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How Changes in Tick Sizes Affect Investors' Execution Costs

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Abstract

The tick size is not just a price unit used when executing an order. It is also a vital component of the execution costs paid by investors. In 2014, the Tokyo Stock Exchange (TSE) started a pilot program to reduce the tick size for the TOPIX 100 constituents, thus lowering the tick size of the high-liquidity stocks. After that, investors pointed out that medium-liquidity stocks, ETFs and ETNs, also had coarse tick sizes. The "Action Program for Strengthening the Functions of the Cash Equity Market," announced in January 2020, indicated that steps would be taken to optimize tick sizes. As of November 29, 2021, the tick table for the TOPIX 100 constituents was applied to ETFs, ETNs, and others (ETFs, etc.) in principle. Consequently, trial calculations showed that all ETFs, etc. that had changes in tick size resulted in a reduction in execution costs of ¥8.6 billion per year.

Consequently, the changes in the tick sizes for ETFs, etc., are not classified by each stock's liquidity or other attributes. Generally, these tick sizes are smaller than for TOPIX 100 stocks. This paper analyzes ETF, etc. issues by dividing them into the top, middle, and bottom trading value groups to determine the effects of the changes in tick sizes by liquidity.

For the top group (Group 1), when the tick size was reduced by 80% or more, the effective spread declined significantly, with a significant decline in intraday volatility. Moreover, because the variance ratio approached 1 after the tick size changed, execution costs in the upper group declined as per the program's aim, meaning that the market quality also improved. At the same time, the variable for change in tick size for the middle and lower groups was not significant. While such change did not necessarily have a favorable impact, the feared negative effects were

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also limited.
Using these analytical findings, we estimated the effect of reducing execution costs (effective spread) when applying the TOPIX 100 tick size table to the Mid 400, an index consisting of medium-liquidity stocks. Our trial calculations showed that it reduced execution costs annually by between ¥55.3 billion and ¥72.2 billion.

Contents

1 Introduction

A "tick" represents the content of an investor's order for shares or other securities on a financial instruments exchange (exchange), and the tick size is the smallest unit in the price of an order. Orders cannot be executed for stocks with less than the minimum tick size limit. Hence, investors registered on the exchange order book[1] who want to prioritize trading in limit orders at the highest priority quote price[2] must execute orders at prices higher than the tick size (1 unit). As a result, the tick size is not merely a unit designating a price but also a crucial part of an investor's execution costs.

From the standpoint of lowering investors' execution costs, smaller tick sizes are generally better. However, there are also drawbacks to having a tick size that is too small. Specifically, it makes it harder to place a large-lot order because it would be spread across several price ranges, leading to a prioritization of almost economically meaningless trades, reduced trading predictability. Thus, determining an appropriate tick size is essential to the trading rules.

This paper analyzes the impact of applying a tick size table with smaller tick sizes used for TOPIX 100 constituents (TOPIX 100 tick size table) to issues in TSE-listed ETFs, etc., as of November 29, 2021.

In section 2, we give an overview of tick sizes in Japan, the U.S., and Europe. Section 3 reviews prior research on changes in tick sizes, and in section 4, we formulate some hypotheses based on prior research. In section 5, we go over the data and analytical methodology used in our analysis, and in section 6, we discuss our analytical results. Section 7 uses the analytical results to estimate the impact of applying the TOPIX 100 tick size table to the stocks that make up the TOPIX Mid 400,[3] and section 8 presents our conclusions.

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[1] The Exchange receives buy and sell orders from trading participants and records. Those orders are arranged by order price with time priority.

[2] For a buy order, it refers to the highest price registered on the order book, and for sell order, it refers to the lowest price registered on the order book.

[3] It is one of the "market capitalization-weighted" indces that classify TOPIX constituents by market capitalization and liquidity (trading value) and consists of 400 stocks with the second highest market capitalization and liquidity after TOPIX100. In this paper, TOPIX Mid400 constitutes are treated as mid-liquidity stocks.

2 Tick sizes

2.1 The development and current status of tick sizes in Japan

The TSE has responded to news about the optimization of tick sizes as it comes out. On January 4, 2010, the launch of the cash trading system known as “arrowhead”[4] saw tick sizes reduced. Then in 2014, it implemented a pilot program (Phases 1 and 2) for TOPIX 100 stocks, and it has reduced the tick size for highly liquid stocks in the TOPIX 100.

Despite these reforms, market participants have been saying that the tick sizes of some stocks remain too coarse. The time weighted average spread of a stock for one day (bid-ask spread) and spread-to-tick ratio (STR)[5] are indicators of the appropriateness of a tick size. If the tick size is too big, the spread will converge with the tick size, and the STR will approach 1. If the tick size is too small, the STR will increase. We used the STR to gain an understanding of current optimal tick sizes. We plotted the following graphs for stock prices in these indices from October 28 through November 26, 2021 (20 business days), with the stock price on the X axis and the STRs counted for each range on the Y axis.[6] As the graphs show, STRs for stocks in the TOPIX 100 are mainly within the optimal range,[7] but many stocks with prices of ¥4,000 or less have relatively large tick sizes. Also, we see that many stocks in the TOPIX Mid 400 have extremely small STRs (the tick size is too large). Most of the tick sizes for stocks in the TOPIX Small and TSE Mothers indexes are in the optimal range. However, while the tick size is too large for those with prices of ¥500 or less, it tends to be too small for those in the ¥1,000–¥3,000 price range.[8]

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[4] In Japan, the tick sizes are not defined by law, and exchanges and PTSs define the tick sizes in their own rules. On the other hand, in Europe and the U.S.. the smallest tick sizes are defined by law.

[5] The calculation method is described later.

[6] The stock price(VWAP) and STR are calculated for each stock for each business day during the data analysis period, and the number of stock is counted for each stock price and STR category.

[7] Referring to Hunang et.al (2017), STR of 1.5 or less is considered to be an excessive tick size and STR of 1.5 to 5.0 is an appropriate range, and the same idea is used in this paper.

[8] The trend for JASDAQ stocks is similar to that for TOPIX Small composition and Mothers stocks, therefore, the graph is omitted.

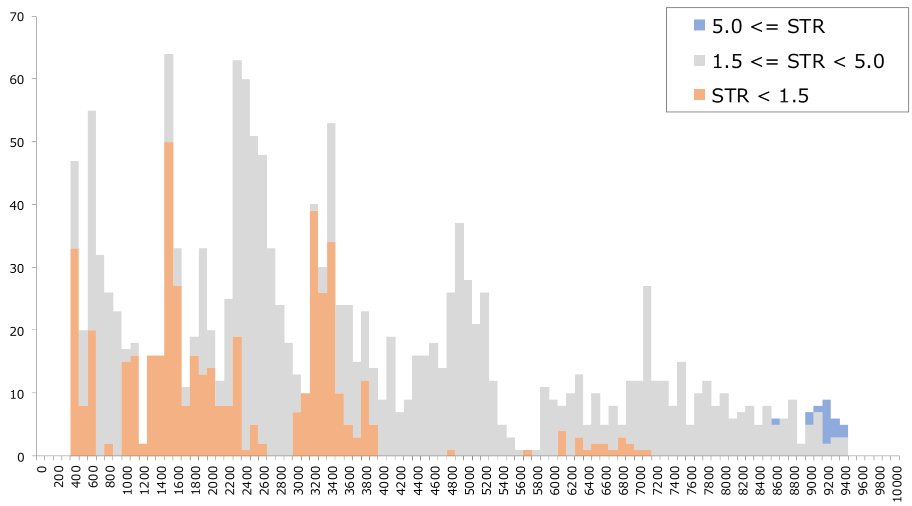

Figure 2.1 STR distribution of TOPIX 100 stocks

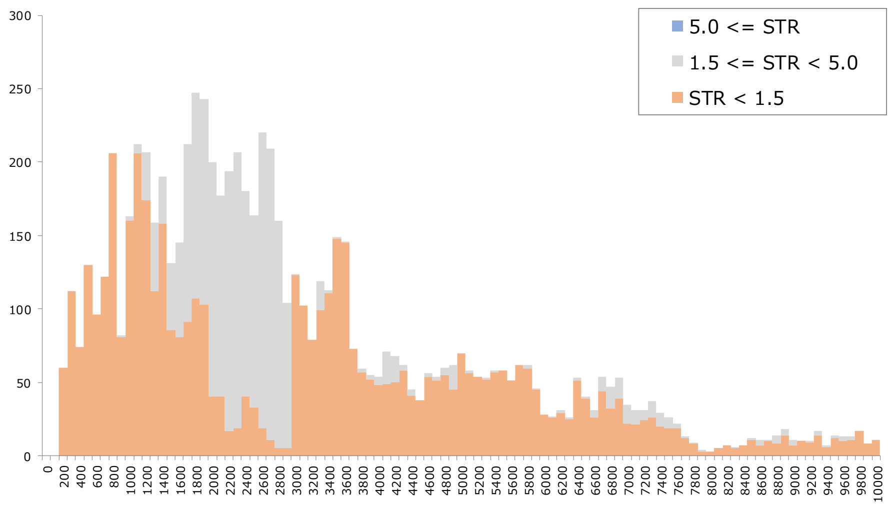

Figure 2.2 STR distribution of TOPIX Mid400 stocks

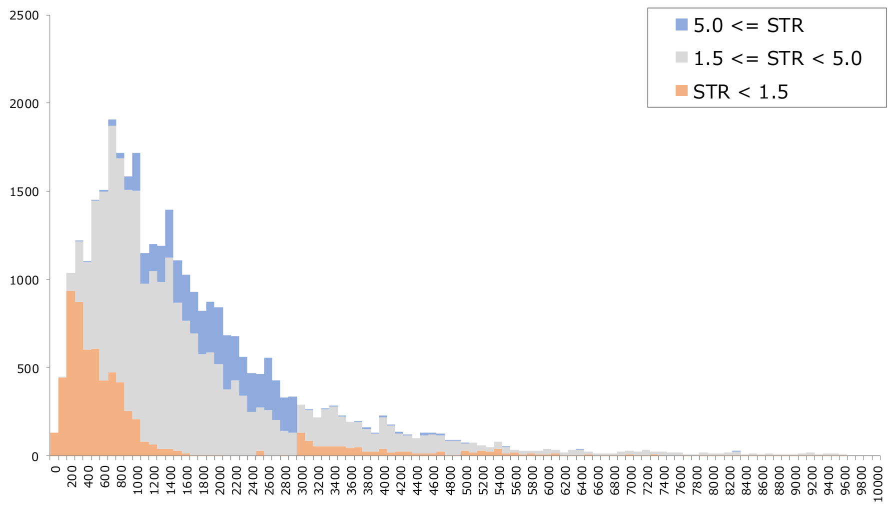

Figure 2.3 STR distribution of TOPIX Small stocks

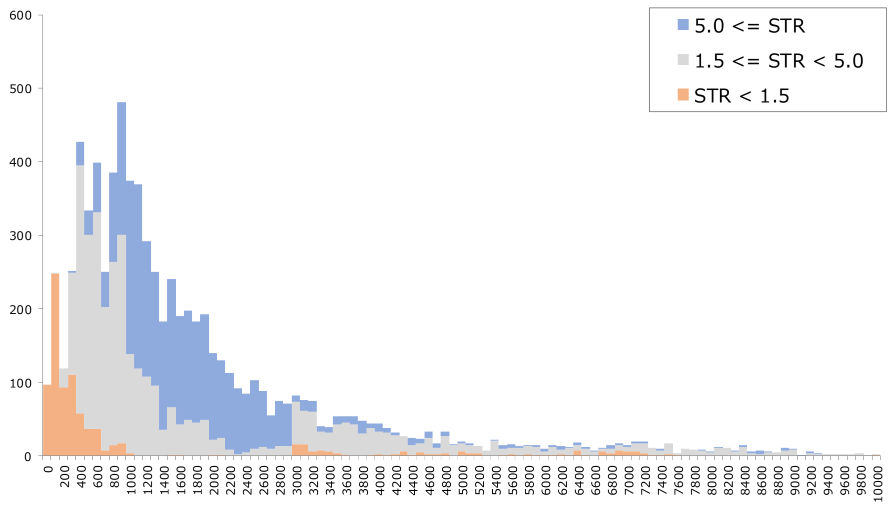

Figure 2.4 STR distribution of TSE Mothers listed stocks

Having a tick size that is too large means that investors have been paying unnecessary execution costs. Optimizing the tick size will enable many individual and long-term investors to pay lower execution costs on their trades. Therefore, on January 30, 2020, the TSE unveiled its Action Program for Strengthening the Functions of the Cash Equity Market,[9] which was meant to optimize tick sizes. On November 29, 2021, it revised the tick sizes in effect for ETFs, etc., so that all these issues would, in principle,[10] use the tick sizes applicable to TOPIX 100 stocks.[11]

[9] For more information on the Action Program for Strenghening the Functions of the Cash Equity Market, please refer to the TSE website(https://www.jpx.co.jp/english/corporate/news/news-releases/0060/20200130-01.html).

[10] The tick size table applied to TOPIX 100 stocks will include fractional yen amounts depending on the price range. Therefore, it is necessary to avoid the case where the trading unit is 1 unit ETFs and ETNs and the trading value contained less than one yen. For ETFs and ETNs with a trading unit of one unit, if the closing price falls below ¥5,000, the other tick size table(not TOPIX100 stocks tick size table) shall, in principle, be applied form the day two business days later. After that, if the closing price subsequently reaches ¥7,000 or more, the TOPIX 100 tick size table will be applied from the day two business days after.

[11] See TSE website (https://www.jpx.co.jp/english/news/1030/20211125-02.html).

