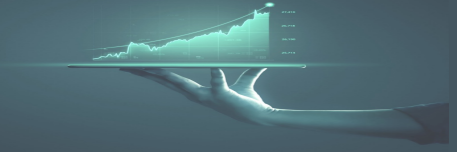


EXEQUITION

Analytics



**Tick Size Optimisation in Japan
Impact on Trading Behaviour**

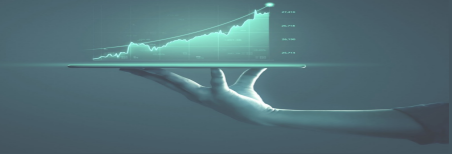


Introduction

Tokyo Stock Exchange implemented the third phase in its 'small tick size' program on June 5th 2023. This program began in 2014 with the introduction of smaller tick sizes for the TOPIX 100 instrument universe and the most recent change extends the smaller tick sizes to include all stocks in the TOPIX 500. We investigate the impact of this change on trading behaviour across Tokyo Stock Exchange (TSE), JapanNext and CBOE Japan by looking at analytics calculated using ICE's Tick History data.

Historical analysis of the changes on the names included in the TOPIX 100 index (representing the 100 largest stocks on TSE by free-float adjusted market capitalization) observed in 2014, allows us to infer some impacts of this change across various aspects of trading behaviour. The most obvious of these is a change in the quoted spreads across the TOPIX 400 instruments, an increase in the number of executions observed throughout the day and a reduction in the average quoted size of the orders. We also expect trading on secondary venues that previously offered a price advantage to the primary venue, because of reduced tick sizes on those venues, to decrease as this advantage disappears.

At ExeQution Analytics we strive to transform data into insights, using ICE Fixed Income and Data Services data, we will move beyond headline numbers to uncover the more unexpected changes in intraday market microstructure. Using ICE's full depth level 3 tick data covering the period May 8th - July 5th 2023 to compare and contrast trading behaviours in the 20 days before and after the change, focusing on a range of analytics that provide additional insight into some of the lesser understood impacts of the tick size change. Throughout this article, we will investigate the impact of the tick size optimisation on the dominance of the primary venue in the national best bid offer, the permanence of the bid-ask spread, the shape of the orderbook, changes to execution price probability and the impact of the changes on price movement rates and intraday volatility.



What Did The Change Involve?

Since TSE first began its small tick size program in 2014, two tick scale maps have been in use for trading on the exchange according to whether the stock is included in the TOPIX 100 index or not. Outside of this index, stocks use a tick scale map with much larger tick sizes.

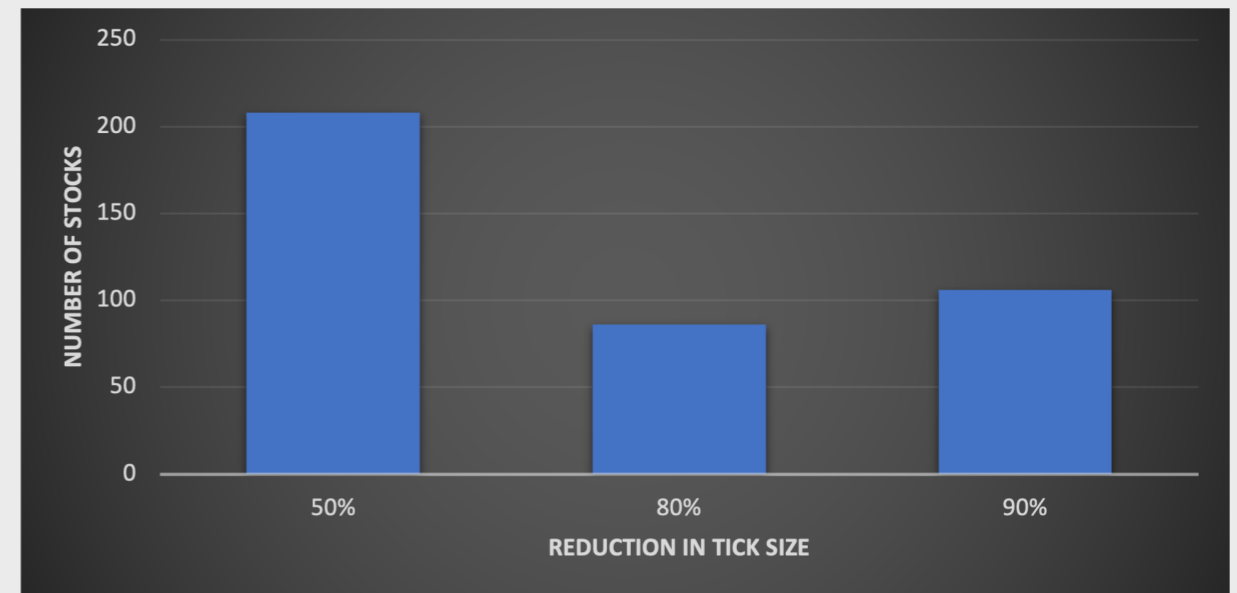
The change implemented on June 5th 2023 applies the TOPIX 100 tick scale map to the next 400 largest stocks trading on TSE - which we will refer to using the term TOPIX 400 for the rest of this analysis. The impact of this change was to reduce tick sizes by 50-90% across the range of prices with the detailed reductions provided in the table below.

Price Range	Tick Size Before	Tick Size After	Reduction
< 1,000	1	0.1	90%
1,000 : 3,000	1	0.5	50%
3,000 : 5,000	5	1	80%
5,000 : 10,000	10	1	90%
30,000 : 50,000	50	10	80%
50,000 : 100,000	100	10	90%

What Type of Stocks Were Impacted ?

There are 4200 stocks trading on TSE. On an average day in 2023, the TOPIX 100 universe accounts for 48% of total traded value across the entire exchange. The TOPIX 400 accounts for a further 29% of trading with the remaining 23% traded across the other 3700 stocks.

We divide the TOPIX 400 stocks into three groups according to the scale of the reduction in tick size, with stocks experiencing either a 50%, 80% or 90% reduction depending on the price at which they were trading prior to the change. We use the close price on June 2nd 2023 to categorise these stocks (the date prior to the tick size optimisation change).



Data Source: ICE Fixed Income & Data Services

Figure 1 : Reduction in tick size of TOPIX 400 stocks

Bid Ask Spread

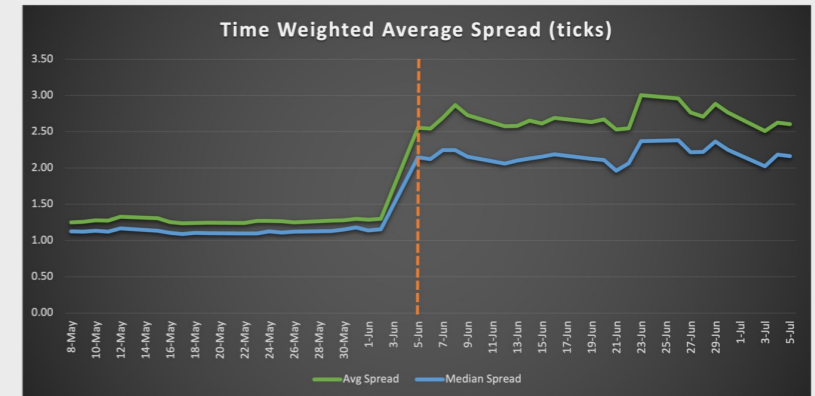
When we express spread as a proportion of tick size and chart the average spread across the 20 days before and after the change, the impact of the change on June 5th is immediately obvious. As can be observed in Figure 2, before the tick size reduction, the bid-ask quoted spread was limited by tick size and hovered just above 1 tick. As soon as the tick size decreased, the average and median time-weighted spread across the universe of 400 stocks jumped to between two to three ticks.

