.3568	0.1665	-0.0002	-0.0009
Without Period t_4												
MO^{Comp}	0.1242	0.2392	0.9261	0.2365	-0.0026	-0.0109	0.1241	0.2386	0.9226	0.2359	-0.0027	-0.0114
$MO^{Comp}(S_2)$ ($MO^{Comp}(B_2)$)	0.0031	0.0000	-0.9970	0.0000	0.0000	0.1114	0.0032	0.0000	-0.9969	0.0000	0.0000	0.1099
$MO^{Comp}(S_1)$ ($MO^{Comp}(B_1)$)	0.0590	0.1196	1.0261	0.1183	-0.0013	-0.0109	0.0588	0.1193	1.0273	0.1179	-0.0014	-0.0114
$Eff.\ Spread^{Comp}$	0.0037	0.0033	-0.0952	0.0033	0.0000	0.0000	0.0037	0.0033	-0.0992	0.0033	0.0000	0.0000
$Quoted\,Spread^{Comp}$	0.0399	0.0380	-0.0469	0.0380	0.0000	-0.0003	0.0399	0.0380	-0.0472	0.0380	0.0000	-0.0003
$BBODepth^{Comp}$	0.5529	0.6017	0.0883	0.6033	0.0015	0.0025	0.5535	0.6026	0.0888	0.6042	0.0016	0.0026
$Depth^{Comp}(S_2)$ ($Depth^{Comp}(B_2)$)	0.0507	0.0026	-0.9494	0.0026	0.0000	0.0027	0.0511	0.0027	-0.9472	0.0027	0.0000	0.0029
$Depth^{Comp}(S_1)$ ($Depth^{Comp}(B_1)$)	0.2275	0.2995	0.3165	0.3003	0.0007	0.0025	0.2274	0.2999	0.3186	0.3007	0.0008	0.0026
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2782	0.3021	0.0860	0.3028	0.0008	0.0025	0.2786	0.3026	0.0864	0.3034	0.0008	0.0026
MS^{Comp}	0.5000	0.9631	0.9262	0.9534	-0.0097	-0.0101	0.5000	0.9613	0.9226	0.9512	-0.0101	-0.0105
With Period t_4												
MO^{Comp}	0.1556	0.2684	0.7242	0.2656	-0.0028	-0.0104	0.1556	0.2677	0.7205	0.2648	-0.0029	-0.0109
$MO^{Comp}(S_2)$ ($MO^{Comp}(B_2)$)	0.0176	0.0005	-0.9724	0.0005	0.0000	0.0117	0.0177	0.0005	-0.9710	0.0005	0.0000	0.0124
$MO^{Comp}(S_1)$ ($MO^{Comp}(B_1)$)	0.0602	0.1071	0.7785	0.1065	-0.0006	-0.0057	0.0601	0.1070	0.7799	0.1063	-0.0006	-0.0059
$Eff.\ Spread^{Comp}$	0.0034	0.0027	-0.2051	0.0027	0.0000	0.0015	0.0034	0.0027	-0.2074	0.0027	0.0000	0.0015
$Quoted\,Spread^{Comp}$	0.0408	0.0403	-0.0130	0.0403	0.0000	-0.0006	0.0408	0.0403	-0.0132	0.0403	0.0000	-0.0007
$BBODepth^{Comp}$	0.5106	0.4884	-0.0435	0.4906	0.0022	0.0044	0.5112	0.4894	-0.0426	0.4917	0.0022	0.0046
$Depth^{Comp}(S_2)$ ($Depth^{Comp}(B_2)$)	0.0543	0.0027	-0.9504	0.0027	0.0000	0.0018	0.0547	0.0028	-0.9481	0.0028	0.0000	0.0020
$Depth^{Comp}(S_1)$ ($Depth^{Comp}(B_1)$)	0.2023	0.2274	0.1240	0.2286	0.0012	0.0054	0.2023	0.2278	0.1263	0.2291	0.0013	0.0056
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2566	0.2301	-0.1034	0.2313	0.0012	0.0053	0.2569	0.2306	-0.1023	0.2319	0.0013	0.0056
MS^{Comp}	0.5000	0.7368	0.4736	0.7328	-0.0040	-0.0054	0.5000	0.7361	0.4723	0.7320	-0.0042	-0.0056

Table A8: **Equilibrium Order Submission Strategies and Market Quality in the Competing Market. Change in MF with Total Fee Change. 3-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.05, 1.95]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF and TF, specifically: for $MF = 0.00$ and $TF = 0.00$ (columns 2 and 7), for $MF = -0.001$ and $TF = 0.001$ (columns 3 and 8), and for $MF = -0.005$ and $TF = 0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001\,\&\,TF = 0.001$ and $MF = -0.005\ \&\,TF = 0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_3) and across all the periods of the trading game (With Period t_3). $AV = 1$ and $\tau = 0.01$.