Table 2.1 Changes in tick sizes on the TSE

<table>
<tr><th rowspan="2">price(JPY)</th><th>all</th><th>all</th><th>all</th><th>all</th><th>all</th><th colspan="3">TOPIX100 stocks</th><th>TOPIX100 stocks and ETFs</th><th>other stocks</th></tr>
<tr><th>1985/12/2</th><th>1998/4/13</th><th>2000/7/17</th><th>2008/7/22</th><th>2010/1/4</th><th>2014/1/14</th><th>2014/7/22</th><th>2014/9/24</th><th>2022/11/29</th><th>2010/1/4～</th></tr>
<tr><td>1,000 or less</td><td>1</td><td rowspan="2">1</td><td rowspan="2">1</td><td rowspan="2">1</td><td rowspan="3">1</td><td rowspan="5">1</td><td>0.1</td><td>0.1</td><td>0.1</td><td rowspan="3">1</td></tr>
<tr><td>>1,000 – 2,000</td><td rowspan="4">10</td><td rowspan="3">0.5</td><td rowspan="2">0.5</td><td rowspan="2">0.5</td></tr>
<tr><td>>2,000 – 3,000</td><td>5</td><td>5</td><td>5</td></tr>
<tr><td>>3,000 – 5,000</td><td rowspan="3">10</td><td rowspan="3">10</td><td rowspan="3">10</td><td>5</td><td rowspan="2">1</td><td rowspan="2">1</td><td>5</td></tr>
<tr><td>>5,000 – 10,000</td><td rowspan="2">10</td><td>1</td><td rowspan="2">10</td></tr>
<tr><td>>10,000 – 30,000</td><td rowspan="3">100</td><td rowspan="2">5</td><td rowspan="2">5</td><td>5</td><td>5</td></tr>
<tr><td>>30,000 – 50,000</td><td>50</td><td>50</td><td>50</td><td>50</td><td rowspan="2">10</td><td rowspan="2">10</td><td>50</td></tr>
<tr><td>>50,000 – 100,000</td><td>100</td><td>100</td><td rowspan="2">100</td><td rowspan="2">100</td><td>10</td><td>10</td><td rowspan="2">100</td></tr>
<tr><td>>100,000 – 300,000</td><td rowspan="3">1,000</td><td rowspan="3">1,000</td><td rowspan="3">1,000</td><td rowspan="2">50</td><td rowspan="2">50</td><td>50</td><td>50</td></tr>
<tr><td>>300,000 – 500,000</td><td rowspan="3">1,000</td><td>500</td><td rowspan="2">100</td><td rowspan="2">100</td><td>500</td></tr>
<tr><td>>500,000 – 1,000,000</td><td rowspan="2">1,000</td><td>100</td><td>100</td><td rowspan="2">1,000</td></tr>
<tr><td>>1,000,000 – 3,000,000</td><td rowspan="7">10,000</td><td rowspan="7">10,000</td><td rowspan="4">10,000</td><td rowspan="2">500</td><td rowspan="2">500</td><td>500</td><td>500</td></tr>
<tr><td>>3,000,000 – 5,000,000</td><td rowspan="3">10,000</td><td>5,000</td><td rowspan="2">1,000</td><td rowspan="2">1,000</td><td>5,000</td></tr>
<tr><td>>5,000,000 – 10,000,000</td><td rowspan="3">10,000</td><td>1,000</td><td>1,000</td><td rowspan="3">10,000</td></tr>
<tr><td>>10,000,000 – 20,000,000</td><td rowspan="3">5,000</td><td rowspan="3">5,000</td><td rowspan="2">5,000</td><td rowspan="2">5,000</td></tr>
<tr><td>>20,000,000 – 30,000,000</td><td>50,000</td><td>50,000</td></tr>
<tr><td>>30,000,000 – 50,000,000</td><td rowspan="2">100,000</td><td rowspan="2">100,000</td><td>50,000</td><td rowspan="2">10,000</td><td rowspan="2">10,000</td><td>50,000</td></tr>
<tr><td>>50,000,000</td><td>100,000</td><td>10,000</td><td>10,000</td><td>100,000</td></tr>
</table>

* unit is JPY

2.2 Overview of tick sizes in the United States and Europe

2.2.1 The United States

Regulation NMS (National Market System) is the legislation proposed by the Securities and Exchange Commission (SEC) in 2004 that deals with comprehensive reform of the market's setup. Article 612 of this act designates $0.01 as the smallest tick size for electronic communications networks (ECNs). Although the one-cent tick size is not compulsory, and it is possible to use tick sizes greater than one cent, the resulting effect was that all exchanges and ECNs made their tick size the lowest amount as determined by Regulation NMS.

Table 2.2 Tick sizes in the U.S.

Price	Exchanges and ECNs
Less than 1USD	0.0001
1USD Or more	0.01

* Unit is U.S. dollars (USD)

In response to comments that such small tick sizes were possibly hindering the trading activity of small-cap stocks with low liquidity, on August 25, 2014, the Financial Industry Regulatory Authority, together with the U.S. national security exchanges, proposed the Tick Size Pilot Plan, which was approved by the SEC on May 6, 2015. Under the Tick Size Pilot Plan, stocks that meet certain conditions[12] (2,400 stocks) were classified into a control group of 1,400 stocks trading with the traditional one cent (0.01USD) tick size and the following three test groups.

Test group 1: The indicated tick size will be $0.05, but the execution price will be unchanged ($0.01 unit).
Test group 2: The quoted and execution prices will be in $0.05 units.
Test group 3: The tick size will be the same as in test group 2, but the trade-at rule[13] will apply.

The changes in market quality achieved under the Tick Size Pilot Plan were announced in a January 2018 SEC white paper.[14] The white paper found that all indicators of market quality, including quoted spread, effective spread, price impact (change in the stock price resulting from a trade), and stock return volatility, increased (i.e., market quality deteriorated) for the groups with larger tick sizes. This outcome differed from the assumption expressed at an SEC roundtable on tick sizes. They predicted that tick size increases would allow market makers to provide incentive to conduct market make and thus improve market quality.

Furthermore, NASDAQ's website[15] has a proposal regarding the "intelligent tick," which seeks to reduce investors' execution costs by using tick sizes appropriate to the quoted spread of individual stocks.[16] This thinking is similar to having a tick size similar to each stock's natural spread. Employing this proposal would make it possible to set small tick sizes that incorporate the characteristics of individual stocks.

As for recent regulatory trends concerning tick size in the U.S., the chairman of the SEC has brought up the issue of the structure of the U.S. markets. In other words, he is leaning toward proposing a comprehensive revision of the regulations concerning best execution for individual investors (expected in fall 2022).[17] Such a revision would also entail reducing tick sizes in the stock exchanges and standardizing them with the tick sizes of off-exchange transactions, being that regulatory imbalance is one reason for the growth of off-exchange transactions. While a definitive proposal for regulatory changes has yet to be made, the differences in tick sizes on and off the U.S. exchanges is a hot topic. According to news reports, the reaction of market participants to such a proposal is mostly favorable. However, since too much of a reduction in

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[12] The conditions are (1) market capitalization of $3 billion or less, (2) average daily volume of 1 million shares or less, (3) the closing price on the last day of the measurement period (the evaluation period prior to the start of the pilot program) is at least $2.00 and the closing prices on all business days of the measurement period are at least $1.50 and (4) VWAP for the measurement period is at least $2.00.

[13] A experimental rule for dark pools that requires that the price for trading in a dark pool must be better than the price on the exchange(not equal to the exchange prices).

[14] For more information, see(https://www.sec.gov/dera/staff-papers/white-papers/dera_wp_tick_size-market_quality).

[15] For more information, see(https://www.nasdaq.com/solutions/intelligent-ticks).

[16] Six tick sizes (0.005USD, 0.01USD, 0.02USD, 0.05USD, 0.10USD, and 0.25USD) are indicated in the proposal.

[17] For more information, see(https://www.sec.gov/news/speech/gensler-remarks-piper-sandler-global-exchange-conference-060822).

tick sizes would adversely affect liquidity, most believe that the appropriate level should be well thought out.

2.2.2 Europe

In Europe, tick sizes are determined by the exchanges in each country. Still, the creation of the Multilateral Trading Facility[18] has caused tick size to be considered a competitive element (differentiating element) between markets. In December 2008, BATS Europe, Chi-X, NASDAQ OMX Europe, Turquoise, and other organizations held discussions regarding pan-European tick sizes, and the Federation of European Stock Exchanges (FESE) continued on from these discussions. Ultimately, they formulated four types of tick tables, and each exchange set rules for complying with them.[19] Albeit only industry rules, in January 2018, the Markets in Financial Instruments Directive (MiFID II) set minimum tick sizes by liquidity indicator based on this directive (MiFID II Article 49, Regulatory Technical Standards 11).

The tick sizes based on these liquidity indicators were determined according to the STR and other indicators. Most tick sizes were set so the STR would be in the 1.3–5.0 range.

Table 2.3 Tick sizes in Europe

Stock price		Liquidity index (average number of trades per day)					
≥	<	0–10 times	10–80 times	80–600 times	600–2,000 times	2,000–9,000 times	9,000– times
	0.1	0.0005	0.0002	0.0001	0.0001	0.0001	0.0001
0.1	0.2	0.001	0.0005	0.0002	0.0001	0.0001	0.0001
0.2	0.5	0.002	0.001	0.0005	0.0002	0.0001	0.0001
0.5	1	0.005	0.002	0.001	0.0005	0.0002	0.0001
1	2	0.01	0.005	0.002	0.001	0.0005	0.0002
2	5	0.02	0.01	0.005	0.002	0.001	0.0005
5	10	0.05	0.02	0.01	0.005	0.002	0.001
10	20	0.1	0.05	0.02	0.01	0.005	0.002
20	50	0.2	0.1	0.05	0.02	0.01	0.005
50	100	0.5	0.2	0.1	0.05	0.02	0.01
100	200	1	0.5	0.2	0.1	0.05	0.02
200	500	2	1	0.5	0.2	0.1	0.05
500	1,000	5	2	1	0.5	0.2	0.1
1,000	2,000	10	5	2	1	0.5	0.2
2,000	5,000	20	10	5	2	1	0.5
5,000	10,000	50	20	10	5	2	1
10,000	20,000	100	50	20	10	5	2
20,000	50,000	200	100	50	20	10	5
50,000		500	200	100	50	20	10

* Unit: Each country's currency

[18] The MiFID, adopted in 2004 and implemented in 2007, was introduced to cover trading of pan-European listed securities.

[19] See BATS(2009).

2.2.3 Comparison of tick weights in Japan, the U.S., and Europe

Figure 2.5 compares tick weights (tick size/stock price)[20] in Japan with those in the U.S. and Europe. High-liquidity stocks are roughly the same in Japan, the U.S., and Europe, at 1–5 bps. However, for other TSE stocks (especially medium liquidity), the tick sizes hinder spread narrowing, which may be a factor in driving up the investors' execution costs.

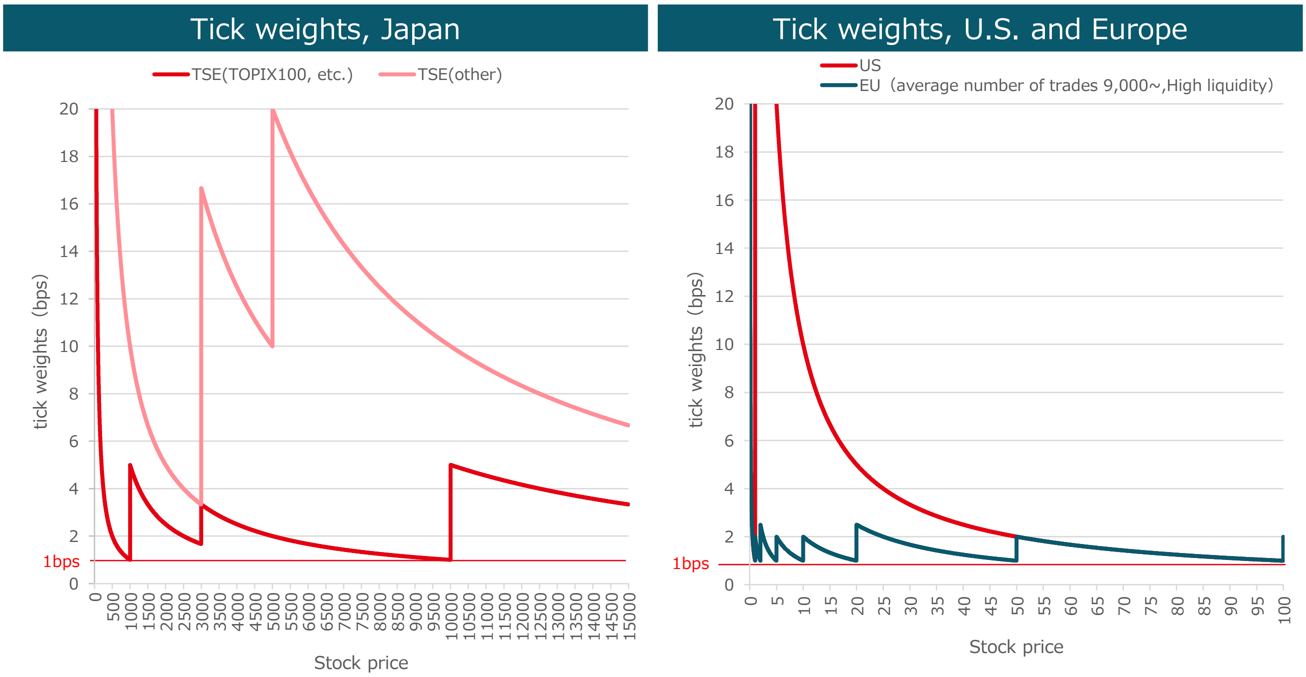

Figure 2.5 Comparison of tick weights in Japan vs. the U.S. and Europe

[20] Tick weights indicate the relative size of tick size at each price level of stocks. Under the assumption that an order exists at the best quote prices, the execution cost paid by an investor to buy or sell a stock with a high tick weight will be higher than when buying or selling a stock with a low tick weight.

3 Prior research

Most empirical analyses thus far[21] hold that the quoted spread and the effective spread shrink with the tick size. They also say that the impact of a tick size reduction varies with the transaction size, while the effective spread declines as the transaction size gets smaller.

Bessembinder (2003), who performed an empirical analysis of decimalization in the U.S.,[22] stated that for small-cap issues, the change in the spread following a change in tick size was not statistically significant. He held that in terms of the impact on price volatility, the variance of the rate of change in the midpoint of the best market price observed each hour declined after a tick size reduction. Furthermore, to investigate changes in market efficiency, the study computed rates of change at different time intervals using the same time-series data. When the data before and after the tick size reduction was compared using the variance ratio, the variance ratio calculated from the rate of change at one-hour intervals and the rate of change per day approached 1 after the tick size was reduced (market efficiency improved[23]). Moreover, Chakravarty (2005) stated that decimalization lowered institutional investors' execution costs by an average of 22 bps. The study also highlighted how execution cost decline was most significant in the stocks with the smallest spreads before a reduction in tick size (the most restricted by tick size). It also found that execution costs were lower when institutional investors conducted trades in several days to complete instead of the trades in one business day.