Spread is more commonly expressed in basis points when measuring its contribution to trading costs. It is clear from Figure 3 that expected transaction costs reduced by approximately 50% across the TOPIX 400 universe once the tick size optimisation goes into effect.

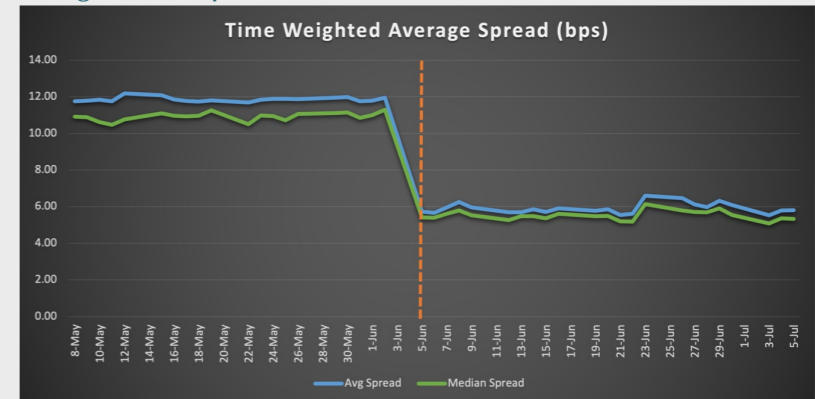
The scale of this decrease in average bid-ask spread across the universe of impacted stocks varied according to both the liquidity of the stock and the extent of the tick size reduction.

In Figure 1, we divided the TOPIX 400 stocks into three groups according to the scale of the reduction in tick size. It is clear from Figure 4 that not only is the extent of the decrease in spread directly correlated with the extent of the tick size reduction, but also that the spread across all stocks converges towards a similar level of approximately six basis points.

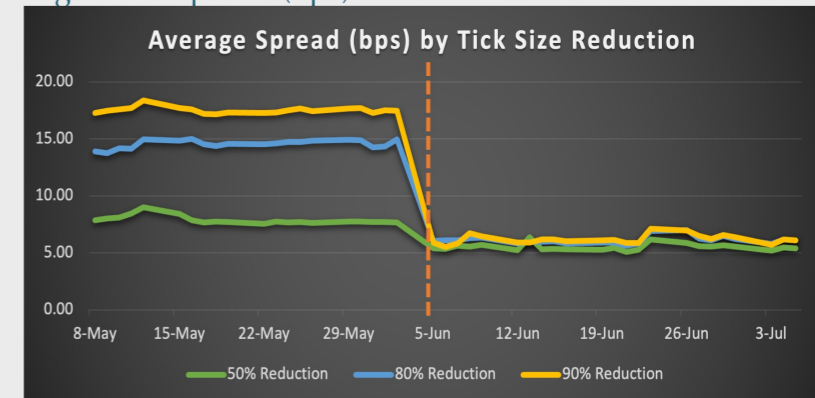
Figure 5 compares average spread before and after the tick size change by liquidity grouping, where liquidity is defined by the average daily value traded. We divide the universe into 10 equal groups of decreasing liquidity. The most liquid stocks appear on the left of Figure 5 and the liquidity of each category decreases along the x-axis. This figure demonstrates that high liquidity stocks have smaller spreads than low liquidity stocks, as well as the largest decrease in spread as a result of the tick size reduction.



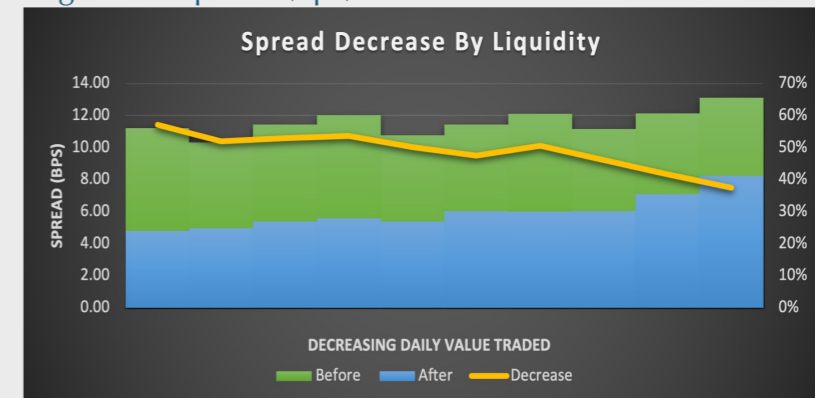
Data Source: ICE Fixed Income & Data Services
Figure 2 : Spread (ticks) of TOPIX 400 stocks over time



Data Source: ICE Fixed Income & Data Services
Figure 3 : Spread (bps) of TOPIX 400 stocks over time



Data Source: ICE Fixed Income & Data Services
Figure 4 : Spread (bps) of TOPIX 400 stocks over time



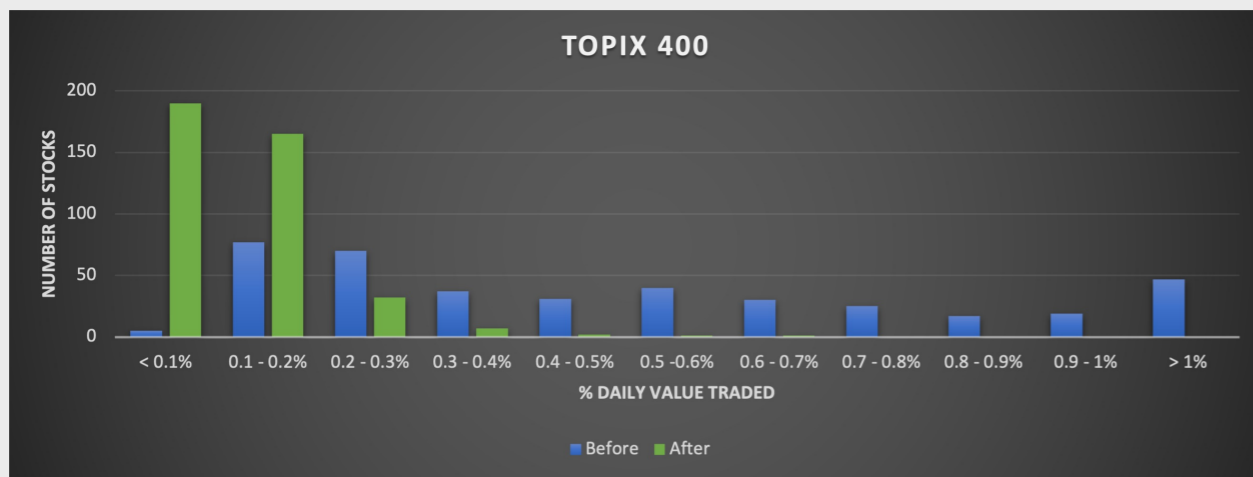
Data Source: ICE Fixed Income & Data Services
Figure 5 : Spread change as liquidity increases