Competing		**$S = [0, 2]$ 3 Periods**						**$S = [0.05, 1.95]$ 3 Periods**				
TF	**0.005**	**0.005**		**0.005**			**0.005**	**0.005**		**0.005**		
MF	**0**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Comp}	0.5135	0.4960	-0.0340	0.4941	-0.0020	-0.0040	0.5142	0.4958	1.0710	0.4938	-0.0021	-0.0042
$LO^{Comp}(S_2)$ $(LO^{Comp}(B_2))$	0.0085	0.0019	-0.7725	0.0029	0.0009	0.4691	0.0090	0.0020	0.0000	0.0030	0.0010	0.4690
$LO^{Comp}(S_1)$ $(LO^{Comp}(B_1))$	0.2482	0.2461	-0.0085	0.2442	-0.0019	-0.0077	0.2481	0.2459	1.0537	0.2439	-0.0020	-0.0081
Without Period t_4			0.0000		0.0000	0.0000					0.0000	0.0000
MO^{Comp}	0.2438	0.2398	-0.0164	0.2370	-0.0028	-0.0116	0.2435	0.2393	0.0000	0.2364	-0.0029	-0.0122
$MO^{Comp}(S_2)$ $(MO^{Comp}(B_2))$	0.0017	0.0000	-1.0000	0.0000	0.0000	0.0000	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000
$MO^{Comp}(S_1)$ $(MO^{Comp}(B_1))$	0.1202	0.1199	-0.0023	0.1185	-0.0014	-0.0116	0.1200	0.1197	0.0000	0.1182	-0.0015	-0.0122
$Eff.\ Spread^{Comp}$	0.0026	0.0025	-0.0275	0.0025	0.0000	0.0000	0.0026	0.0025	0.0000	0.0025	0.0000	0.0000
$Quoted\,Spread^{Comp}$	0.0349	0.0351	0.0064	0.0352	0.0001	0.0022	0.0348	0.0351	-0.2241	0.0352	0.0001	0.0023
$BBODepth^{Comp}$	0.7661	0.7483	-0.0232	0.7453	-0.0030	-0.0040	0.7669	0.7482	2.1251	0.7450	-0.0031	-0.0042
$Depth^{Comp}(S_2)$ $(Depth^{Comp}(B_2))$	0.0104	0.0019	-0.8135	0.0029	0.0009	0.4691	0.0110	0.0020	0.0000	0.0030	0.0010	0.4690
$Depth^{Comp}(S_1)$ $(Depth^{Comp}(B_1))$	0.3744	0.3722	-0.0059	0.3698	-0.0024	-0.0065	0.3744	0.3721	2.1078	0.3695	-0.0025	-0.0068
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.3848	0.3741	-0.0278	0.3726	-0.0015	-0.0040	0.3853	0.3741	2.1251	0.3725	-0.0016	-0.0042
MS^{Comp}	1.0000	0.9846	-0.0154	0.9772	-0.0074	-0.0075	1.0000	0.9839	0.0000	0.9761	-0.0077	-0.0079
With Period t_4			0.0000		0.0000	0.0000					0.0000	0.0000
MO^{Comp}	0.2508	0.2448	-0.0236	0.2433	-0.0016	-0.0065	0.2508	0.2446	5.1615	0.2429	-0.0017	-0.0069
$MO^{Comp}(S_2)$ $(MO^{Comp}(B_2))$	0.0028	0.0006	-0.7720	0.0009	0.0003	0.4691	0.0029	0.0007	0.0000	0.0010	0.0003	0.4690
$MO^{Comp}(S_1)$ $(MO^{Comp}(B_1))$	0.1226	0.1218	-0.0065	0.1207	-0.0011	-0.0090	0.1225	0.1216	5.1274	0.1205	-0.0012	-0.0095
$Eff.\ Spread^{Comp}$	0.0026	0.0025	-0.0209	0.0026	0.0000	0.0058	0.0026	0.0025	2.1950	0.0026	0.0000	0.0061
$Quoted\,Spread^{Comp}$	0.0381	0.0383	0.0054	0.0384	0.0001	0.0014	0.0381	0.0383	-0.1365	0.0384	0.0001	0.0014
$BBODepth^{Comp}$	0.6011	0.5847	-0.0273	0.5830	-0.0017	-0.0029	0.6020	0.5848	1.0920	0.5829	-0.0018	-0.0031
$Depth^{Comp}(S_2)$ $(Depth^{Comp}(B_2))$	0.0082	0.0020	-0.7613	0.0029	0.0009	0.4691	0.0086	0.0021	0.0000	0.0030	0.0010	0.4690
$Depth^{Comp}(S_1)$ $(Depth^{Comp}(B_1))$	0.2911	0.2906	-0.0018	0.2888	-0.0018	-0.0061	0.2911	0.2905	1.0774	0.2887	-0.0019	-0.0064
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.2993	0.2925	-0.0226	0.2917	-0.0009	-0.0029	0.2997	0.2926	1.0923	0.2917	-0.0009	-0.0031
MS^{Comp}	1.0000	0.9763	-0.0237	0.9687	-0.0075	-0.0077	1.0000	0.9751	5.1473	0.9672	-0.0079	-0.0081

Table A9: **Equilibrium Order Submission Strategies and Market Quality in the Competing Market. Change in MF with Total Fee Change. 4-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.5, 1.5]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF and TF, specifically: for $MF = 0.00$ and $TF = 0.00$ (columns 2 and 7), for $MF = -0.001$ and $TF = 0.001$ (columns 3 and 8), and for $MF = -0.005$ and $TF = 0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001\,\&\,TF = 0.001$ and $MF = -0.005\,\&\,TF = 0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3, t_4$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_4) and across all the periods of the trading game (With Period t_4). $AV = 1$ and $\tau = 0.01$.