One analysis of the TSE by Kondo (2015) assessed the trading impact of tick size changes for TOPIX 100 stocks on the TSE in 2014, investigating whether the changes improved the situation of investors' transaction costs. This study compared quoted spreads, effective spreads, and intraday volatility by order size before and after the tick size reduction. It observed a decline in the quoted and effective spread for all stocks, a decline in the effective spread (half) for all stocks in the TOPIX 100 from 5.55 bps to 1.79 bps, and a significant decline in one-minute volatility following the tick size reduction.

In discussing the TSE's 2014 tick size changes, Huang et al. (2017) accurately predicted the costs of market and limit orders following tick size changes using variables such as the frequency a contracted price was executed during a specific period by the opposing side's price with one tick (one-tick unit) and for the frequency and ratio it was executed on the same side (the same as the preceding price). Hatakenaka (2018) proved that the TSE's 2014 tick size changes reduced quoted spreads, reduced cumulative depth (i.e., the total order volume (number of shares) at each price on the exchange's order book), reduced the number of shares traded per

[21] Furfine (2003); Chakaravarty, Wood, Harris (2001); Chung and Ness (2001); Chung and Chuwonganant (2004), etc.

[22] In January 2000, the SEC instructed U.S. exchanges and NASDAQ to change the tick sizes to one cent. In April 2001, the tick sizes were changed to on cent on all exchanges, the series of processes are known as decimalization.

[23] The closer the variance ratio is to 1, the more long-term price movements are an extension of short-term price movements, i.e., stock prices move closer to Brownian motion.

order, and increased transactions per day. From the variance ratio test results, this study also proved that tick size reductions led to changes in the price discovery function of limit orders. It pointed out that the relative amount of information in best market limit orders declines and that market orders for immediate execution tended to be prioritized.

Regarding depth, according to SEC (2012), a reduction in tick size causes a reduction in indicated depth, which can lead to a worsening of execution costs. However, even if the displayed depth declines due to new orders (hidden liquidity), the transaction costs borne by the investor (effective spread) could increase. Thus, the effective spread should be used to measure transaction costs.[24] Also, the thinking goes that the effective spread will go down for all stocks following a reduction in the tick size. And so, reducing the tick size will cut transaction costs and give limit orders and market makers an incentive to provide liquidity, leading to improved depth and liquidity. However, some believe that a reduction in tick size will ultimately reduce depth by lowering market makers' profitability, thus suppressing orders by HFTs, which provide liquidity.

European Securities and Market Authority (ESMA)[25] released a consultation paper in December 2014. The paper stated that when restrictions were put on tick size (tick size being too large), liquidity moved from lit pools (exchanges and such) to dark pools. It also commented on how there was more incentive to execute at the midpoint of the best market price in the lit pool and how if a market's tick size is too large, it will take longer to execute a limit order, so liquidity will move to markets where tick sizes are smaller. This paper also discusses the reasoning behind the establishment of tick size tables for different levels of liquidity. It uses three decision functions[26] that put STR in a range of 1.3–5 to determine the tick price tables after assessing the tables grouped by liquidity.

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[24] On the other hand, even with effective spread, it is difficult to fully grasp the overall execution cost when the investor splits the order.

[25] See ESMA (2015).

[26] Three decision functions are used: (1) one that allows the quote spread to be constrained by the tick size, (2) one that allows the quote spread to widen(i.e., not be constrained by tick size), and (3) one that is inter mediate between (1) and (2).

4 Hypotheses

In light of the prior research, we believe that a change in tick size will narrow the quote spread and the effective spread. So, for the case of the 2021 change in tick size for ETFs, etc. (the "2021 change"), we will formulate several hypotheses to analyze whether a similar effect occurred.

First, the 2021 change focused on all ETFs, etc., including those with low liquidity. Hence, it differed from the 2014 change in tick size for TOPIX 100 stocks, which had large market capitalizations and very high liquidity. We thought that, since those with the lowest transaction value were mostly in price ranges where orders do not get the best quoted prices, a change in the tick size could negatively impact the quoted and effective spreads. We thus explored the following hypotheses.

Hypothesis 1: For the higher liquidity ETFs, etc., a change in the tick size will reduce the quoted spread and the effective spread.

Hypothesis 2: For the lower liquidity ETFs, etc., a change in the tick size will increase the quoted spread and the effect spread.

For intraday volatility and high-liquidity ETFs, etc., if the tick size is too big, the price volatility of a tick will go up, and the price discovery function may not work well (the existence of a market price that matches supply and demand and is less than one tick). We think that after the tick size is reduced, there will be sufficient orders for each price, so price movement will smooth out, and price volatility will go down. Furthermore, regarding high-liquidity ETFs, etc. and the variance ratio representing market efficiency, we thought there would tend to be an overconcentration of orders in various price ranges prior to changing the tick size, which the tick size changes would resolve. This would increase the degree of freedom of price changes and the variance ratio to approach 1 (market efficiency would improve).

Hypothesis 3: For the higher liquidity ETFs, etc., a change in the tick size will reduce intraday volatility.

Hypothesis 4: For the higher liquidity ETFs, etc., a change in the tick size will improve market efficiency.

For depth, we thought that a change in the tick size would increase the degree of freedom for each price at which an order was fulfilled. Since the orders, concentrated in one price before the change, would spread across a wide range of prices, the depth of the best quoted price after the change would decline dramatically from their pre-change level. In our opinion, this effect would be more significant for those ETFs, etc. with a reduced tick size.

Hypothesis 5: A change in tick size reduces depth at the best quoted price for all issue groups, and the size of this reduction depends on the size of the tick size reduction.

Finally, we thought that a change in the tick size would increase the STR but that the percentage increase for the higher liquidity ETFs, etc. would be relatively low.

Hypothesis 6: After a change in the tick size, the rate of increase in the STRs of the higher liquidity ETFs, etc. is relatively low.

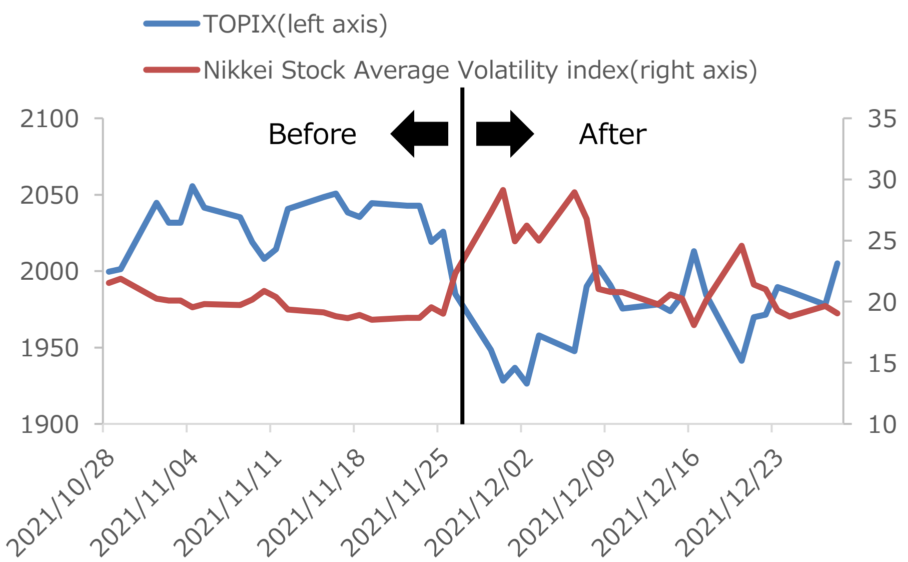
5 Description of analysis

5.1 Data employed

This analysis used detailed data replicated from the order book[27] from October 28 through December 24, 2021. This period constituted 20 business days before and after (40 business days) November 29, 2021, the date tick sizes for ETFs, etc. were changed. The issues analyzed consisted of 228 ETFs, etc. (excluding issues that did not trade before or after the change in tick size and newly listed issues and issues that were delisted during the period under analysis; also excluding issues that transitioned to a tick size with a different volume-weighted average price (VWAP) during the period under analysis[28]).

Figure 5.1 shows the trend in TOPIX index and the Nikkei Stock Average Volatility index[29] during the data analysis period. The period after the change in tick size includes when stock prices plunged due to concerns about the spread of the omicron strain of COVID-19.

Figure 5.1 Trend in TOPIX index and the Nikkei Stock Average Volatility index during the data analysis period



Source : Bloomberg

For ETFs, etc. trading units of one lot, we used the TOPIX 100 tick size table when the

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[27] Detail data in which data concerning each and every order and execution is recorded.

[28] For example, if the VWAP of "A" issue on November 26, 2021 is ¥2,990 and the VWAP of the issue on November 29, 2021 is ¥3,010, the effect of tick size changing is different from November 26 (if the issue's price is below ¥3,000, the reduction in the tick size is -50%, while if the issue's price exceeds ¥3,000, the reduction in the tick size is 80%), therefore, I excluded such ETFs, etc. from the analysis.

[29] The higher the index value, the more investors expect the market to fluctuate significantly in the future.

November 25, 2021 closing price[30] was more than ¥5,000, and we used the tick size table for others when it was ¥5,000 or less. This made it possible to separate the issues using the TOPIX 100 tick size table from those using the tick size table for others[31]. We were able to compare the two and analyze the impact of the tick size changes while controlling the effect of market conditions and the like.

5.2 Analytical methodology

We computed daily metrics for each business day before and after the tick size reduction. We calculated the means for the periods before and after the reduction and ran a multiple regression analysis on each metric after the tick size reduction using the mean for the period as the explained variable.

Since we assumed that the effect of the tick size reduction would vary with the degree of liquidity, we classified the issues into three groups by liquidity (trading value[32]): a top group (Group 1), a middle group (Group 2), and a bottom group (Group 3).

The number of issues held by ETFs, etc. and the number of futures open interests, etc. are published as a portfolio composition file (PCF). The assets owned by the ETF net asset values (NAV)) during trading hours are also disclosed. They thus differ from equities in that investors and others can calculate the prices of the ETFs, etc. Therefore, although it would be difficult to assess the impact of a tick size reduction for ETFs, etc. the same way as for equities, we thought it would be helpful to analyze the impact of a tick size reduction on low-liquidity issues.

A market-making scheme[33] has been set up for ETFs, etc., which includes a scheme (the sponsored market making[34]) that gives incentive payments to market makers who meet additional obligations set up by the ETF management firm. The management firm pays extra in addition to regular market making. It signs up market makers for issues that are difficult to create markets for and expects them to display higher level quotations to make it possible to influence ETFs' liquidity. Therefore, we included a dummy variable for whether sponsored market making had been set up (1 = sponsored market making was set up; 0 = sponsored market making was not set up).

The degree of the tick size reduction depends on the share price level, and Table 5.1 gives the degree of the tick size reductions by price range. Using the TOPIX 100 tick size table, we can classify the degrees of tick size reduction as −50%, −80%, and −90%. Since this analysis

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[30] In principle, the last traded price (or if it ends with special quote then the quote price) shall be used, and if none is available, the base price of the day shall be used.

[31] Of the 228 issues, 167 used the TOPIX100 tick size table and 61 used the tick size table for others.

[32] Caluculating the average trading value for the period prior to the change in the tick size (October 28 to Nobember 26, 2021), sorting in descending order of the average trading value, and clasifing into three groups by tertile number.

[33] For an overview of the market making scheme, etc., see the TSE website (https://www.jpx.co.jp/english/equities/products/etfs/market-making/index.html).

[34] For details on the conditions for sponsored market making , etc., see the TSE website (https://www.jpx.co.jp/english/equities/products/etfs/market-making/03.html).

considers that the impact of a tick size reduction will differ depending on its reduction size, we inserted a flag (dummy variable) for the group with a 50% reduction in tick size and the group with an 80% or more reduction in tick size.[35]

Table 5.1 Tick size tables for TOPIX 100 and other issues and tick size reductions

Price	TOPIX 100 tick size table	Tick size table for others	% reduction in tick size (Other→TOPIX 100)
1,000 or less	0.1	1	-90%
>1,000 - 3,000	0.5		-50%
>3,000 - 5,000	1	5	-80%
>5,000 - 10,000		10	-90%
>10,000 - 30,000	5		-50%
>30,000 - 50,000	10	50	-80%
>50,000 - 100,000		100	-90%
>100,000 - 300,000	50		-50%
>300,000 - 500,000	100	500	-80%
>500,000 - 1,000,000		1,000	-90%
>1,000,000 - 3,000,000	500		-50%
>3,000,000 - 5,000,000	1,000	5,000	-80%
>5,000,000 - 10,000,000		10,000	-90%
>10,000,000 - 30,000,000	5,000		-50%
>30,000,000 - 50,000,000	10,000	50,000	-80%
>50,000,000		100,000	-90%

* Unit is JPY

Quoted spread (half)

We took the difference between the best quoted bid and ask prices each time there was a change in the best quoted price after trading commenced (the number of changes in the quoted price each business day was i = 1, 2, 3,⋯, n) and divided it by 2. We then divided this by the median of the best quoted price and multiplied it by the duration of the best quoted price. We calculated n iterations of changes in quoted prices, added them up, and then divided this by total trading hours ($\sum_{k=1}^{n}\Delta t^{i}$)[36] to get the time-weighted-average.

$$qs = \frac{\sum_{k=1}^{n}\left(\frac{\left(P_{best\ ask}^{i} - P_{best\ bid}^{i}\right)/2 \times \Delta t^{i}}{P_{mid}^{i}}\right)}{\sum_{k=1}^{n}\Delta t^{i}} \quad (1)$$

[35] Because the number of samples for the -80% deduction in tick size is relatively small and the impact is not considered to be significantly different from that of the -90% deduction in tick size.

[36] $\sum_{k=1}^{n}\Delta t^{k}$ is the time excluding the duration of a special quote, etc., if there is no special quote, etc., in the day, the time is about 18,000 seconds (5 hours) in total.