Quote Sizes : TSE

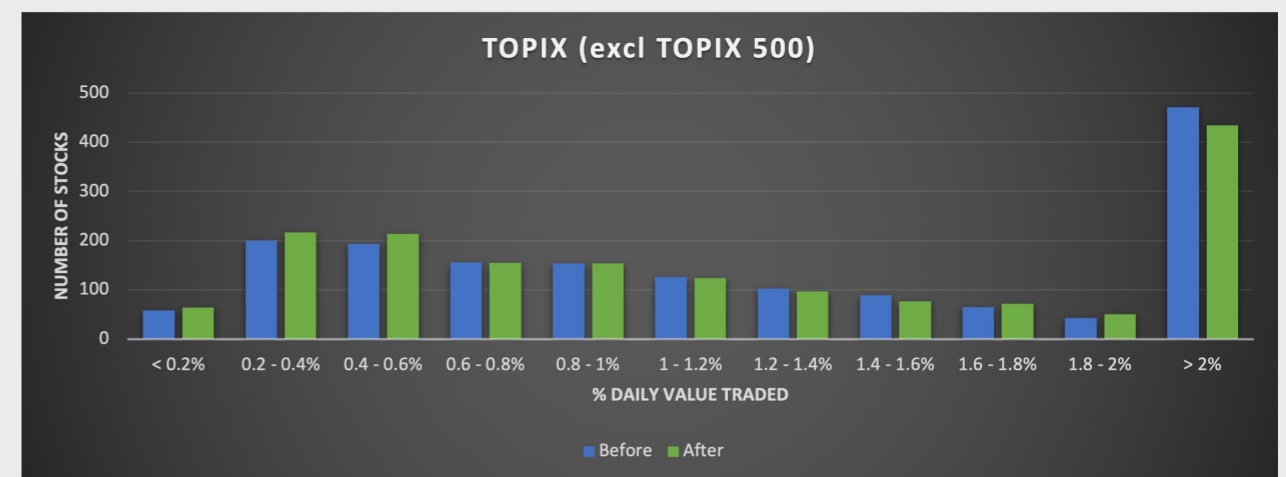
Typically, bid-ask spreads and quote sizes are highly correlated so it is sensible to expect a decrease in quote sizes once the tick sizes are reduced. As the cost of crossing the spread reduces, trading participants will place smaller passive order sizes. To demonstrate this, we calculated the time-weighted average value of shares available across either the bid or the ask at any point in time during continuous trading. We normalise the per-stock data by the total daily value traded to allow for reliable comparison across stocks.

Figure 6 show the distribution of this analytic across the universe of TOPIX 400 stocks whilst Figure 7 shows the same calculation for a group of stocks representative of the wider exchange (stocks included in the TOPIX index, excluding the TOPIX 500). Comparing the distributions before and after the tick size change of these two graphs highlights the reductions across all stocks within the TOPIX 400 universe but very little change across the wider universe.



Data Source: ICE Fixed Income & Data Services

Figure 6 : Distribution of quote sizes as a proportion of daily value traded



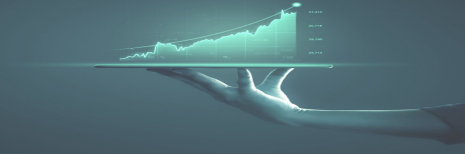
Data Source: ICE Fixed Income & Data Services

Figure 7 : Distribution of quote sizes as a proportion of daily value traded

Table 2 shows the average before and after metrics across the 400 impacted stocks highlighting a significant average decrease across the TOPIX 400 stocks.

Metric	Before	After
Simple Avg	0.55%	0.12%
Median	0.44%	0.11%

Data Source: ICE Fixed Income & Data Services



Quote Sizes By Venue

Before the tick size optimisation by TSE, the secondary venues JapanNext and CBOE supported smaller tick sizes for TOPIX 400 stocks. However, despite this price improvement advantage, quote sizes at best bid/ask prices were much higher on TSE than the equivalent quote sizes on CBOE and JapanNext. This is true before the tick optimisation and remains true afterwards.

Table 3 shows the average aggregate quote size on the best bid/offer for TOPIX 400 names across the three venues over the 20 days before and after the tick size change.

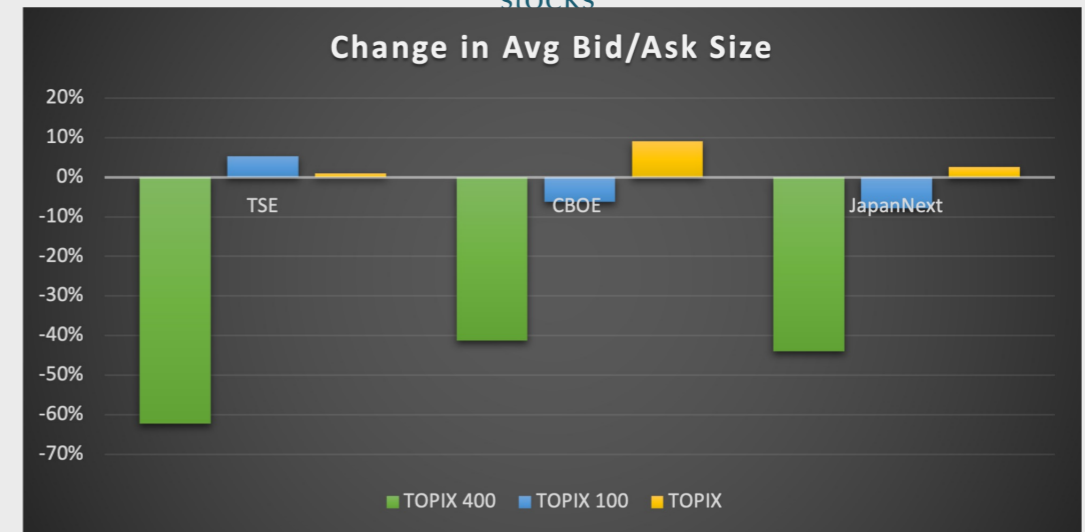
As expected, quote sizes dropped on TSE as a result of the tick size optimisation, but they also dropped quite significantly on both the secondary venues. This result suggests that once the price advantage was eliminated on the secondary venues, trading participants chose TSE as their preferred venue on which to add liquidity to the order book and reduced their passive posting across both secondary venues.