Competing	**$S = [0, 2]$ 3 Periods**						**$S = [0.05, 1.95]$ 3 Periods**					
TF	**0.005**	**0.005**		**0.005**			**0.005**	**0.005**		**0.005**		
MF	**0**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**	**0**	**-0.001**	**Δ%**	**-0.005**	**Δ**	**Δ%**
LO^{Comp}	0.6700	0.5918	-0.1168	0.3365	-0.2553	-0.4314	0.6702	0.5915	-0.1175	0.3367	-0.2548	-0.4308
$LO^{Comp}(S_2)$ $(LO^{Comp}(B_2))$	0.1667	0.1278	-0.2333	0.0018	-0.1260	-0.9863	0.1667	0.1275	-0.2348	0.0018	-0.1257	-0.9855
$LO^{Comp}(S_1)$ $(LO^{Comp}(B_1))$	0.1683	0.1681	-0.0014	0.1665	-0.0016	-0.0096	0.1684	0.1682	-0.0014	0.1665	-0.0017	-0.0101
Without Period t_4			0.0000		0.0000	0.0000			0.0000		0.0000	0.0000
MO^{Comp}	0.2484	0.2393	-0.0367	0.2365	-0.0028	-0.0116	0.2483	0.2388	-0.0384	0.2359	-0.0029	-0.0122
$MO^{Comp}(S_2)$ $(MO^{Comp}(B_2))$	0.0043	0.0000	-0.9934	0.0000	0.0000	-0.6452	0.0046	0.0000	-0.9922	0.0000	0.0000	-0.6879
$MO^{Comp}(S_1)$ $(MO^{Comp}(B_1))$	0.1199	0.1196	-0.0020	0.1183	-0.0014	-0.0114	0.1196	0.1194	-0.0021	0.1179	-0.0014	-0.0120
$Eff.\ Spread^{Comp}$	0.0036	0.0033	-0.0749	0.0033	0.0000	-0.0004	0.0036	0.0033	-0.0780	0.0033	0.0000	-0.0006
$Quoted\,Spread^{Comp}$	0.0354	0.0361	0.0203	0.0380	0.0019	0.0524	0.0354	0.0361	0.0206	0.0380	0.0019	0.0522
$BBODepth^{Comp}$	0.8636	0.7922	-0.0827	0.6033	-0.1889	-0.2385	0.8651	0.7926	-0.0838	0.6042	-0.1884	-0.2377
$Depth^{Comp}(S_2)$ $(Depth^{Comp}(B_2))$	0.2525	0.1930	-0.2355	0.0026	-0.1905	-0.9867	0.2526	0.1927	-0.2371	0.0027	-0.1900	-0.9859
$Depth^{Comp}(S_1)$ $(Depth^{Comp}(B_1))$	0.3020	0.3017	-0.0009	0.3003	-0.0014	-0.0047	0.3025	0.3022	-0.0010	0.3007	-0.0015	-0.0050
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.5544	0.4947	-0.1077	0.3028	-0.1919	-0.3878	0.5551	0.4949	-0.1085	0.3034	-0.1915	-0.3869
MS^{Comp}	1.0000	0.9638	-0.0362	0.9534	-0.0104	-0.0108	1.0000	0.9621	-0.0379	0.9512	-0.0109	-0.0113
With Period t_4			0.0000		0.0000	0.0000			0.0000		0.0000	0.0000