Effective spread (half)

For the effective spread for trade j executed during trading hours, we calculated the effective spread (es^j) for trade j by dividing the difference between the absolute value of the midpoint of the executed price and the best quoted price prior to execution by the midpoint for the best quoted price. We then calculated the weighted average price during one business day by weighting the executed volumes.

$$es^j = \frac{|P_{exe}^j - P_{mid}^j|}{P_{mid}^j} \tag{2}$$

$$es^d = \frac{\sum_{j=1}^{n}(es^j \times Q_{exe}^j)}{\sum_{j=1}^{n} Q_{exe}^j} \tag{3}$$

Although the above equation assumes execution at one execution price, if it took place at several prices (k=1, 2,⋯m), we took the execution volume to be the total volume executed at all prices and calculated the weighted average execution price from the execution volume at each execution price.

$$Q_{exe}^j = \sum_{k=1}^{m} Q_{part}^k \tag{4}$$

$$P_{exe}^j = \frac{\sum_{k=1}^{m}(P_{part}^k \times Q_{part}^k)}{Q_{exe}^j} \tag{5}$$

Intraday volatility and the variance ratio

Intraday volatility and the variance ratio were calculated per Borkovec and Heidle (2010). For intraday volatility, we calculated by the variance ratio for the applicable business day d using the natural logarithm of the rate of change in the midpoint of the best quoted price starting at time t−1 for time t (t=1, 2,・・・,N[37]) at 1-minute and 10-minute intervals following the setting of the opening price. Here we use 1-minute volatility and 10-minute volatility.

$$\mu^d = \frac{1}{N}\sum_{t=1}^{N}(logP_{mid}^t - logP_{mid}^{t-1}) \tag{6}$$

$$(\sigma^d)^2 = \frac{1}{N}\sum_{t=1}^{N}(logP_{mid}^t - logP_{mid}^{t-1} - \mu^d)^2 \tag{7}$$

[37] Since there are 5 hours of trading hours in a day, N is approximately 300 for every minute and 30 for every 10 minutes per business day.

We also use 1-minute and 10-minute volatilities to calculate the variance ratio for each business day d.

$$vr^d = \frac{(\sigma_{10}^d)^2}{10 \times (\sigma_1^d)^2} \tag{8}$$

Depth

For the five prices above and below the best quoted price, we did calculations for each change in the order volume (QQ_{ask}^l、QQ_{bid}^l) recorded for prices 1–5 from the best quotes and then calculated the time-weighted average for the applicable business days. For each order size on a given business day (the time-weighted average price), we took the average of each price's bid and ask to be the level's depth.

$$QQ_{ask}^l = \frac{\sum_{p=1}^{n}\left(QQ_{ask}^l \times \Delta t^p\right)}{\sum_{p=1}^{n} \Delta t^p} \tag{9}$$

$$QQ_{bid}^l = \frac{\sum_{q=1}^{n}\left(QQ_{bid}^l \times \Delta t^q\right)}{\sum_{q=1}^{n} \Delta t^q} \tag{10}$$

$$depth^l = \frac{QQ_{ask}^l + QQ_{bid}^l}{2} \tag{11}$$

STR（spread to tick ratio）

STR is calculated by dividing the time-weighted average price for the difference between the best ask and bid prices on each business day by the tick size.

$$STR^d = \frac{\sum_{k=1}^{n}\left(\left(P_{best\ ask}^i - P_{best\ bid}^i\right) \times \Delta t^i\right)}{\sum_{k=1}^{n} \Delta t^i} \Big/ TS \tag{12}$$

6 Analytical results

6.1 Descriptive statistics on the analytical data

Before looking at the analytical results, we offer Tables 6.1–6.3, which contain descriptive statistics for each of the three groups classified by trading value.

Table 6.1 Top group in terms of trading value (Group 1)

	Before				After			
	Mean	Median	Std.	Count	Mean	Median	Std.	Count
No. of orders	61,069	12,630	148,516	76	90,058	23,985	186,910	76
Order volume (lots)	392,766,204	77,727,653	964,830,992	76	646,593,040	154,725,653	1,499,338,620	76
Trading volume (lots)	1,241,903	52,583	5,656,819	76	1,291,823	62,548	6,391,989	76
No. executed	2,369.2	456.8	7,097.3	76	3,486.8	563.8	11,405.2	76
Trading volume (¥ million)	2,974.8	174.6	14,260.0	76	2,942.3	227.1	13,841.1	76
Transaction amount per contract	313.5	82.9	661.5	76	296.3	75.6	556.7	76
Quoted spread (bps)	7.2	5.2	6.7	76	5.6	4.5	5.4	76
Effective spread (bps)	7.1	4.7	7.2	76	5.5	3.9	5.9	76
1-minute volatility	4.3×10^{-3}	3.6×10^{-4}	2.8×10^{-2}	76	5.5×10^{-4}	4.2×10^{-4}	4.6×10^{-4}	76
10-minute volatility	3.3×10^{-3}	1.1×10^{-3}	1.6×10^{-2}	76	1.6×10^{-3}	1.4×10^{-3}	1.3×10^{-3}	76
Variance ratio	0.74	0.73	0.28	76	0.89	0.93	0.22	76
Depth (1st)	190,650	27,751	729,782	76	68,932	15,135	285,945	76
Depth (2nd)	250,159	41,695	895,300	76	110,985	22,697	400,209	76
Depth (3rd)	213,594	40,519	733,458	76	117,574	24,841	413,179	76
Depth (4th)	141,533	27,349	529,938	76	96,680	20,150	379,865	76
Depth (5th)	97,151	11,998	417,702	76	71,012	13,165	318,288	76
STR	1.8	1.4	1.2	76	3.6	2.4	4.6	76
50% reduction in tick size (dummy variable)	0.50	0.50	0.50	76				
≥80% reduction in tick size (dummy variable)	0.21	0.00	0.41	76				
Market maker (dummy variable)	0.20	0.00	0.40	76				

Table 6.2 Middle group in terms of trading value (Group 2)

	Before				After			
	Mean	Median	Std.	Count	Mean	Median	Std.	Count
No. of orders	6,461	4,978	5,549	76	13,385	9,128	15,333	76
Order volume (lots)	34,116,305	12,765,448	45,940,262	76	68,897,799	27,505,763	126,226,891	76
Trading volume (lots)	9,380	4,052	22,234	76	8,830	3,383	16,735	76
No. executed	99.3	85.6	71.3	76	104.0	78.7	82.1	76
Trading volume (¥ million)	13.5	11.2	9.1	76	16.0	10.4	18.1	76
Transaction amount per contract	62.4	17.9	98.9	76	65.9	15.1	116.0	76
Quoted spread (bps)	16.7	11.2	12.4	76	18.7	13.4	13.6	76
Effective spread (bps)	17.6	11.3	14.5	76	22.5	14.0	38.6	76
1-minute volatility	1.2×10^{-3}	5.5×10^{-4}	3.6×10^{-3}	76	2.6×10^{-3}	6.9×10^{-4}	9.3×10^{-3}	76
10-minute volatility	3.1×10^{-3}	1.4×10^{-3}	1.1×10^{-2}	76	7.5×10^{-3}	1.7×10^{-3}	2.9×10^{-2}	76
Variance ratio	0.68	0.70	0.29	76	0.73	0.72	0.24	76
Depth (1st)	17,401	3,831	42,217	76	10,023	2,342	15,672	76
Depth (2nd)	25,186	3,880	89,172	76	11,262	2,539	18,334	76
Depth (3rd)	18,354	2,453	65,986	76	8,045	1,834	17,355	76
Depth (4th)	8,072	1,141	24,673	76	5,783	1,109	15,655	76
Depth (5th)	3,510	721	9,051	76	3,999	729	11,134	76
STR	3.5	3.0	2.2	76	15.2	8.3	20.2	76
50% reduction in tick size (dummy variable)	0.38	0.00	0.49	76				
≥80% reduction in tick size (dummy variable)	0.37	0.00	0.49	76				
Market maker (dummy variable)	0.26	0.00	0.44	76				

Table 6.3 Bottom group in terms of trading value (Group 3)

	Before				After			
	Mean	Median	Std.	Count	Mean	Median	Std.	Count
No. of orders	5,813	4,237	5,739	76	11,202	6,588	16,327	76
Order volume (lots)	14,415,133	4,376,152	30,092,592	76	26,048,337	5,053,592	64,493,355	76
Trading volume (lots)	642	222	910	76	1,016	267	2,135	76
No. executed	33.9	23.4	33.9	76	32.5	21.3	35.6	76
Trading volume (¥ million)	1.5	1.2	1.1	76	2.3	1.3	4.0	76
Transaction volume per contract	13.8	8.0	15.5	76	22.2	9.4	39.3	76
Quoted spread (bps)	38.6	26.0	32.6	76	50.8	35.2	41.6	76
Effective spread (bps)	36.9	27.1	29.2	76	46.3	30.2	54.9	76
1-minute volatility	4.9×10^{-3}	8.3×10^{-4}	2.0×10^{-2}	76	1.1×10^{-2}	1.2×10^{-3}	4.7×10^{-2}	76
10-minute volatility	1.3×10^{-2}	1.7×10^{-3}	6.2×10^{-2}	76	2.8×10^{-2}	2.3×10^{-3}	1.2×10^{-1}	76
Variance ratio	0.64	0.62	0.24	76	0.63	0.64	0.20	76
Depth (1st)	2,407	459	5,426	76	2,439	391	6,077	76
Depth (2nd)	2,630	399	6,374	76	2,687	428	6,826	76
Depth (3rd)	1,849	366	5,329	76	1,649	302	3,264	76
Depth (4th)	1,017	254	2,983	76	1,261	281	2,513	76
Depth (5th)	590	205	1,825	76	823	194	1,576	75
STR	23.8	8.3	65.6	76	182.8	26.3	703.3	76
50% reduction in tick size (dummy variable)	0.49	0.00	0.50	76				
≥80% reduction in tick size (dummy variable)	0.25	0.00	0.44	76				
Market maker (dummy variable)	0.11	0.00	0.31	76				

6.2 Quoted spread (half)

Below are the results of multiple regression analyses of quoted spreads after the change in tick sizes, with the variable for the change in tick size as the explanatory variable. Regarding the variables in the multiple regression analyses, we thought that Group 1, with the highest liquidity, would be most susceptible to a change in tick size. We applied the same model to verify the impact of changes in the others (Groups 2 and 3). For the explanatory variables in our multiple regression analysis model, we decided to use the step-down method[38] for the data in Group 1.

[38] However, 50% reduction in tick size (dummy variable) and 80% reduction in tick size (dummy variable) are included in the explanatory variables in order to check the difference in ther impact (even if the impact is relatively small, both variables are included in the explanatory vaiables). Also, in each analysis, multiple regression analyses were conducted after eliminating outliers. The same applies to the following analyses.

The results for the multiple regression analysis on the quoted spread showed that for Group 1, the dummy variables for an 80% or more tick reduction and a 50% tick reduction and the regression coefficient for depth (first-level depth for the best quoted price) were significant and negative (10% significance for the 50% tick reduction dummy variables), while 1-minute volatility was significant and positive. For the 50% and 80% or more tick reduction dummy variables, the quoted spread declined more when the tick size declined by 80% or more, which is consistent with Hypothesis 1. Also, we thought that issues with greater depth (1st) would have a greater concentration of orders at the best quoted price and that when the tick size changed, the orders would tend to disperse and the quoted spread would narrow (or conversely, if few orders were at the best quoted price, there would be less impact from the change in the tick size).

For Group 2, the dummy variables for a 50% and 80% or more reduction in the tick size were not significant. We saw that either the change in tick size did not affect the quoted spread or that such effect was limited.

Table 6.4 Results of the multiple regression analysis of the quoted spread (half) (Group 1)

				95% confidence interval for non-std coefficients		
	Non-standardized	Standardized coefficient	p-value	Minimum	Maximum	VIF[39]
Constant	2.55***	5.63***	0.001	1.10	4.00	4.83
Quoted spread (before change)	0.76***	5.08***	0.000	0.65	0.88	1.38
Depth (1st)	-1.64×10^{-6}***	-1.19***	0.002	-2.63×10^{-6}	-6.49×10^{-7}	1.18
1-min. volatility (before change)	26.77**	0.74**	0.031	2.49	51.04	1.02
50% tick reduction (dummy)	-1.40*	-0.70*	0.081	-2.97	0.18	1.42
≥80% tick reduction (dummy)	-7.03***	-2.87***	0.000	-9.01	-5.04	1.50
No. of observations	76					
R-squared	0.76					
Adj. R-squared	0.75					

*** p < 0.01, ** p < 0.05, * p < 0.10

[39] Variance inflation Factor, an index for detecting multicollinearity among explanatory variables, which is generally considered acceptable if it is less than 10.

Table 6.5 Results of the multiple regression analysis of the quoted spread (half) (Group 2)

	Non-standardized coefficient	Standardized coefficient	p-value	95% confidence interval for non-std coefficients: Minimum	Maximum	VIF
Constant	3.68**	18.65**	0.031	0.35	7.00	4.63
Quoted spread (before change)	1.01***	12.42***	0.000	0.84	1.18	1.86
Depth (1st)	-1.00×10^{-4}***	-4.33***	0.000	-1.35×10^{-4}	-6.52×10^{-5}	1.06
1-min. volatility (before change)	222.35	0.80	0.323	-222.96	667.66	1.06
50% tick reduction (dummy)	0.57	0.27	0.785	-3.56	4.69	1.68
≥80% tick reduction (dummy)	-1.37	-0.66	0.596	-6.51	3.77	2.57
No. of observations	74					
R-squared	0.77					
Adj. R-squared	0.75					

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 6.6 Results of the multiple regression analysis of the quotation spread (half) (Group 3)

	Non-standardized coefficient	Standardized coefficient	p-value	95% confidence interval for non-std coefficients: Minimum	Maximum	VIF
Constant	4.20	50.83	0.303	-3.87	12.28	5.70
Quoted spread (before change)	1.22***	39.47***	0.000	1.10	1.33	1.21
Depth (1st)	-7.79×10^{-5}	-0.42	0.817	-1.00×10^{-3}	1.00×10^{-3}	1.14
1-min. volatility (before change)	-67.48	-1.35	0.435	-238.78	103.81	1.02
50% tick reduction (dummy)	3.09	1.54	0.469	-5.37	11.54	1.56
≥80% tick reduction (dummy)	-5.66	-2.45	0.275	-15.94	4.61	1.73
No. of observations	76					
R-squared	0.88					
Adj. R-squared	0.87					

*** p < 0.01, ** p < 0.05, * p < 0.10

6.3 Effective spread (half)

Table 6.7 shows the effective spread for the periods before and after the tick size change. The effective spread for all ETF, etc. issues with changes in tick size declined by 1.67 bps[40] (or by about 42%). Also, changing the tick size lowered execution costs for all ETF, etc. issues[41] by an average of ¥34 million per day[40], equivalent to about ¥8.6 billion[40] annually.[42]

[40] Values are revised on October 28, 2022.