Figure 8 shows the comparison of quote sizes before and after the tick size optimisation for the TOPIX 400 stocks, large cap stocks in the TOPIX 100, and the wider exchange (TOPIX excluding TOPIX 500) which clearly demonstrates that the scale of this decrease is specific to the TOPIX 400 names whose tick sizes changed.

	TSE	CBOE Japan	JapanNext
Before	17,777	550	551
After	6,714	324	309
Decrease	62%	41%	44%

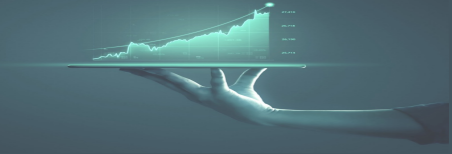
Data Source: ICE Fixed Income & Data Services

Table 2 : Changes in Average Quote Sizes across TOPIX 400 stocks



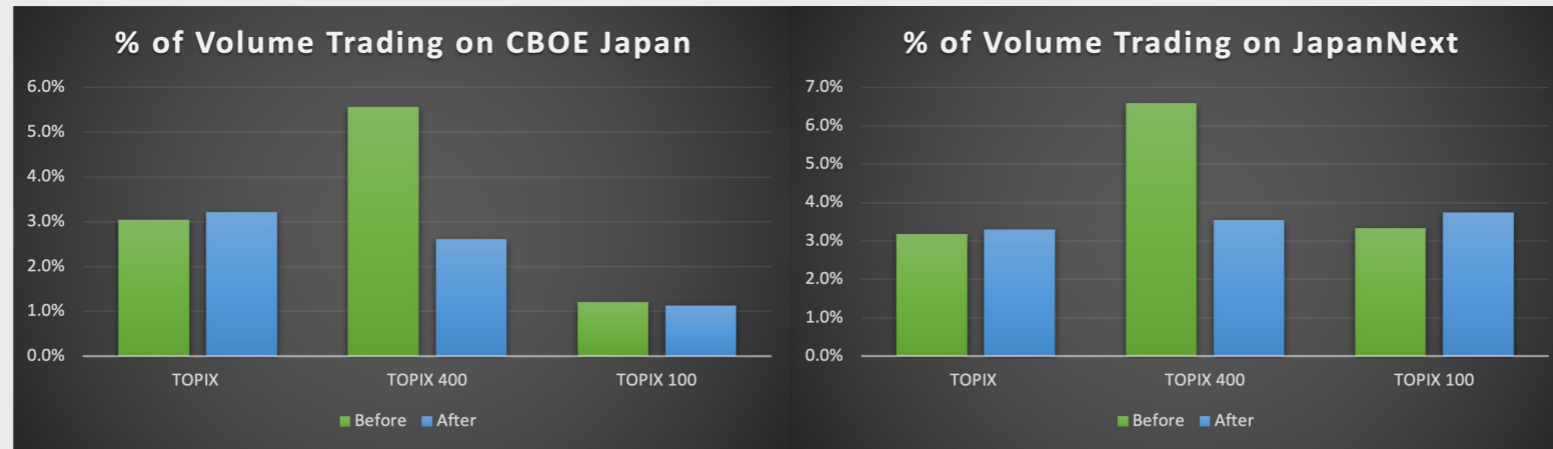
Data Source: ICE Fixed Income & Data Services

Figure 8 : Change in quote sizes after the tick size reduction



Trading Volume Fragmentation

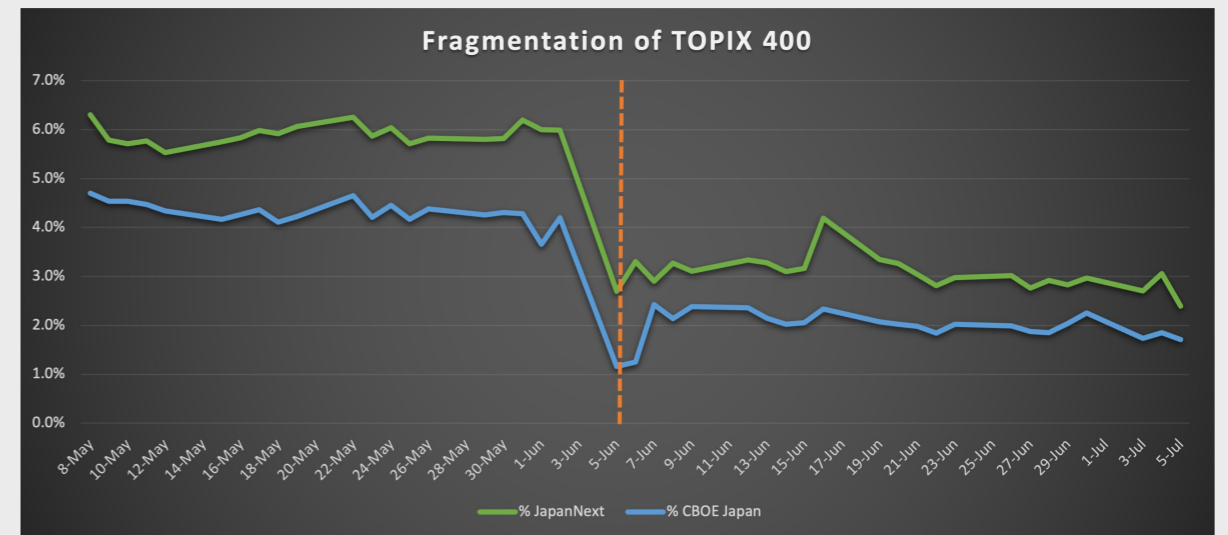
The historical price advantage offered by the secondary venues JapanNext and CBOE, due to the smaller tick sizes available on these venues, resulted in higher trading activity on stocks within the TOPIX 400 universe when compared to both the large cap stocks (TOPIX 100) and the wider exchange (TOPIX excluding TOPIX 400) as can be seen below in Figure 9. When prices were limited by tick sizes on the primary venue, smaller spread capture costs on the secondary venues enticed participants to trade more.



Data Source: ICE Fixed Income & Data Services
Figure 9 : Proportion of volume trading on CBOE & JapanNext

Figure 10 graphs the proportion of continuous traded volume in TOPIX 400 names traded on CBOE and JapanNext, before and after the tick size optimisation. It is clear to see the change caused an immediate drop in traded volume across both venues as trading volume transferred to the primary venue.

We limit our analysis to continuous volume to avoid the skews introduced by the high closing auction volumes on index rebalance days on May 31st and June 16th. The data suggests no significant difference in the distribution of volume between the auction and continuous periods as a result of the tick size change.