MO^{Comp}	0.1863	0.1990	0.0680	0.2656	0.0666	0.3346	0.1863	0.1986	0.0665	0.2648	0.0662	0.3331
$MO^{Comp}(S_2)$ $(MO^{Comp}(B_2))$	0.0479	0.0349	-0.2716	0.0005	-0.0344	-0.9859	0.0479	0.0347	-0.2748	0.0005	-0.0342	-0.9850
$MO^{Comp}(S_1)$ $(MO^{Comp}(B_1))$	0.1077	0.1075	-0.0016	0.1065	-0.0010	-0.0097	0.1076	0.1074	-0.0017	0.1063	-0.0011	-0.0102
$Eff.\ Spread^{Comp}$	0.0042	0.0037	-0.1174	0.0027	-0.0010	-0.2770	0.0042	0.0037	-0.1194	0.0027	-0.0010	-0.2761
$Quoted\,Spread^{Comp}$	0.0371	0.0379	0.0216	0.0403	0.0024	0.0627	0.0371	0.0379	0.0219	0.0403	0.0024	0.0626
$BBODepth^{Comp}$	0.8078	0.7280	-0.0987	0.4906	-0.2375	-0.3262	0.8092	0.7286	-0.0996	0.4917	-0.2369	-0.3252
$Depth^{Comp}(S_2)$ $(Depth^{Comp}(B_2))$	0.2662	0.2059	-0.2264	0.0027	-0.2032	-0.9869	0.2662	0.2056	-0.2276	0.0028	-0.2028	-0.9862
$Depth^{Comp}(S_1)$ $(Depth^{Comp}(B_1))$	0.2445	0.2419	-0.0105	0.2286	-0.0133	-0.0551	0.2450	0.2425	-0.0104	0.2291	-0.0134	-0.0552
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.5107	0.4479	-0.1230	0.2313	-0.2166	-0.4835	0.5112	0.4481	-0.1235	0.2319	-0.2162	-0.4824
MS^{Comp}	1.0000	0.8835	-0.1165	0.7328	-0.1507	-0.1705	1.0000	0.8820	-0.1180	0.7320	-0.1500	-0.1701

Table A8: **Equilibrium Order Submission Strategies and Market Quality in the Competing Market. Change in TF with Total Fee Change. 3-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\,Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.05, 1.95]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF and TF, specifically: for $MF = 0.00$ and $TF = 0.00$ (columns 2 and 7), for $MF = -0.001$ and $TF = 0.001$ (columns 3 and 8), and for $MF = -0.005$ and $TF = 0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001\,\&\,TF = 0.001$ and $MF = -0.005\,\&\,TF = 0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_3) and across all the periods of the trading game (With Period t_3). $AV = 1$ and $\tau = 0.01$.