[41] Calculated based on the TSE's auction trading value of the total of buy and sell.

[42] Calculated assuming 250 businness days per year.

Table 6.7 Changes in the effective spread[43]

Degree of change in tick size	Change in effective spread (One business day average, ¥)	Trading value during TSE trading hours[44] (average for the 20 business days after the change, ¥)	Effective spread (pre-change average, bps)	Effective spread (post-change average, bps)	After vs. before (bps)
Down 80% or more	-9,382,580 [40]	20,940,801,648	8.88	3.33	-5.55
Down 50%	-25,034,713 [40]	181,250,507,896	3.54	2.24	-1.30
All issues with tick size changes	-34,417,294 [40]	202,191,309,544	4.02	2.35	-1.67
No reduction	-671,624 [40]	51,602,904,883	9.20	8.25	-0.96

As with the analysis of the quoted spread, we ran a multiple regression analysis with the effective spread after the change in tick size as the explained variable. The analysis results are shown in Tables 6.8–6.10. Overall, there is a similarity to the analytical results for the quoted spread/ However, the results for Group 1 showed that 1-minute volatility is no longer significant. Instead, the number of trades per execution (transaction unit) is significant and positive. It seems more likely that the larger-lot orders dispersed in the various price ranges will be executed at several prices, causing the effective spread to widen. Among the dummy variables for tick size, all non-standard coefficients, except in the case of Group 1, were positive but not significant. Among issues with relatively low liquidity, the change in tick size led to either a null or limited impact on the effective spread.

Table 6.8 Results of the multiple regression analysis of the effective spread (half) (Group 1)

				95% confidence interval for non-std coefficients		
	Non-standardized coefficient	Standardized coefficient	p-value	Minimum	Maximum	VIF
Constant	1.48*	5.53*	0.090	-0.24	3.20	6.93
Effective spread (before change)	-0.22***	5.57***	0.000	-0.32	-0.11	1.27
Depth (1st)	-2.70×10^{-6}***	-1.96***	0.000	-3.82×10^{-6}	-1.58×10^{-6}	1.54
No. of trades per execution	1.60×10^{-3}**	1.03**	0.017	0.20×10^{-3}	3.00×10^{-3}	1.65
50% tick reduction (dummy)	-0.82	-0.41	0.348	-2.55	0.91	1.75
≥80% tick reduction (dummy)	-4.96***	-2.02***	0.000	-7.07	-2.85	1.74
No. of observations	76					
R-squared	0.78					
Adj. R-squared	0.77					

*** p < 0.01, ** p < 0.05, * p < 0.10

43 The effective spread is calculated as a trading value-weighted average of each issue.

44 Trading value in TSE auction trading is the total trading value per one business day of stocks that change tick sizes.

Table 6.9 Results of the multiple regression analysis of the effective spread (half) (Group 2)

	Non-standardized coefficient	Standardized coefficient	p-value	95% confidence interval for non-std coefficients: Minimum	Maximum	VIF
Constant	3.07	17.70	0.164	-1.28	7.42	6.53
Effective spread (before change)	-0.24***	10.79***	0.003	-0.40	-0.08	1.70
Depth (1^{st})	-7.05×10^{-5}***	-2.99***	0.001	-9.97×10^{-5}	-2.92×10^{-5}	1.06
No. of trades per execution	0.01	0.91	0.348	-0.01	0.03	1.26
50% tick reduction (dummy)	2.73	1.32	0.241	-1.87	7.33	1.71
≥80% tick reduction (dummy)	2.91	1.40	0.320	-2.88	8.70	2.68
No. of observations	74					
R-squared	0.71					
Adj. R-squared	0.69					

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 6.10 Results of the multiple regression analysis of the effective spread (half) (Group 3)

	Non-standardized coefficient	Standardized coefficient	p-value	95% confidence interval for non-std coefficients: Minimum	Maximum	VIF
Constant	12.85*	39.60*	0.057	-0.42	26.11	12.09
Effective spread (before change)	-0.24***	21.12***	0.003	-0.40	-0.09	1.29
Depth (1^{st})	-4.00×10^{-4}	-2.09	0.327	-1.00×10^{-3}	2.00×10^{-4}	1.22
No. of trades per execution	-0.06	-0.89	0.728	-0.39	0.27	1.78
50% tick reduction (dummy)	0.55	0.27	0.920	-10.31	11.40	2.02
≥80% tick reduction (dummy)	3.53	1.54	0.565	-8.63	15.68	1.94
No. of observations	74					
R-squared	0.67					
Adj. R-squared	0.65					

*** p < 0.01, ** p < 0.05, * p < 0.10

6.4 Intraday volatility and the variance ratio

Similarly, we ran a multiple regression analysis on intraday volatility (1-minute and 10-minute) before and after the change. The results are given in Tables 6.11 and 6.12. We ran multiple regression analyses on Groups 1, 2,[45] and 3. Only Group 1 had a significance for a tick size reduction of 80% or more (dummy variable), and the regression coefficient was negative for both 1-minute and 10-minute volatility. So, for high-liquidity issues, volatility decreases when the tick size is reduced by 80% or more, which is consistent with Hypothesis 3. For high-liquidity issues, the overly large tick size pushes price volatility for each tick unit up, so the price discovery function does not work effectively. However, this situation is resolved following changes in tick sizes, making changes in share prices smoother due to excessive stock price volatility being suppressed.

[45] Results of multiple regression analysis for group 2 and 3 are omitted.

Table 6.10 Results of the multiple regression analysis on 1-minute volatility (Group 1)

				95% confidence interval for non-std coefficients		
	Non-standardized coefficient	Standardized coefficient	p-value	Minimum	Maximum	VIF
Constant	2.00×10^{-4}***	5.00×10^{-4}***	0.000	9.81×10^{-5}	3.02×10^{-4}	6.35
1-minute volatility (pre-change)	0.92***	4.00×10^{-4}***	0.000	0.85	1.00	1.19
STR	-3.70×10^{-5}***	-4.60×10^{-5}***	0.009	-6.46×10^{-5}	-9.38×10^{-6}	1.17
Order size	1.20×10^{-13}***	1.00×10^{-4}***	0.000	5.94×10^{-14}	1.80×10^{-13}	3.43
Depth (1^{st})	-1.73×10^{-10}***	-1.00×10^{-4}***	0.000	-2.54×10^{-10}	-9.25×10^{-11}	3.54
50% tick reduction (dummy)	-1.74×10^{-5}	-8.70×10^{-6}	0.654	-9.46×10^{-5}	5.98×10^{-5}	1.48
≥80% tick reduction (dummy)	-2.00×10^{-4}***	-8.62×10^{-5}***	0.000	-4.00×10^{-4}	0.00	1.64
No. of observations	73					
R-squared	0.92					
Adj. R-squared	0.91					
				*** p < 0.01, ** p < 0.05, * p < 0.10		

Table 6.11 Results of the multiple regression analysis on 10-minute volatility (Group 1)

				95% confidence interval for non-std coefficients		
	Non-standardized coefficient	Standardized coefficient	p-value	Minimum	Maximum	VIF
Constant	4.00×10^{-4}***	1.60×10^{-3}***	0.000	0.00	1.00×10^{-3}	6.64
10-minute volatility (pre-change)	1.04***	1.20×10^{-3}***	0.000	0.96	1.12	1.10
STR	-1.00×10^{-4}***	-1.00×10^{-5}***	0.006	-1.95×10^{-4}	-3.13×10^{-5}	1.10
Order size	2.46×10^{-13}***	2.00×10^{-4}***	0.006	7.40×10^{-14}	4.18×10^{-13}	3.44
Depth (1^{st})	-3.62×10^{-10}***	-3.00×10^{-4}***	0.002	-5.91×10^{-10}	-1.33×10^{-10}	3.51
50% tick reduction (dummy)	-3.66×10^{-5}	-1.83×10^{-5}	0.740	-2.56×10^{-4}	1.83×10^{-4}	1.47
≥80% tick reduction (dummy)	-3.00×10^{-4}**	-1.00×10^{-4}**	0.028	-1.00×10^{-3}	-3.49×10^{-5}	1.65
No. of observations	73					
R-squared	0.92					
Adj. R-squared	0.91					
Constant				*** p < 0.01, ** p < 0.05, * p < 0.10		

For the variance ratio, we compared the mean values of the variance ratios of the issues using the TOPIX 100 tick size table and the issue groups using the other tick size table before and after the change (using a paired t-test). We also analyzed the data by group and the variance ratio change by tick size table for the entire sample.

The results are shown in Table 6.13. For high-liquidity issues in Group 1, those issues using the TOPIX 100 tick size table had dramatically higher variance ratios (asymptotic to 1), so the difference was statistically significant. The results for Group 2 were similar. For Group 3, no such change occurred after the tick size changed for the issue group using the TOPIX 100 tick size table. From this, we can surmise that market efficiency improves when the tick size for more liquid issues is reduced, which is consistent with Hypothesis 4.

Table 6.12 Changes in the variance ratio before and after a change in tick size

	Degree of freedom	Before	After	t-value	p-value
Total sample					
Using the TOPIX 100 tick size table	166	0.66	0.75	-5.01***	0.00
Using the other tick size table	60	0.79	0.76	1.28	0.21
Group 1					
Using the TOPIX 100 tick size table	53	0.73	0.92	-6.43***	0.00
Using the other tick size table	21	0.79	0.82	-1.13	0.27
Group 2					
Using the TOPIX 100 tick size table	58	0.62	0.69	-2.47**	0.02
Using the other tick size table	18	0.84	0.83	0.35	0.73
Group 3					
Using the TOPIX 100 tick size table	53	0.62	0.63	-0.27	0.79
Using the other tick size table	19	0.73	0.64	2.25**	0.04

*** p < 0.01, ** p < 0.05, * p < 0.10

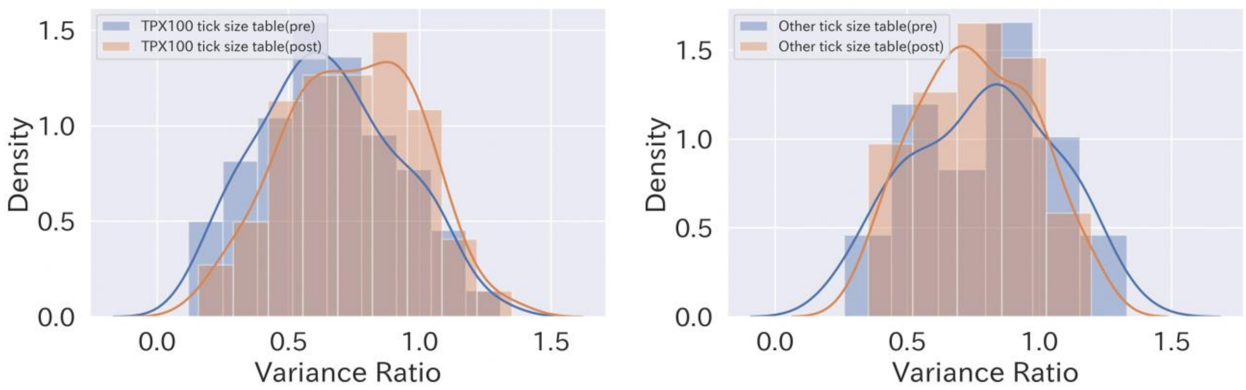

Figure 6.1 Variance ratio before and after by tick size table (total sample)

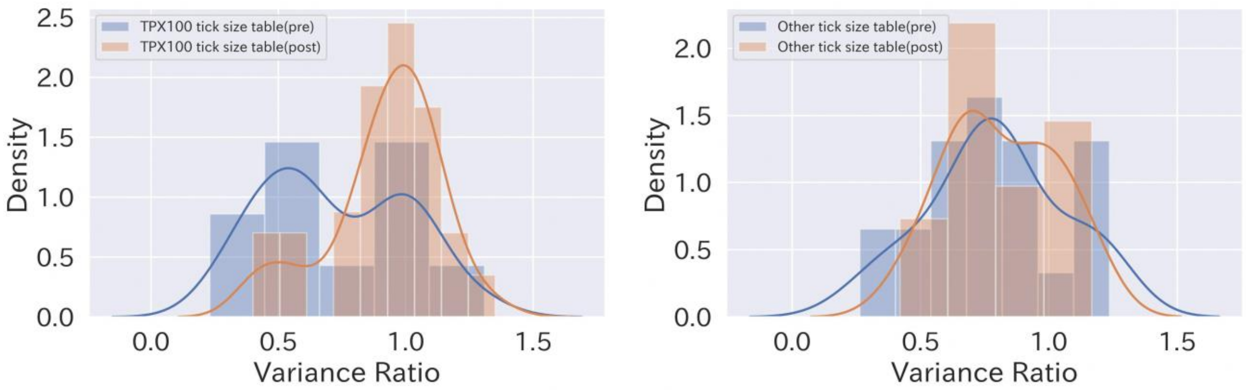

Figure 6.2 Variance ratio before and after by tick size table (Group 1)

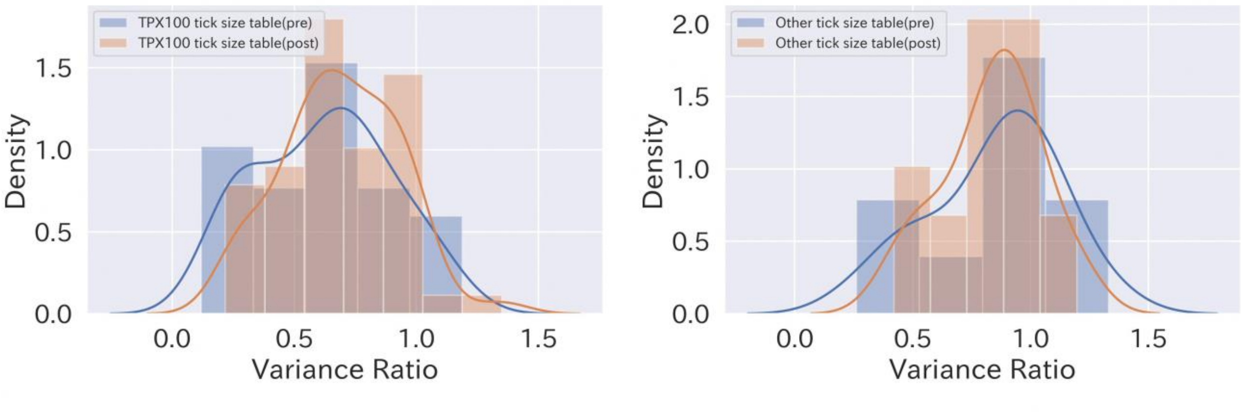

Figure 6.3 Variance ratio before and after by tick size table (Group 2)