Data Source: ICE Fixed Income & Data Services
Figure 10 : Daily Proportion of Value Traded of TOPIX 400

National Best Bid/Offer (NBBO)

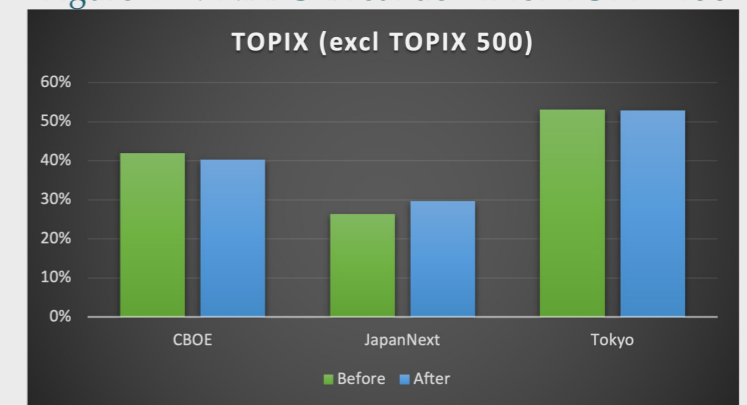
We aligned tick level data from three individual feeds from TSE, CBOE Japan and JapanNext to create an aggregated feed containing the best bid and offer across all venues at each point in time and calculate the proportion of time that each individual venue is present at the best bid or best offer for a stock. The aggregated proportions may exceed 100% as multiple venues can contain the best bid or ask at any point in time.

Figure 11 demonstrates the proportions across the TOPIX 400 stocks whilst Figure 12 shows the same calculation for a group of stocks representative of the wider exchange (stocks in the TOPIX index excluding the TOPIX 500). It is clear to see from Figure 11 that the low representation of TSE within the national best bid/offer for TOPIX 400 names was significantly increased by the tick size reduction. Conversely, the share of best bid/offer on the secondary venues decreased after the change, implying that investors are more likely to favour TSE as the preferred venue on which to add liquidity once the price advantage offered by the secondary venues disappears. Figure 12 shows relatively unchanged proportions across the wider exchange.

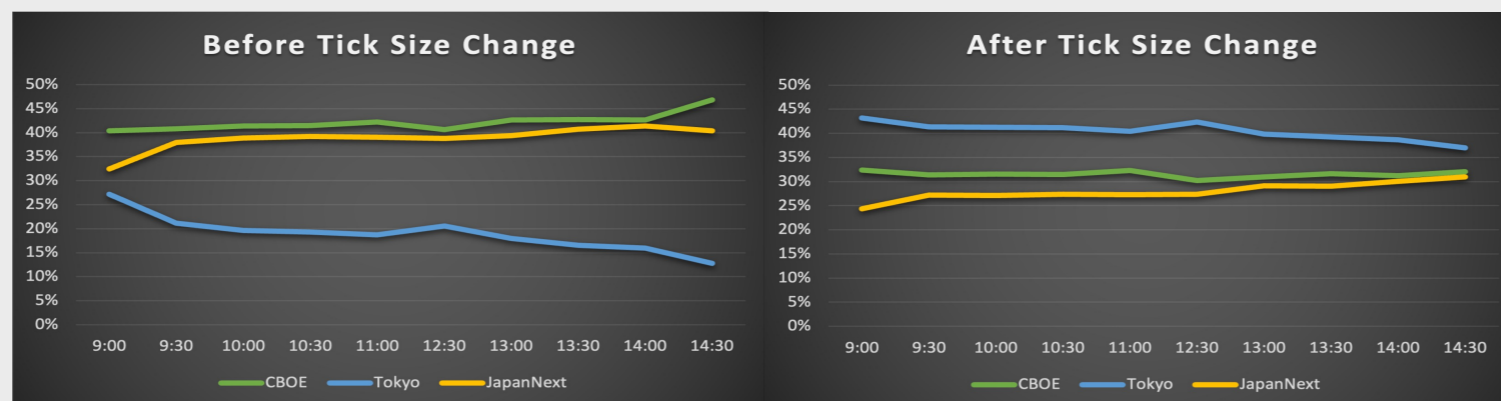
We were interested to understand whether the make up of the NBBO was consistent throughout the day. We divided the day into 30 minute bins and measured the average participation of each venue in each 30 minute bin across the TOPIX 400 stocks. Figure 13 shows a clear decrease in the participation of TSE within the NBBO for these names as the trading day progresses. Before the tick size change, TSE contained the primary bid or ask during the opening 30 minute only 27% of the time and this decreased over the day to a low of 13% in the final 30 minute bin. After the tick size optimisation, TSE is much more dominant, containing the best bid or ask 43% of the time, more often than either of the other two venues, and whilst this continues to decrease throughout the day, ending the day at 37%, the slope of this decrease is much less significant after the tick size change.



Data Source: ICE Fixed Income & Data Services
Figure 11 : NBBO Breakdown for TOPIX 400



Data Source: ICE Fixed Income & Data Services
Figure 12 : NBBO Breakdown for TOPIX stocks



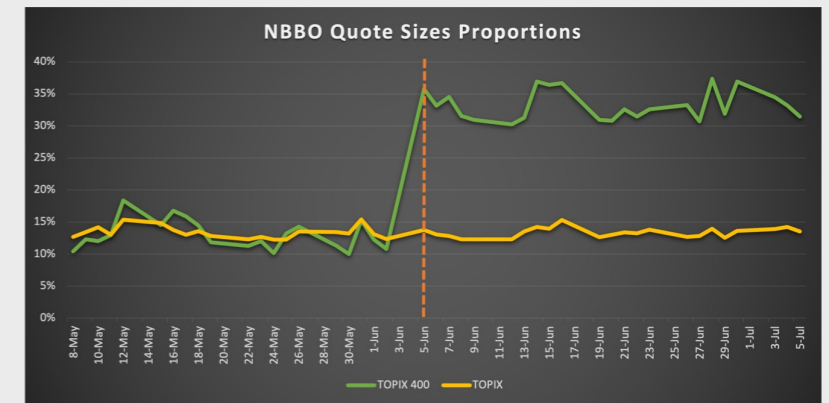
Data Source: ICE Fixed Income & Data Services
Figure 13 : Intraday NBBO By Venue for TOPIX 400 Stocks



NBBO Quote Sizes

This conclusion on the previous page prompted us to investigate how the tick size optimisation impacted the depth of the orderbook by representing the volume available at the top level of the orderbook as a proportion of the total volume across the top ten levels of depth. Figure 14 shows how this metric changed for both the TOPIX 400 whilst it remained consistent across the wider universe represented by the TOPIX excluding the TOPIX 500.

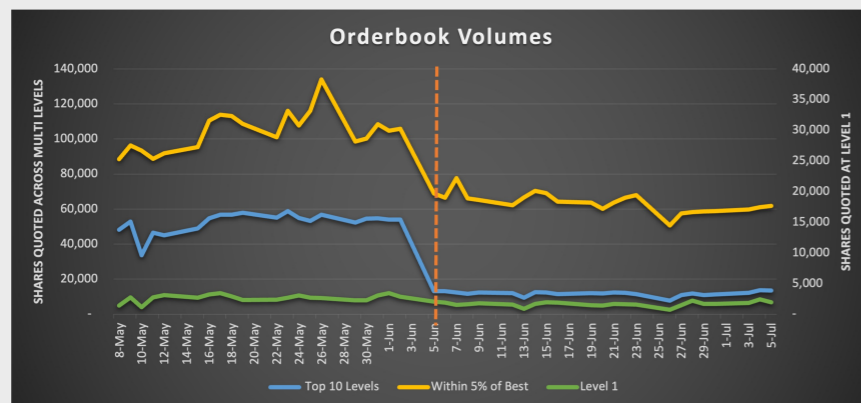
This is a fairly intuitive result as the tick size change reduced the range of prices represented by the top ten levels of depth, so it is expected that NBBO volumes are a higher proportion of the volume available within this narrower price range.