Competing	$S = [0, 2]$ **3 Periods**						$S = [0.05, 1.95]$ **3 Periods**					
TF	**0**	**0.001**		**0.005**			**0**	**0.001**		**0.005**		
MF	**-0.001**	**-0.001**	**Δ%**	**-0.001**	**Δ**	**Δ%**	**-0.001**	**-0.001**	**Δ%**	**-0.001**	**Δ**	**Δ%**
LO^{Comp}	0.2399	0.4959	1.0675	0.4960	0.0001	0.0002	0.2394	0.4957	1.0710	0.4958	0.0001	0.0002
$LO^{Comp}(S_2)$ $(LO^{Comp}(B_2))$	0.0000	0.0020	0.0000	0.0019	0.0000	-0.0147	0.0000	0.0021	0.0000	0.0020	0.0000	-0.0154
$LO^{Comp}(S_1)$ $(LO^{Comp}(B_1))$	0.1199	0.2460	1.0511	0.2461	0.0001	0.0003	0.1197	0.2458	1.0537	0.2459	0.0001	0.0004
Without Period t_4												
MO^{Comp}	0.0000	0.2397	0.0000	0.2398	0.0001	0.0004	0.0000	0.2392	0.0000	0.2393	0.0001	0.0005
$MO^{Comp}(S_2)$ $(MO^{Comp}(B_2))$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$MO^{Comp}(S_1)$ $(MO^{Comp}(B_1))$	0.0000	0.1199	0.0000	0.1199	0.0001	0.0004	0.0000	0.1196	0.0000	0.1197	0.0001	0.0005
$Eff.\ Spread^{Comp}$	0.0000	0.0025	0.0000	0.0025	0.0000	0.0000	0.0000	0.0025	0.0000	0.0025	0.0000	0.0000
$Quoted\,Spread^{Comp}$	0.0452	0.0351	-0.2240	0.0351	0.0000	-0.0001	0.0452	0.0351	-0.2241	0.0351	0.0000	-0.0001
$BBODepth^{Comp}$	0.2399	0.7481	2.1189	0.7483	0.0001	0.0002	0.2394	0.7480	2.1251	0.7482	0.0001	0.0002
$Depth^{Comp}(S_2)$ $(Depth^{Comp}(B_2))$	0.0000	0.0020	0.0000	0.0019	0.0000	-0.0147	0.0000	0.0021	0.0000	0.0020	0.0000	-0.0154
$Depth^{Comp}(S_1)$ $(Depth^{Comp}(B_1))$	0.1199	0.3721	2.1025	0.3722	0.0001	0.0003	0.1197	0.3720	2.1078	0.3721	0.0001	0.0003
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.1199	0.3741	2.1189	0.3741	0.0001	0.0002	0.1197	0.3740	2.1251	0.3741	0.0001	0.0002
MS^{Comp}	0.0000	0.9842	0.0000	0.9846	0.0004	0.0004	0.0000	0.9835	0.0000	0.9839	0.0004	0.0004
With Period t_4												
MO^{Comp}	0.0398	0.2448	5.1537	0.2448	0.0001	0.0003	0.0397	0.2445	5.1615	0.2446	0.0001	0.0003
$MO^{Comp}(S_2)$ $(MO^{Comp}(B_2))$	0.0000	0.0006	0.0000	0.0006	0.0000	-0.0147	0.0000	0.0007	0.0000	0.0007	0.0000	-0.0154
$MO^{Comp}(S_1)$ $(MO^{Comp}(B_1))$	0.0199	0.1217	5.1211	0.1218	0.0000	0.0004	0.0198	0.1216	5.1274	0.1216	0.0000	0.0004
$Eff.\ Spread^{Comp}$	0.0008	0.0025	2.1854	0.0025	0.0000	-0.0001	0.0008	0.0025	2.1950	0.0025	0.0000	-0.0002
$Quoted\,Spread^{Comp}$	0.0444	0.0383	-0.1363	0.0383	0.0000	-0.0001	0.0444	0.0383	-0.1365	0.0383	0.0000	-0.0001