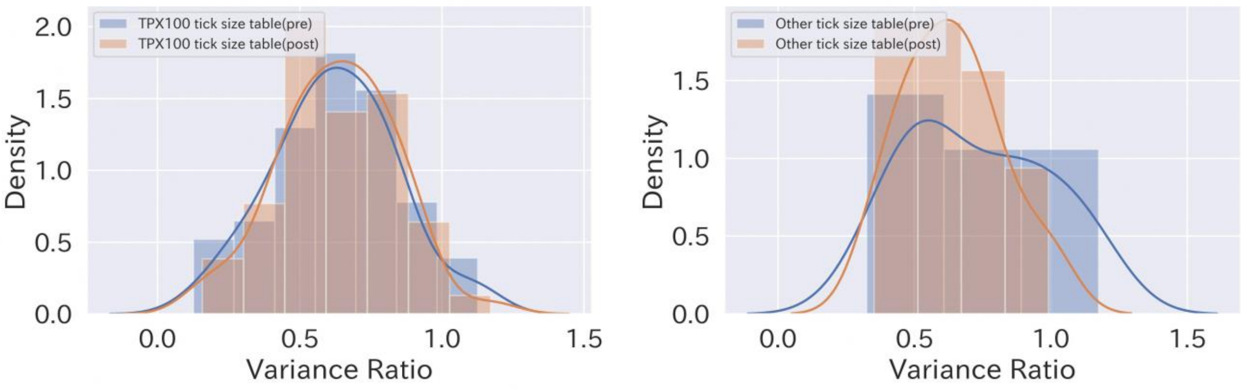

Figure 6.4 Variance ratio before and after by tick size table (Group 3)

6.5 Depth

The impact on depth varies with the degree of change in tick size. Figure 6.5 gives our findings regarding the change (median) in depth before and after the tick size change for Group 1, for which the impact of the tick size change on trading value was the greatest. Depth was drastically reduced in the cases of depth (1st) and depth (2nd) for the best quoted prices for groups with tick size changes. The size of the depth reduction was particularly significant for the group with a tick size change of more than 80%. This should lead to a dispersion of orders, as the change in tick size further increases the degree of freedom of the prices of orders that can include limits.

In addition, Figures 6.6–6.11 show the findings for changes in depth (median) and distance (bps)[46] standardized at the median price for the Nth quoted price (the Nth ask price and the Nth bid price) and the best quoted price for Group 1, which had the highest trading value as per previously observed. At the same time, the cumulative depth did not show much difference before and after the change in tick size. For example, the Nth depth appears much lower in the group where the tick size changed by 80% or more (see Figure 6.10). However, there was almost no change before and after the tick size change for cumulative depth, as seen by the distance from the midpoint of the best quoted price (see Figure 6.11). Therefore, the negative impact on execution costs (the effective spread) from a reduction in depth was limited.

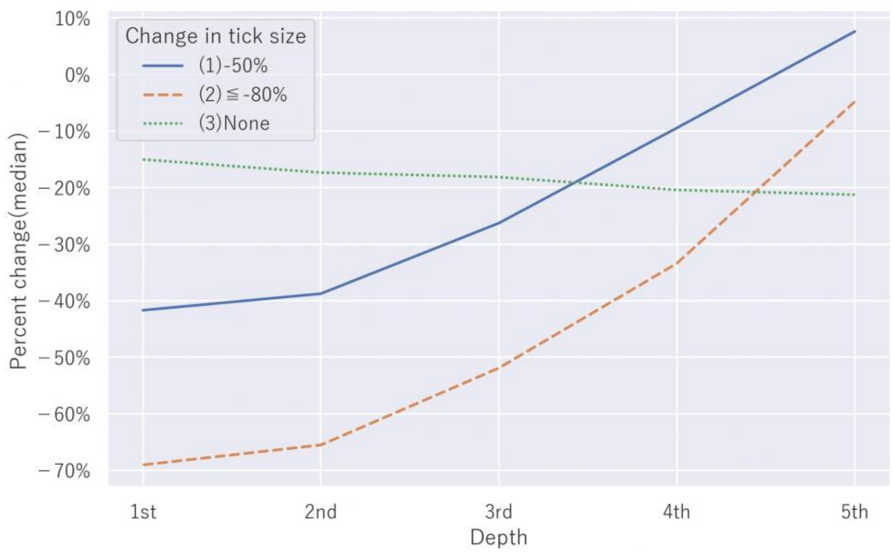

Figure 6.5 Change in the depth (median) after a change in the tick size (Group 1)

[46] (Nth ask price – Nth bid price) / 2 / midpoint of best bid and ask

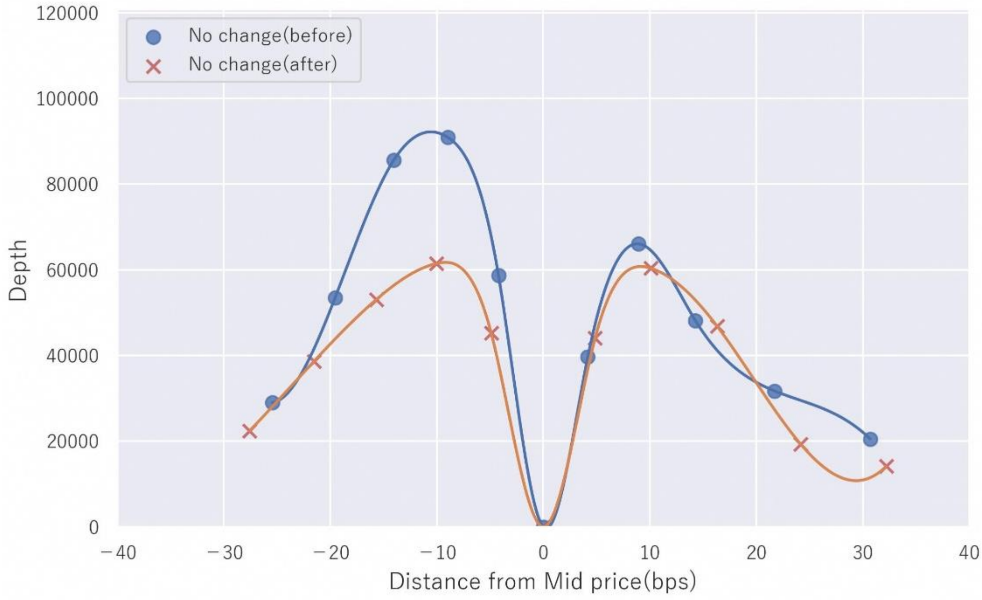

Figure 6.6 Distance and depth from the midpoint of best quoted price for Bids (1–5) and Asks (1–5) (Group 1, no change in tick size)

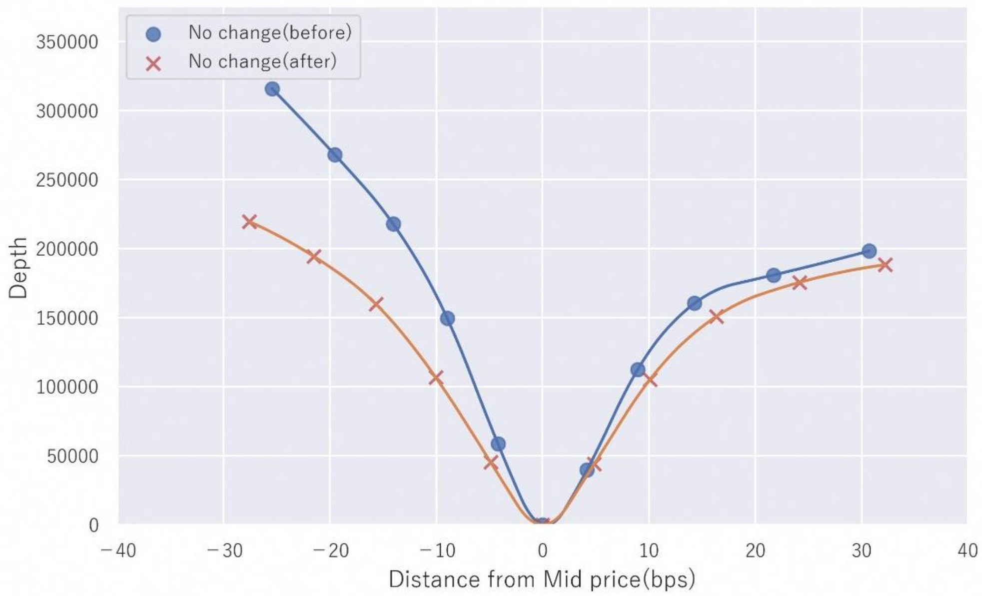

Figure 6.7 Distance and **cumulative depth** from the midpoint of best quoted price for Bids (1–5) and Asks (1–5) (Group 1, no change in tick size)

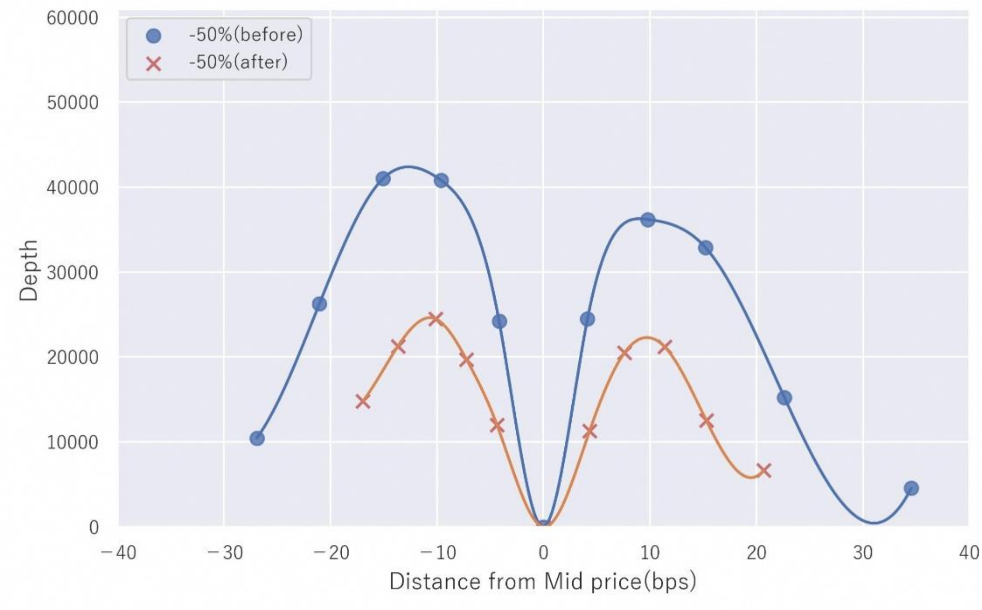

Figure 6.8 Distance and depth from the midpoint of the best quoted price for Bids (1–5) and Asks (1–5) (Group 1, tick size −50%)

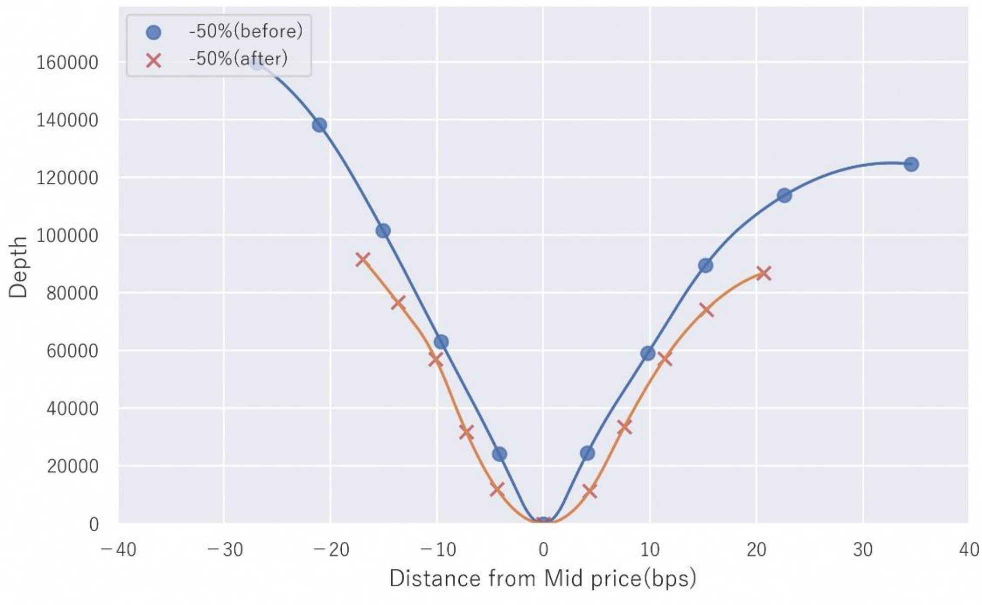

Figure 6.9 Distance and **cumulative depth** from the midpoint of the best quoted price for Bids (1–5) and Asks (1–5) (Group 1, tick size −50%)

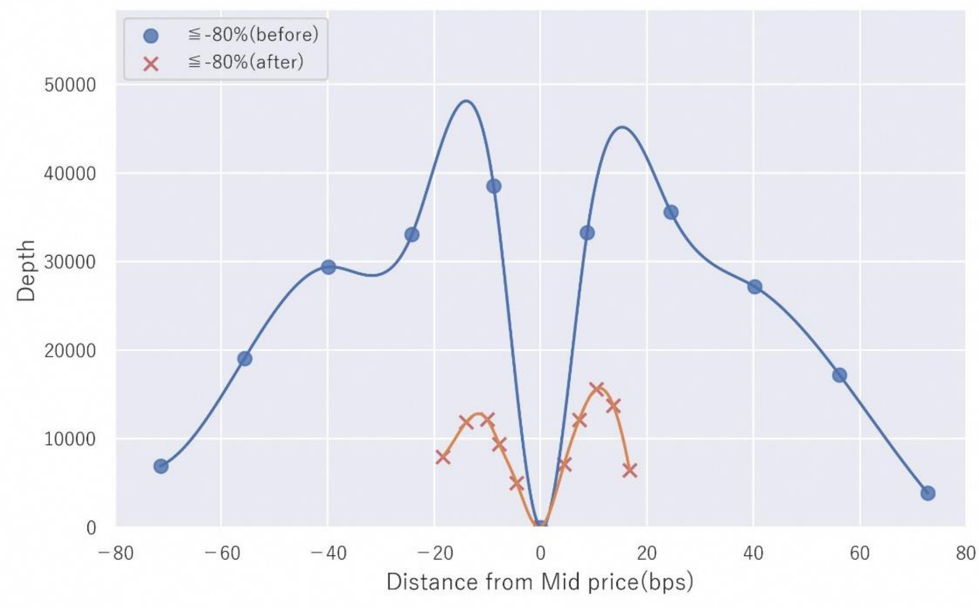

Figure 6.10 Distance and depth from the midpoint of best quoted price for Bids (1–5) and Asks (1–5) (Group 1, tick size ≤-80%)