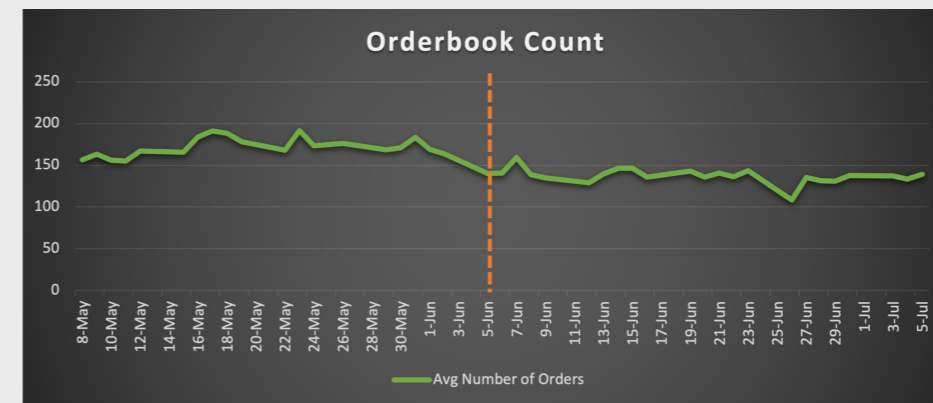
Data Source: ICE Fixed Income & Data Services
Figure 14 : Average % of NBBO Quote Sizes to Top 10 Levels

As previously noted in Figure 6, the volume available at the top level of the orderbook decreased as a result of the tick size optimisation. As the cost of crossing the spread decreased, trading participants responded by resting less volume passively. To measure whether this reduction in order quantity occurs throughout the orderbook as a whole, it is not sufficient to measure the volume across only the top 10 levels as the range of prices within the top ten levels narrows as a result of the tick size change.

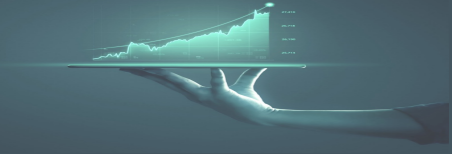
A better way to investigate this pattern is to use full orderbook data. We calculated the total volume at all prices that are entered within 5% of the current best bid and best ask. The purpose of this limit is to focus our analysis on orders that have a reasonable chance of execution throughout the day. We did not want to skew the results with orders that are highly unlikely to impact trading activity. Whilst this range of prices will increase in granularity as a result of the tick size optimisation, the range itself is independent of the tick size so does not change. Figure 15 shows that similar to the top level, the total volume available within this range decreased significantly as a result of the tick size optimisation. Not only did total quote sizes reduce across all levels but Figure 16 shows that the total number of orders posted across the same price range also reduced, albeit less significantly.



Data Source: ICE Fixed Income & Data Services
Figure 15 : Average Orderbook Volumes for TOPIX 400

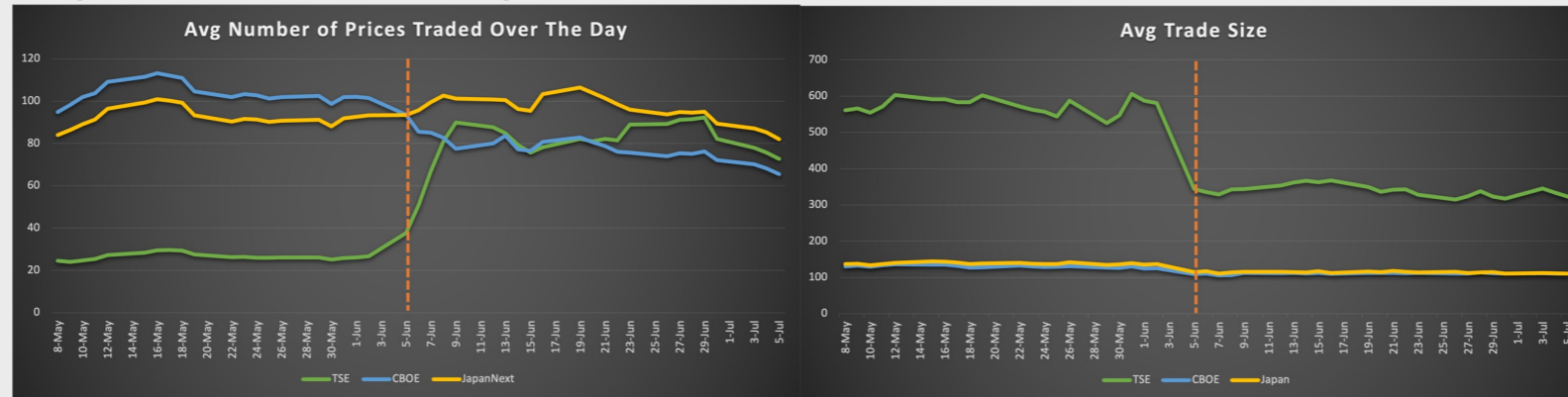


Data Source: ICE Fixed Income & Data Services
Figure 16 : Average Number of Orders within 5% of Best Bid/Ask for TOPIX 400



Stock Volatility

We measure stock volatility using a number of different metrics. Obviously, the introduction of reduced tick sizes enables significantly more prices to trade within the same price range on any given day. Figure 17 shows the number of distinct prices increased on TSE as soon as the change goes into effect, yet interestingly still lies below the number of distinct prices trading on JapanNext. This change goes hand-in-hand with a decrease in the average trade size on TSE, although the average trade size on this venue remains significantly higher than the average trade sizes quoted on CBOE and JapanNext.