$BBODepth^{Comp}$	0.2800	0.5846	1.0875	0.5847	0.0001	0.0001	0.2795	0.5847	1.0920	0.5848	0.0001	0.0002
$Depth^{Comp}(S_2)$ $(Depth^{Comp}(B_2))$	0.0000	0.0020	0.0000	0.0020	0.0000	-0.0134	0.0000	0.0021	0.0000	0.0021	0.0000	-0.0141
$Depth^{Comp}(S_1)$ $(Depth^{Comp}(B_1))$	0.1400	0.2903	1.0736	0.2906	0.0002	0.0008	0.1397	0.2903	1.0774	0.2905	0.0003	0.0009
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.1400	0.2923	1.0877	0.2925	0.0002	0.0007	0.1397	0.2924	1.0923	0.2926	0.0002	0.0008
MS^{Comp}	0.1589	0.9759	5.1401	0.9763	0.0003	0.0003	0.1586	0.9747	5.1473	0.9751	0.0004	0.0004

Table A9: **Equilibrium Order Submission Strategies and Market Quality in the Competing Market. Change in TF with Total Fee Change. 4-period model:** $S = [0, 2]$ **and** $S = [0.05, 1.95]$

This Table reports for the primary market ($Prim$) (column 1) the average equilibrium probabilities of the following order flows and market quality metrics: limit orders, $LO^j(P_i)$, and market orders, $MO^j(P_i)$, with the limit order breakdown for the outside (S_2 and B_2) and inside (S_1 and B_1) price levels, market share, MS^j, No trade ($No\ Trade$), Effective Spread ($Eff.\ Spread^j$), Quoted Spread ($Quoted\,Spread^j$), BBOdepth ($BBODepth^j$), Depth at P_i ($Depth^j(P_i)$), and total Depth ($Depth^j(P_2) + Depth^j(P_1)$). The table reports results obtained under two protocols, one with support $S = [0, 2]$ (raws 2 through 6) and with support $S = [0.5, 1.5]$ (raws 7 through 11). MF and TF are reported in raws 1 and 2. Results are reported for different values of MF and TF, specifically: for $MF = 0.00$ and $TF = 0.00$ (columns 2 and 7), for $MF = -0.001$ and $TF = 0.001$ (columns 3 and 8), and for $MF = -0.005$ and $TF = 0.005$ (columns 4 and 9). Columns 5 and 10 report the change in the market quality metrics (Δ) between $MF = -0.001\,\&\,TF = 0.001$ and $MF = -0.005\,\&\,TF = 0.005$ and columns 6 and 11 report the percentage change ($\Delta\%$). The trading game has 3 periods, $t_z = t_1, t_2, t_3, t_4$. The metrics are reported both as average across the first two periods of the trading game (Without Period t_4) and across all the periods of the trading game (With Period t_4). $AV = 1$ and $\tau = 0.01$.