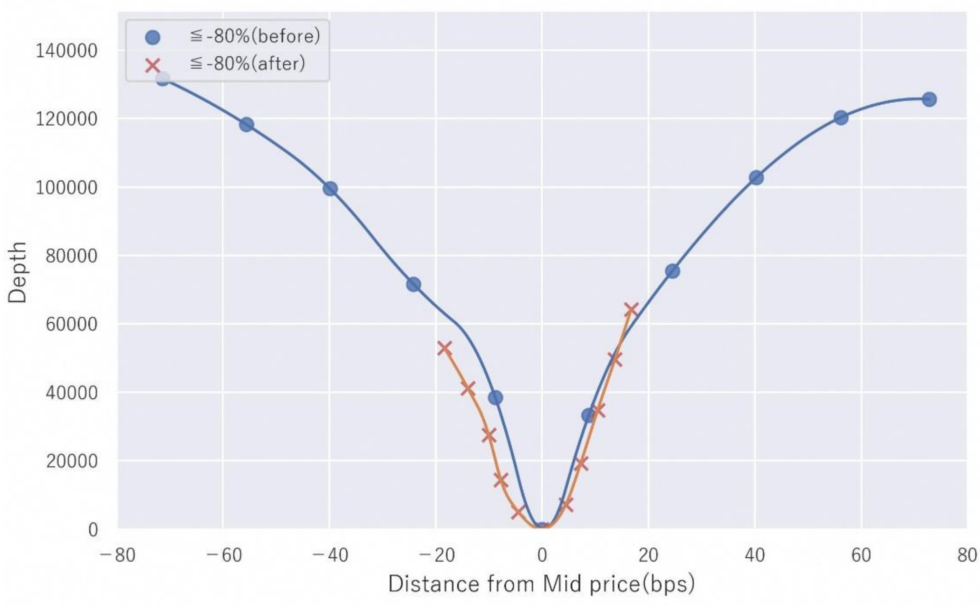

Figure 6.11 Distance and **cumulative depth** from the midpoint of best quoted price for Bids (1–5) and Asks (1–5) (Group 1, tick size ≤-80%)

Table 6.14 shows the results of our multiple regression analysis on the sample, excluding outliers, for all depths for Group 1 following the tick size change. Although not shown in the table, the VIF is 10 or lower for all variables, and there were no issues with multicollinearity (also true for the multiple regression analyses for Groups 2 and 3). Depths (1st and 2nd) were significant and negative for a tick size decline of 50% (dummy variable) and a tick size decline of 80% or more (dummy variable), while depth (3rd) was significant and negative for a tick size decline of 80% or more (dummy variable). Depth declined when the quoted price approached the best quoted price. In terms of the degree of decline, the non-standardized coefficient for a tick size decline of 80% or more (dummy variable) was larger, which is consistent with Hypothesis 5. In the multiple regression analysis for depth (1st), the market maker (dummy variable) was significant at the 10% level. However, if market making was sponsored, the impact on depth (1st) was positive, demonstrating the effectiveness of market making scheme. Also, although the quoted spread was significant at the 10% level, the impact was positive, and since the quoted spread before the change in tick size had been large, we believed it would cause a situation in which more orders concentrated at the best quoted price (increase in depth).

In addition, when we performed the same analysis on Groups 2 and 3, we did not obtain significant results for the post-change dummy for depth (1st), of which we thought the impact would be most significant. However, we verified a significant market-making effect (an effect of increasing depth) for depth (1st) and depth (2nd). Therefore, increasing depth seemed to have a more significant impact on issues with low liquidity.

Table 6.13 Results of the multiple regression analysis of depth following a change in tick size (Group 1)

	Depth (1st)	Depth (2nd)	Depth (3rd)	Depth (4th)	Depth (5th)
	Non-std. coeff.	Non-std. coeff.	Non-std. coeff.	Non-std. coeff.	Non-std. coeff.
Constant	15,800**	24,570**	19,150*	13,520	13,680
Depth (1st, pre-change)	0.48***	-	-	-	-
Depth (2nd, pre-change)	-	0.55***	-	-	-
Depth (3rd, pre-change)	-	-	0.60***	-	-
Depth (4th, pre-change)	-	-	-	0.58***	-
Depth (5th, pre-change)	-	-	-	-	0.51***
Quoted spread (pre-change)	322*	469	278	-40	-163
Market maker (dummy)	13,420*	9,504	13,380	12,080	3,783
50% tick reduction (dummy)	-21,490***	-31,890***	-19,510	-1,887	1,543
≥80% tick reduction (dummy)	-40,180***	-59,780***	-40,890**	-16,860	-11,280
No. of observations	73	73	73	73	73
R-squared	0.76	0.75	0.76	0.58	0.44
Adj. R-squared	0.74	0.73	0.74	0.55	0.40

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 6.14 Results of the multiple regression analysis of depth following a change in tick size (Group 2)

	Depth (1st) Non-std. Coeff.	Depth (2nd) Non-std. Coeff.	Depth (3rd) Non-std. Coeff.	Depth (4th) Non-std. Coeff.	Depth (5th) Non-std. Coeff.
Constant	3,302	4,292	-68	-817	-1,153
Depth (1st, pre-change)	0.27***	-	-	-	-
Depth (2nd, pre-change)	-	0.16***	-	-	-
Depth (3rd, pre-change)	-	-	0.23***	-	-
Depth (4th, pre-change)	-	-	-	0.58***	-
Depth (5th, pre-change)	-	-	-	-	0.94***
Quoted spread (pre-change)	-12	-22	-16	-6	-7
Market maker (dummy)	11,300***	13,310***	6,894***	2,029	1,439
50% tick reduction (dummy)	339	1,028	4,496*	2,302	2,035
≥80% tick reduction (dummy)	-1,754	-448	2,894	1,976	2,589
No. of observations	76	76	76	76	76
R-squared	0.70	0.76	0.79	0.86	0.62
Adj. R-squared	0.68	0.74	0.77	0.85	0.59

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 6.15 Results of the multiple regression analysis of depth following a change in tick size (Group 3)

	Depth (1st) Non-std. Coeff.	Depth (2nd) Non-std. Coeff.	Depth (3rd) Non-std. Coeff.	Depth (4th) Non-std. Coeff.	Depth (5th) Non-std. Coeff.
Constant	-195	-360	276	123	306
Depth (1st, pre-change)	1.05***	-	-	-	-
Depth (2nd, pre-change)	-	1.03***	-	-	-
Depth (3rd, pre-change)	-	-	0.50***	-	-
Depth (4th, pre-change)	-	-	-	0.35***	-
Depth (5th, pre-change)	-	-	-	-	0.20*
Quoted spread (pre-change)	2	1	-4*	-6**	-4**
Market maker (dummy)	1,457**	1,304**	1,110	1,376	318
50% tick reduction (dummy)	-226	173	860*	1452**	792*
≥80% tick reduction (dummy)	-210	361	786	1,290*	1,045*
No. of observations	75	75	75	75	75
R-squared	0.97	0.97	0.78	0.32	0.15
Adj. R-squared	0.96	0.97	0.76	0.27	0.09

*** p < 0.01, ** p < 0.05, * p < 0.10

6.6 STR（Spread to Tick Ratio）

These are the results of the multiple regression analysis on STR. For Group 1, the high-liquidity group, all dummy variables for tick size were significant and positive. The STR increased more for issues with a larger reduction in tick size. For the other groups, the dummy variable for a tick size reduction of 80% or more was significant and positive. For either group, reducing the tick size increased the STR. However, if we incorporate the results of a multiple regression analysis on the effective spread, it seems that an increase in the STR does not necessarily lead to an increase in the effective spread (execution cost) for issues with medium and low liquidity.

Table 6.16 Results of the multiple regression analysis of STR (Group 1)

	Non-standardized coefficient	Standardized coefficient	p-value	95% confidence interval for non-std coefficients: Minimum	95% confidence interval for non-std coefficients: Maximum	VIF
Constant	-2.17***	3.14***	0.000	-2.96	-1.39	10.31
STR (pre-change)	2.54***	1.75***	0.000	2.13	2.95	1.33
Depth (1st)	-1.91×10^{-7}	-0.14	0.276	-5.37×10^{-7}	1.56×10^{-7}	1.07
1-minute volatility	13.74***	0.38***	0.004	4.63	22.85	1.07
50% tick reduction (dummy)	1.06***	0.53***	0.001	0.48	1.65	1.45
≥80% tick reduction (dummy)	2.92***	1.17***	0.000	2.18	3.65	1.44
No. of observations	75					
R-squared	0.79					
Adj. R-squared	0.77					

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 6.17 Results of the multiple regression analysis of STR (Group 2)

	Non-standardized coefficient	Standardized coefficient	p-value	95% confidence interval for non-std coefficients: Minimum	95% confidence interval for non-std coefficients: Maximum	VIF
Constant	-15.98***	14.99***	0.000	-22.98	-8.98	6.69
STR (pre-change)	7.40***	14.41***	0.000	5.81	8.99	1.31
Depth (1st)	-1.82×10^{-5}	-0.78	0.590	-8.55×10^{-5}	4.91×10^{-5}	1.13
1-minute volatility	-384.57	-1.40	0.326	-1,159.92	390.78	1.09
50% tick reduction (dummy)	-4.11	-1.98	0.269	-11.47	3.25	1.72
≥80% tick reduction (dummy)	21.57***	10.42***	0.000	14.55	28.60	1.57
No. of observations	73					
R-squared	0.70					
Adj. R-squared	0.68					

*** p < 0.01, ** p < 0.05, * p < 0.10

Table 6.18 Results of the multiple regression analysis of STR (Group 3)

	Non-standardized coefficient	Standardized coefficient	p-value	95% confidence interval for non-std coefficients: Minimum	Maximum	VIF
Constant	-26.01***	34.68***	0.002	-42.14	-9.87	6.45
STR (pre-change)	3.97***	29.25***	0.000	3.04	4.90	1.16
Depth (1st)	6.00×10^{-4}	3.59	0.298	-1.00×10^{-3}	2.00×10^{-3}	1.15
1-minute volatility	53.53	1.11	0.731	-256.40	363.46	1.02
50% tick reduction (dummy)	10.68	5.34	0.171	-4.75	26.11	1.48
≥80% tick reduction (dummy)	68.02***	27.91***	0.000	49.11	86.94	1.49
No. of observations	70					
R-squared	0.65					
Adj. R-squared	0.62					

*** p < 0.01, ** p < 0.05, * p < 0.10

7 Impact forecast when the TOPIX 100 tick size table is applied to stocks in the Mid 400

The analysis results thus far allow us to estimate the changes in the effective spread and the STR when the TOPIX 100 tick size table is applied to the constituents in the Mid 400, an index with medium-liquidity stocks (i.e., changes when the tick size is too large)[47]. The average (mean) trading value for each stock in the Mid 400 is about ¥1.4 billion. This is greater liquidity than Group 1,[48] the top group for ETFs. However, since Group 1 was the group with the highest liquidity in our analysis, it is appropriate to use this data to make forecasts. We, therefore, built a high-performance forecast model that applied Leave One Out Cross Validation (LOOCV)[49] to the data for Group 1, allowing us to perform an impact forecast.

Additionally, the coefficient of determination after adjusting for the degree of freedom in this multiple regression analysis on Group 1 was relatively high, at 0.77, for the effective spread and the STR. Therefore, there is a certain logic to running an impact forecast based on a multiple regression analysis. As a reference, we used the multiple regression analysis model and the same sample (the data for Group 1) to conduct an impact forecast using a neural network (NN)[50], a nonlinear model.

NNs

NNs are mathematical models that mimic the brain's nerve network, with the brain's nerve network represented by a system of artificial neurons (perceptrons). Figure 7.1 shows the structure of a perceptron. Inputs ranging from x1 to x3 are multiplied with weight vectors (w1-w3),[51] yielding y'.

$$x1 \times w1 + x2 \times w2 + x3 \times w3 = y' \qquad (13)$$

Function f, "an activation function[52]," converts y', giving y as the final output. It would be no different from a typical linear model without the activation function. However, using the

[47] Forecast is conducted using data of constituents of Mid 400 from October 28 through Nobember 26, 2021.

[48] The median trading value per issue for Group 1 from October 28 to November 26, 2021 is approximately ¥180 million.

[49] All samples (N samples) are divided to N partitions, and building a model by using N-1 samples. Using the model, forecasting for the remaining one sample. Conducting the cycle for all cases(N times). It is possible to use limited samples effectively.

[50] The details of the NN are omitted, but for the activation function, after trying several functions, I decided to use the ReLU function that was the best fit. Also, the number of intermediate layer is set to 3 because there are not so many variables in this analysis.

[51] By adjusting the weight vectors through learning, the optimal parameters can be set automatically. For example, the parameters can be optimaized by decreasing the weight vectors that have less impact to output and increasing the weight vectors that have more impact to output.

[52] Sigmoid function $f(x) = 1/(1+e^{-x})$ and ReLU（Rectified Linear Unit）$f(x) = max\{0, x\}$ etc., are used as an activation function.

activation function for the conversion makes it possible to express with a complex model what cannot be expressed with a linear model.

$$f(y') = y \tag{14}$$

Although NNs can be understood as a complex combination of perceptrons, they contain many intermediate layers (hidden layers),[53] making it possible to perform complex analyses. At the same time, having intermediate layers increases complexity. In NN learning (calculating the slope of the loss function[54]), it is difficult to calculate a normal partial differential, so backpropagation[55] is used to deal with the partial differential more effectively. These are used for learning,[56] and the one that minimizes the loss function[57] is used as the forecasting model.