Data Source: ICE Fixed Income & Data Services

Figure 17 : Avg Number of Prices and Trade Sizes for TOPIX 400 Stocks

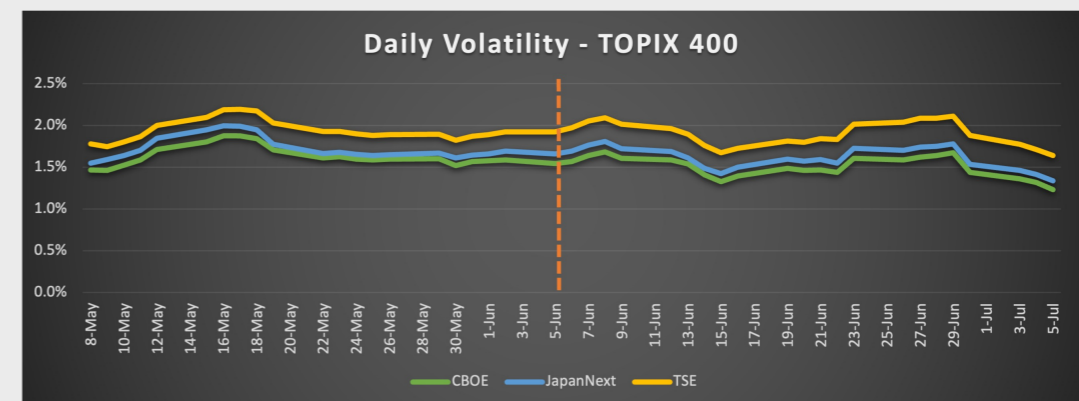
What is arguably more important to understand is if this additional price granularity has increased or decreased volatility in terms of the difference between absolute movement between the high and low price traded over the day. Table 4 shows a small decrease on TSE, and a slightly larger decrease on the secondary venues

However, charting this calculation by date in Figure 18 suggests this decrease lies within the regular day to day variation on each venue.

	TSE	CBOE Japan	JapanNext
Before	196	165	174
After	186	145	157
Ratio	94%	88%	90%

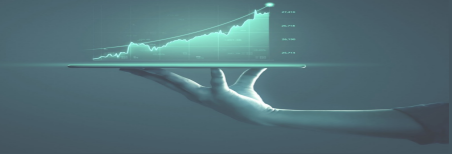
Data Source: ICE Fixed Income & Data Services

Table 4 : Average Daily High-Low Movement (bps) for TOPIX 400



Data Source: ICE Fixed Income & Data Services

Figure 18 : Average Daily High-Low Movement (%) for TOPIX 400



Intraday Volatility

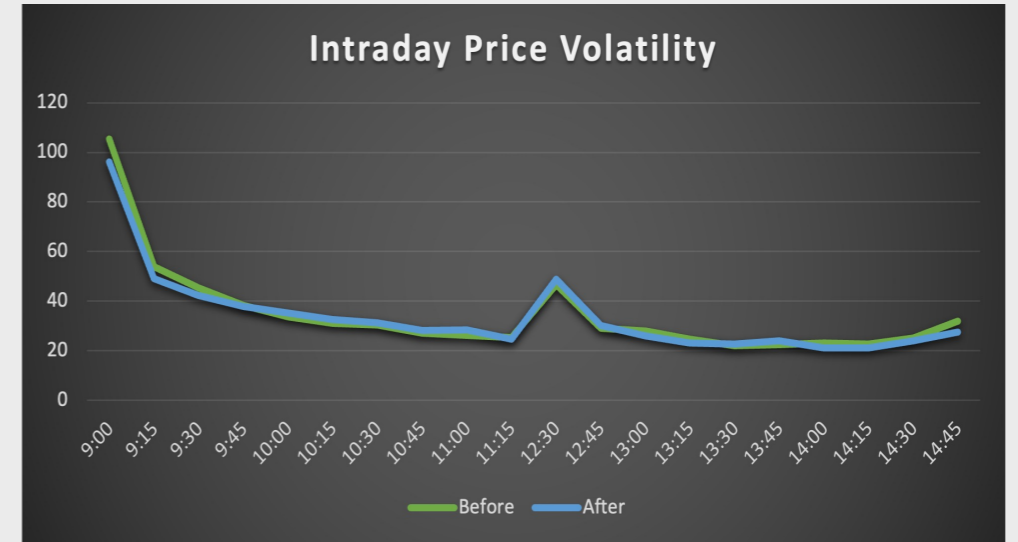
When we split the trading day into smaller windows, the decrease in volatility is subtle, and only noticeable in the opening and closing bins of the day. Figure 19 shows average basis point high-low movement in 15 minute bins on TSE and clearly demonstrates that intraday volatility continues to show the same shape before and after the tick size change, with excess price movement in the morning, flattening as the day progresses and a temporary increase around the lunch break auctions.

Another measure of intraday price volatility is how fast we expect prices to move. To measure this we focus on the mid-price of top level quotes on TSE to ensure our analysis is not skewed by bid-ask bounce, and consider two primary measures of the volatility of mid price.

Firstly, we measure the variance ratio of each stock, which we define as the log of the mid-price returns observed at one minute intervals throughout the trading day. We average this throughout the day to obtain a variance ratio per stock, per day and compare the average values before and after the tick size change.

Universe	Before	After	% Change
TOPIX 400	5.28	6.31	20%

Data Source: ICE Fixed Income & Data Services
Table 5 : Changes in Variance Ratio



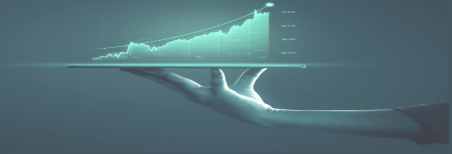
Data Source: ICE Fixed Income & Data Services

Figure 19 : Average high low movement in 15 minute bins for TOPIX 400

Secondly, we define mid-time move as the average duration that a mid-price is constant before a change in price. This measure shows increased micro volatility as a result of the tick size change, with the average duration for TOPIX 400 names decreasing to half its previous value.

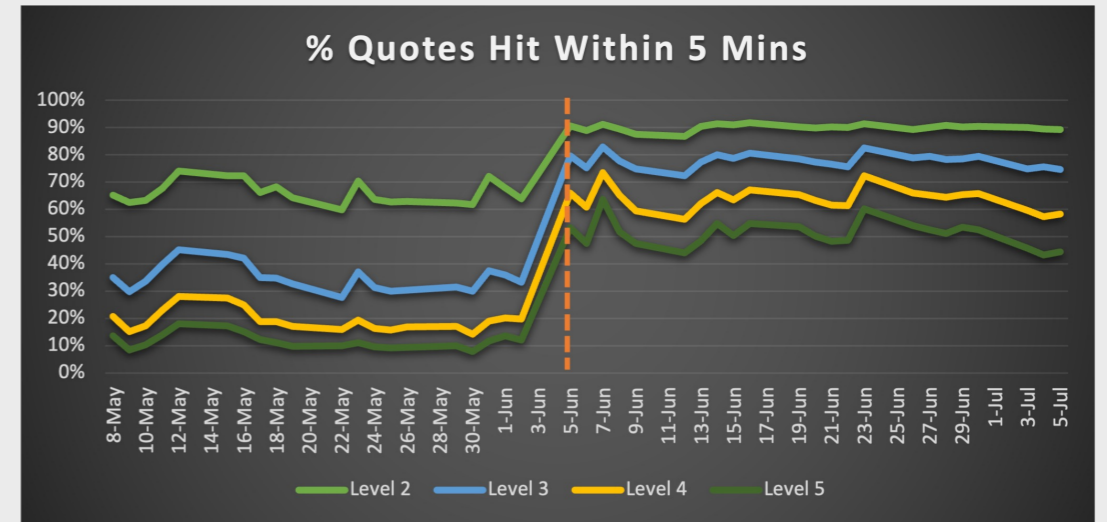
Universe	Before	After	% Change
TOPIX 400	0:00:25	0:00:12	-51%