Competing		**$S = [0, 2]$ 4 Periods**						**$S = [0.05, 1.95]$ 4 Periods**				
TF	**0**	**0.001**		**0.005**			**0**	**0.001**		**0.005**		
MF	**-0.001**	**-0.001**	**Δ%**	**-0.001**	**Δ**	**Δ%**	**-0.001**	**-0.001**	**Δ%**	**-0.001**	**Δ**	**Δ%**
LO^{Comp}	0.1622	0.3368	1.0765	0.5918	0.2550	0.7573	0.1620	0.3370	1.0804	0.5921	0.2551	0.7572
$LO^{Comp}(S_2)$ ($LO^{Comp}(B_2)$)	0.0000	0.0017	64.4511	0.1278	0.1260	72.5530	0.0000	0.0018	61.9237	0.0657	0.0639	34.8613
$LO^{Comp}(S_1)$ ($LO^{Comp}(B_1)$)	0.0811	0.1666	1.0558	0.1681	0.0015	0.0089	0.0810	0.1666	1.0585	0.1077	-0.0590	-0.3540
Without Period t_4												
MO^{Comp}	0.0387	0.2392	5.1844	0.2393	0.0002	0.0007	0.0385	0.2386	5.1939	0.2060	-0.0326	-0.1365
$MO^{Comp}(S_2)$ ($MO^{Comp}(B_2)$)	0.0000	0.0000	10.2570	0.0000	0.0000	2.1325	0.0000	0.0000	10.7227	0.0081	0.0081	807.8850
$MO^{Comp}(S_1)$ ($MO^{Comp}(B_1)$)	0.0193	0.1196	5.1841	0.1196	0.0001	0.0005	0.0193	0.1193	5.1936	0.0928	-0.0265	-0.2222
$Eff.\ Spread^{Comp}$	0.0017	0.0033	1.0003	0.0033	0.0000	0.0005	0.0017	0.0033	1.0003	0.0038	0.0005	0.1388
$Quoted\,Spread^{Comp}$	0.0444	0.0380	-0.1423	0.0361	-0.0019	-0.0500	0.0444	0.0380	-0.1427	0.0347	-0.0033	-0.0869
$BBODepth^{Comp}$	0.2822	0.6017	1.1321	0.7922	0.1904	0.3165	0.2818	0.6026	1.1387	0.9364	0.3338	0.5539
$Depth^{Comp}(S_2)$ ($Depth^{Comp}(B_2)$)	0.0000	0.0026	86.9799	0.1930	0.1905	74.3079	0.0000	0.0027	83.7796	0.0938	0.0911	33.7191
$Depth^{Comp}(S_1)$ ($Depth^{Comp}(B_1)$)	0.1411	0.2995	1.1231	0.3017	0.0022	0.0072	0.1409	0.2999	1.1293	0.1605	-0.1394	-0.4649
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.1411	0.3021	1.1409	0.4947	0.1926	0.6376	0.1409	0.3026	1.1480	0.2543	-0.0484	-0.1598
MS^{Comp}	0.1558	0.9631	5.1835	0.9638	0.0007	0.0007	0.1552	0.9613	5.1929	0.9289	-0.0324	-0.0337
With Period t_4												
MO^{Comp}	0.1239	0.2684	1.1667	0.1990	-0.0694	-0.2585	0.1238	0.2677	1.1625	0.1750	-0.0927	-0.3463
$MO^{Comp}(S_2)$ ($MO^{Comp}(B_2)$)	0.0000	0.0005	92.7144	0.0349	0.0344	70.5555	0.0000	0.0005	89.3480	0.0297	0.0292	56.8478
$MO^{Comp}(S_1)$ ($MO^{Comp}(B_1)$)	0.0296	0.1071	2.6143	0.1075	0.0004	0.0040	0.0295	0.1070	2.6201	0.0769	-0.0301	-0.2814
$Eff.\ Spread^{Comp}$	0.0014	0.0027	0.9186	0.0037	0.0010	0.3852	0.0014	0.0027	0.9201	0.0037	0.0010	0.3614
$Quoted\,Spread^{Comp}$	0.0445	0.0403	-0.0945	0.0379	-0.0024	-0.0596	0.0445	0.0403	-0.0950	0.0360	-0.0043	-0.1074
$BBODepth^{Comp}$	0.2740	0.4884	0.7824	0.7280	0.2396	0.4906	0.2737	0.4894	0.7882	0.8813	0.3918	0.8006
$Depth^{Comp}(S_2)$ ($Depth^{Comp}(B_2)$)	0.0000	0.0027	73.9433	0.2059	0.2032	75.4716	0.0000	0.0028	71.0169	0.0897	0.0869	30.6227