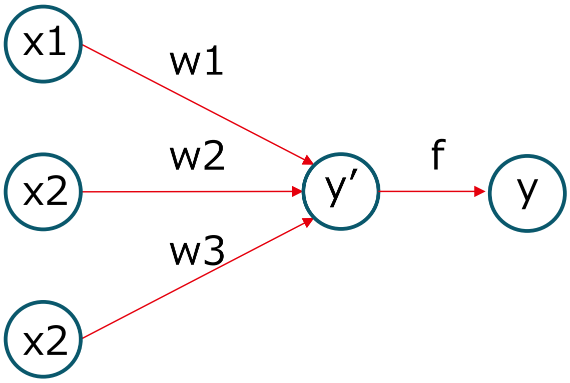

Figure 7.1 Perceptrons

[53] NNs with three or more intermediate layers are generally referred to as deep learning.

[54] The loss function is a function of the magnitude of the difference between prediction and actual values. The smaller value of the loss function, the more accurate model. Mean squared error, mean absolute error and mean squared logarithmic error, etc. are used as a loss function.

[55] The method to adjust weight vectors sequentially by transmitting the difference (error) between the output (output layer) and the target value from the output layer to the intermediate layers and to the input layer.

[56] In order to prevent overfitting (excessive adaptation to the trading data), training is terminated when the training has reached a certain level of learning progress (i.e., when the loss is less likely to decrease). It is often used Early Stopping.

[57] Absolute mean error is used.

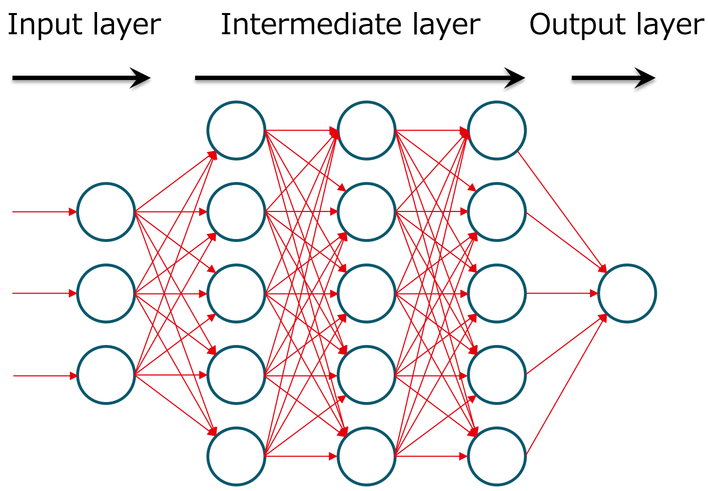

Figure 7.2 Neural network structure

7.1 Impact forecast for effective spreads

The changes in effective spreads when the TOPIX 100 tick size table was applied to stocks in the Mid 400 were as follows. When the forecast was made using the results of a multiple regression analysis, the result showed that the effective spread actually increased for the group with a 50% reduction in the tick size. In comparison, it declined dramatically for the group with an 80% or more tick size reduction. Therefore, the overall result of our calculation was a ¥290 million decline in execution costs per business day for all buys and sells (a 39% decline in the effective spread) [58]. For the NN model, although the effective spread declined for the group with a 50% reduction in tick size, the degree of decline in the effective spread for the group with an 80% or more tick size reduction was less than in the multiple regression analysis model. Overall, the result of our calculation was a ¥220 million decline in execution costs (a 31% decline in the effective spread) [58]. Annualizing the decline in execution costs obtained from these models gives a decline in execution costs of about ¥55.3 billion to ¥72.2 billion per year[59].

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[58] Values are revised on September 26, 2022.

[59] Calculated as 250 business days per year.

Table 7.1 Forecasted changes in effective spreads (multiple regression analysis model)

Degree of change in tick size	**Change in effective spread (One business day average, ¥)**	Trading value during TSE open hours (average for the 20 business days after the change, ¥)	Effective spread (pre-change average, bps)	**Effective spread (post-change average, bps)**	**After vs. before (bps)**
Down 80% or more	**-310,020,521** [58]	561,780,187,870	9.06	**3.57**	**-5.48**
Down 50%	**21,515,681** [58]	450,625,764,415	4.86	**5.35**	**0.49**
All stocks in the Mid 400	**-288,504,840** [58]	1,012,405,952,285	7.18	**4.38**	**-2.81**

Table 7.2 Forecasted changes in effective spreads (NN model)

Degree of change in tick size	**Change in effective spread (One business day average, ¥)**	Trading value during TSE open hours (average for the 20 business days after the change, ¥)	Effective spread (pre-change average, bps)	**Effective spread (post-change average, bps)**	**After vs. before (bps)**
Down 80% or more	**-201,565,696** [58]	561,780,187,870	9.06	**5.40**	**-3.65**
Down 50%	**-19,564,324** [58]	450,625,764,415	4.86	**4.37**	**-0.49**
All stocks in the Mid 400	**-221,130,020** [58]	1,012,405,952,285	7.18	**4.96**	**-2.23**

7.2 Impact forecast for STR

Similar to the previous impact forecast for the effective spread, we used both the multiple regression analysis model and the NN model to forecast changes in the STR when the TOPIX 100 tick size table was applied to stocks in the Mid 400. Based on Huang et al. (2017), we calculated (forecast) the STR for each stock on each business day (from October 28 through November 26, 2021). We then classified the STRs into three categories (less than 1.5, 1.5–5.0, and 5.0 and above) and tabulated them by stock price level (on the x axis).

Figure 7.3 gives the current STR distribution based on the data from October 28 through November 26, 2021. About 70% of the STRs are less than 1.5, meaning the tick size is too big. Figure 7.4 gives the forecasted STR distribution after the change in tick size using the results of a multiple regression analysis. While the stock of the tick size being too big is resolved, the tick size may become overly small instead. When making predictions using the NN model, the large tick size stock is resolved similarly to the multiple regression model, and the tick size is appropriate in almost all price ranges. For the STR forecast, there were slight differences between the two models. One reason could be that the multiple regression model is linear while the NN model is nonlinear. However, we also need to find out what kind of distribution will ensue and which model it will be closest to, in addition to the change in execution costs when the tick size changes for stocks in the Mid 400.

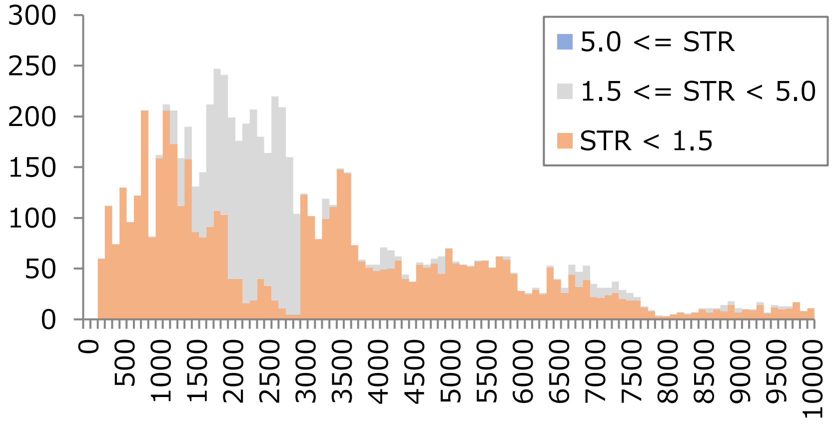

Figure 7.3 Distribution of STR for TOPIX Mid 400 stocks (current)

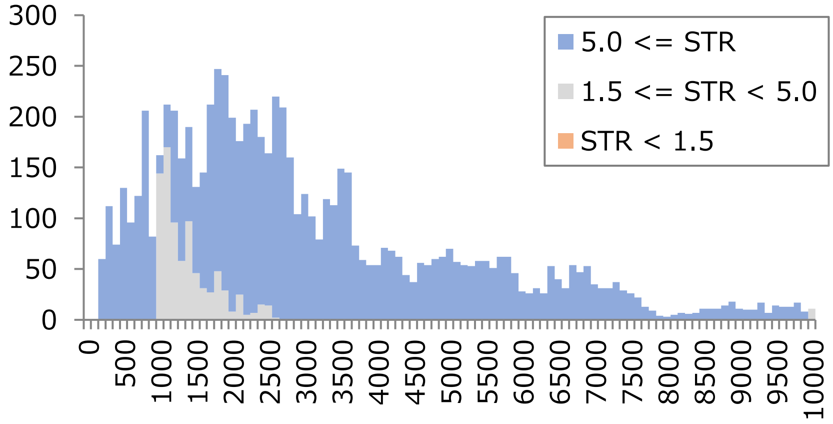

Figure 7.4 Distribution of STR for TOPIX Mid 400 stocks
(post-change, multiple regression analysis model)

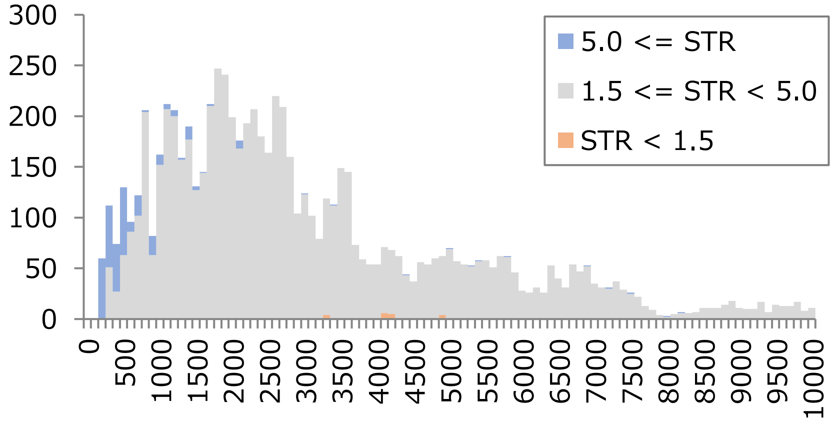

Figure 7.5 Distribution of STR for TOPIX Mid 400 stocks (post-change, NN model)

8 Conclusion

8.1 Investigation results for the effects of changes in tick sizes on ETFs, etc.

The 2021 change resulted in the effective spread decreasing 1.67 bps from 4.02 bps (about a 42% decline). Furthermore, the execution costs for the entire market declined by an average of about ¥34million per day. The objective of lowering investors' execution costs was therefore achieved.

For ETFs, etc., the 2021 change was applied to all issues using the TOPIX 100 tick size table in principle, and we did not observe any negative effect (increase in the effective spread) from the tick size reduction. However, since the tick size change was for ETFs, etc., there could be an effect on indicative NAVs,[60] the market-making scheme, or other aspects that do not involve equities. However, despite the dummy variable for the market maker having a significant effect on depth, its effect on other explained variables was not significant. Thus, the issue properties of ETFs, etc. did not seem to affect execution costs much.

The results of our investigation for each of our four hypotheses are as follows.

Hypothesis 1: For the higher liquidity ETFs, etc., a change in the tick size will reduce the quoted spread and the effective spread.

Hypothesis 2: For the lower liquidity ETFs, etc., a change in the tick size will increase the quoted spread and the effective spread.

The group of issues with the highest liquidity and where the tick size declined by 80% or more had greater declines in the quoted spread and the effective spread, which is consistent with Hypothesis 1. Regarding Hypothesis 2, for the sample's middle and bottom groups in terms of trading value, the dummy variables for the change in tick size were not significant for the quoted spread or the effective spread. For that reason, we surmise that the negative impact of the change in tick size was limited.

Hypothesis 3: For the higher liquidity ETFs, etc., a change in the tick size will reduce intraday volatility.

Hypothesis 4: For the higher liquidity ETFs, etc., a change in the tick size will improve market efficiency.

For the issues in the high-liquidity group where the tick size declined by 80% or more, the decline in intraday volatility was significant. For the middle and bottom groups, the tick size

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[60] Indicative NAV is the estimated Net Asset Value owned by ETFs per unit during trading hours. It can be confirmed on the TSE website.

decline did not significantly affect intraday volatility, which is consistent with Hypothesis 3. Moreover, when looking at the variance ratio for market efficiency, the variance ratio for the top and middle groups in terms of trading value showed significant change compared to before the tick size change, with it approaching 1. This showed that market efficiency improved for the top group in terms of trading value, which is consistent with Hypothesis 4.

Hypothesis 5: A change in tick size reduces depth at the best quoted price for all issue groups, and the level of reduction depends on how much the tick size is reduced.

We observed that the depth (1st and 2nd) decreased more significantly for the issue group with the highest liquidity, where the tick size was reduced by 80% or more. Although we assumed that the reduction in tick size would reduce the depth for the middle and bottom groups in terms of trading value, we found the impact of the tick size reduction to be non-significant and the impact on depth to be limited. In addition, it was very interesting that we got a significant and positive result for the impact of the market maker dummy variable on depth (1st and 2nd) for the middle and bottom groups in terms of trading value. We can regard this as showing that the market-making scheme is functioning effectively.

Hypothesis 6: After a change in the tick size, the rate of increase in the STRs of the higher liquidity ETFs, etc., is relatively low.

In analyzing all the groups, the impact was significant and positive for the issues with tick size reductions of 80% or more. The coefficient (non-standardized coefficient) for the top group was lower than for the middle and lower groups, so the rate of increase in the STR was relatively low, which was consistent with Hypothesis 6.

8.2 Impact forecast when the TOPIX 100 tick size table is applied to Mid 400 stocks

We analyzed the impact of the tick size change on ETFs, etc. and used the results to perform an impact analysis of the change in the effective spread and STR when the TOPIX 100 tick size table was applied to stocks in the Mid 400. Our forecasting used both a multiple regression analysis model and an NN model. The results were that execution costs could go down for each business day by about ¥220 million to ¥290 million (or about ¥55.3 billion to ¥72.2 billion annually). Thus, we believe a tick size reduction for medium-liquidity stocks in the Mid 400 will reduce execution costs and improve market efficiency.

Also, in terms of STR, we predicted that a change in tick size would resolve problems when the tick sizes for stocks in the Mid 400 were too big. However, the STR may rise beyond an appropriate level in the multiple regression analysis model. Thus, we believe this necessitates an analysis of the impact on investors when changing the tick size for stocks in the Mid 400.

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