Data Source: ICE Fixed Income & Data Services
Table 5 : Changes in Mid Time Move



Execution Price Probability

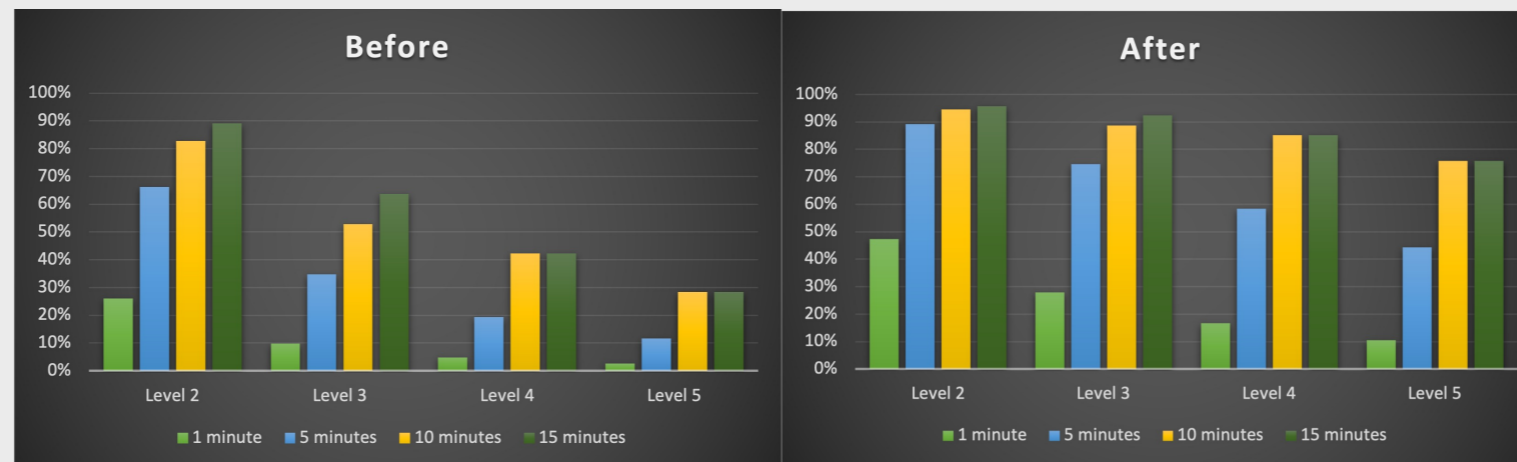
We finish our analysis with a measurement of execution price probability which we define as the likelihood of a passive order entered below the best bid, or above the best offer, executing within a specified time frame. We dive into the orderbook data available on TSE and measure the proportion of times a price, quoted in the orderbook at 2-5 levels of depth, was executed within the subsequent five minute window. Figure 20 shows how this probability changes over the 20 days before and after the tick size optimisation. The increase in the execution price probability across the top five levels of depth is an obvious consequence of the narrowing price range between each level.



Data Source: ICE Fixed Income & Data Services

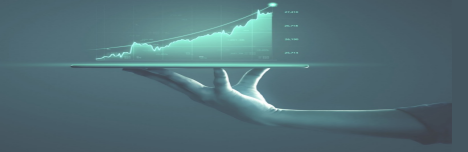
Figure 20 : Execution price probability within 5 minutes for TOPIX 400

Figure 21 extends the same calculation over a number of time frames to offer a summary comparison of execution price probability in TSE before and after the tick size change. Many algorithmic trading strategies place passive volume at several levels in the orderbook with the goal of capturing temporary price movements in their favour, minimising market impact and price slippage. To ensure execution patterns remain within configurable risk constraints, it is important to understand the likelihood of each level being executed within various time frames.



Data Source: ICE Fixed Income & Data Services

Figure 21 : Execution Price Probability across different time windows for TOPIX 400



Conclusions

The most recent phase in the Tokyo Stock Exchange 'Small Tick Size Program' impacted 400 mid-cap stocks which, combined, account for approximately 29% of trading on the exchange. These 400 stocks saw tick size reductions of between 50-90% on June 5th 2023.

The impact of this change was to reduce average spread by about 50% across the 400 stocks on average, with the most liquid stocks showing the largest decreases. Average quote sizes (the quantity posted on the bid or offer at any given point in time) saw an even greater reduction, across all three venues. When normalised by the average daily value traded, the median value on TSE dropped by 75% and the simple average by 79%.

As the secondary venues, CBOE Japan and JapanNext previously offered smaller tick sizes for these stocks, they historically saw a greater share of trading in TOPIX 400 stocks when compared to the wider exchange. Once this price advantage was removed, participation in TOPIX 400 stocks on CBOE Japan dropped from 5.5% to 2.8% and on JapanNext from 6.5% to 3.5%. This led to an increase in continuous trading participation on TSE from 88% to 94%. The data suggests no significant change in the distribution of volume between auction and continuous trading periods.

As a result of the price advantage on secondary venues, prior to the change TSE was under represented in the NBBO (national best bid/offer) for TOPIX 400 stocks, containing the best bid or offer only 28% of the time. With the introduction of the tick size optimisation and the removal of this price advantage, this participation doubled, whilst participation by the secondary venues decreased. The dominance of the primary exchange in the NBBO is not static throughout the day but decreases as the day progresses. Comparing this calculation over dates before and after the tick size change shows that the slope of the decrease is less steep after the tick size optimisation.

Aggregate order size at the best bid or offer decreased not only on TSE but across all venues for the universe of names impacted by the change. Aggregate order size over the top ten levels of depth decreased by approximately 75% as a result of the optimisation, which is intuitive when we consider the range of prices across these levels decreased similarly.

Peak volatility occurs at the very start of the day in TSE, in the first few minutes after the exchange opens, then decreases as the day progresses (with a spike at the time of the lunch break auctions) before increasing again towards the close. This pattern is unaffected by the tick size optimisation but the data suggests a small decrease in intraday volatility at peak times as traders can now choose between a more granular range of prices. The tick size optimisation did not have significant impact on absolute high-low movement observed at a daily level.

Measuring the rate of price change moves and the stability of the spread shows the variance ratio increased by 20% whilst time between mid-price changes decreased by half. Execution price probability analysis shows significant increases in the likelihood of an order entered at depth being executed within a range of time windows after the optimisation was introduced.

EXEQUTION

A n a l y t i c s

At ExeQution Analytics, we pride ourselves on our ability to harness the power of market data to offer detailed analysis on the ever-evolving world of market microstructure and trading behaviours. Analysing financial trading data presents many hurdles and opportunities. The sheer volume of data, coupled with its granularity and complexity poses challenges to overcome but each piece of information holds a wealth of insights waiting to be unlocked. Amidst the chaos and noise, lies the potential of discovery and innovation. Every tick, every trade, and every market event offers an opportunity to uncover hidden patterns, exploit inefficiencies, and gain a competitive edge. We strive to identify these opportunities and transform data into actionable strategies.

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