$Depth^{Comp}(S_1)$ ($Depth^{Comp}(B_1)$)	0.1370	0.2274	0.6599	0.2419	0.0145	0.0640	0.1368	0.2278	0.6651	0.1215	-0.1063	-0.4665
$Depth^{Comp}(S_2)(B_2) + Depth^{Comp}(S_1)(B_1)$	0.1370	0.2301	0.6791	0.4479	0.2178	0.9466	0.1368	0.2306	0.6854	0.2113	-0.0194	-0.0840
MS^{Comp}	0.3295	0.7368	1.2362	0.8835	0.1467	0.1991	0.3293	0.7361	1.2354	0.8442	0.1081	0.1468

Table A10: **Descriptive Statistics for 2013 Event, ASX Sample.**
This table reports summary statistics for the control group ASX variables. Our 120 ASX listed stocks sample is stratified by price and market capitalization, based on daily averages for the month of January 2012. All variables reported in the tables, daily measures at the stock level, are for the listing exchange only. *Volume* is defined as the daily number of shares (in 000s) at the end-of-day files from Thomson Reuters Tick History (TRTH). *Depth* is defined as the daily average of the intraday quoted depth at the ask-side and the bid-side of each quote respectively. *Spread* is defined as the time-weighted daily average of the intraday difference between the ask price and the bid price of each quote. *%Spread* is defined as the time weighted daily average of the intraday ask price minus the bid price divided by the midquote of each quote. The descriptive statistics for the four measures of market quality are based on daily numbers for each stock in the one-month pre-period (December 2012). We also report *market capitalization* (in £millions) and *price* levels (in £) both variables are daily measures for the month of January 2012. In addition to the overall samples, for all of our variables we also report summary statistics for the subsamples of the highest (*Large*) and lowest (*Small*) market capitalization terciles.

Market Quality Measures		**Mean**	**Median**	**ST dev**	**Q1**	**Q3**
	Large	4,795	4,054	1,778	3,652	5,202
Volume (000s)	Small	2,714	2,536	1,044	2,118	2,745
	Overall	3,905	3,553	1,506	3,016	4,228
	Large	60,644	60,506	9,633	54,803	63,221
Depth	Small	114,969	123,049	37,122	81,329	141,860
	Overall	87,779	88,367	16,151	75,053	99,292
	Large	0.019	0.018	0.002	0.018	0.020
Spread	Small	0.014	0.014	0.001	0.013	0.014
	Overall	0.016	0.016	0.001	0.016	0.016
	Large	0.167%	0.166%	0.009%	0.161%	0.175%
% Spread	Small	0.560%	0.567%	0.021%	0.545%	0.576%
	Overall	0.357%	0.358%	0.011%	0.347%	0.367%
	Large	18,540	8,600	23,366	5,296	18,670
Market Capitalization (AUD Mill)	Small	1,050	1,063	168	909	1,178
	Overall	7,290	2,014	15,595	1,183	5,158
	Large	15.440	11.450	13.721	4.460	24.000
Price	Small	3.654	2.640	3.663	1.371	4.703
	Overall	9.172	4.525	11.687	2.620	11.341