The impact of minimum tick size on the liquidity of the New Zealand stock market

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A dissertation submitted to

Auckland University of Technology

in partial fulfilment of the requirements for the degree

of

Master of Business (MBus)

2014

School of Business

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1. Introduction

As stated in the journal "New Zealand Examines Liquidity" (Foster, 1996), the New Zealand stock market is less liquid than other major markets. Investors also realize the low liquidity in New Zealand stock market (Rickard, 2011). A simple way to consider liquidity is how quickly and cheaply an asset can be converted into cash. The higher the cost is, the lower the liquidity is. Illiquidity means that buying and selling stocks is costly in New Zealand stock market. For example, in the same journal "New Zealand Examines Liquidity", a local fund manager criticizes that the illiquidity in the stock market leads they cannot freely buy or sell stocks at the market price. Not only the institutions but also the individual investors pay more resources in order to get the stocks in New Zealand market. Based on Gerhold *et al.* (2011), the correlation between trading volume and liquidity is positive. This is consistent with low trading volume in New Zealand market. Volatility is high in a illiquid stock market (Chordia, Huh, & Subrahmanyam, 2009). The investors in New Zealand faced more risks, like they cannot find the investors on the other side to take the order at the preferred price.

To consider the resources paid here, transaction costs for stock trading, there are four main components – brokerage cost, bid-ask spread, price impact and opportunity cost, while the stock price is low in general. Most stocks in New Zealand market are traded below $10.00; the stocks traded above $10.00 are in the financial industry, which is different from other industries in many fields, like JP Morgan Overseas Investment Trust and Westpac Banking Corporation. Around 95% of stocks trade below $10 (9 out of 149), about 15% of stocks trade below $0.20 (25 out of 149). To take account of the low stock price, the transaction cost is relative high in the New Zealand market. I think that the relatively high transaction cost is one of the possible explanations for the market illiquidity. The bid-ask spread is one aspect of transaction cost.

The effects of bid-ask spread on market activities present in several ways. Firstly, the bid-ask spread refers to the spread between the price at which you can buy an asset (the dealer's ask price) and the price at which you can sell the same asset at the same point in time (the dealer's bid price). The effects of bid-ask spreads on the market activity are recognized for long time. Amihud and Mendelsn (1986) find that the bid-ask spread is a significant factor for the liquidity. More specifically, Studies by Tinic and West (1972) and Stoll (1978) find that spreads as a percentage of the price are correlated negatively with the price level, volume and the number of market makers, and positively with volatility.

Secondly, the minimum tick size (MTS) correlates with the bid-ask spread (Easley & O'Hara, 1992). It means that any changes in the MTS can cause a change in the transaction cost, hence, market liquidity. MTS determines the minimum transaction cost for entering and exiting a position, also determines the minimum price to acquire order precedence through price priority when time precedence is applied.

The rules applied in New Zealand stock market are as followed:

- for stocks with price less than $0.20 the MTS is $0.001;
- for stocks with price equal and greater than $0.20 the MTS is $0.01;
- some exceptions not follow above rules[1]

To compare with the rules applied in Australian exchange market:

- for stocks with price less than $0.01 the MTS is $0.001;
- for stocks with price from $0.10 to $0.50 the MTS is 0.005;
- for stocks with price greater than $0.50 the MTS is $0.01.

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[1] On the 23rd February 2011 the NZX announced that MTS reduce from $0.01 to $0.005 after 10th March 2011 for five companies (Telecom, Kiwi Income Property Trust, Guinness Peat Group, Fisher & Paykel Appliances and Auckland International Airport). On the 23rd October 2011, the NZX extended the scheme to a further 12 stocks and become effective on the 7th November 2011(Air New Zealand, Infratil, New Zealand Oil & Gas, CDL Investment and AMP NZ Office, Argosy Property Trust, DNZ Property Fund, Goodman Property Trust, Kermadee Property Fund, National Property Trust, Property for Industry, and Vital Healthcare Property Trust).

It is obvious that MTS in New Zealand is higher than in Australia. It supports that the relative transaction cost is high in New Zealand stock market. If the stock price is $0.20, and the tick size equals to MTS, the transaction cost is 5% per lot in New Zealand stock market, the transaction cost is 2.5% per lot in Australian exchange market. The investors need to gain at least 5% to cover the costs they suffered when they enter the New Zealand market, and at least 2.5% to cover the costs they suffered when they enter the Australian market. As a result of high MTS, the bid-ask spread is high as well. As a consequence, in general sense, both domestic investors and international investors may not put their money into the New Zealand market, as there are very little potential to make profits.

There is a lot of empirical research studying the impact of tick size on the stock market activity in details. This research falls into two categories. The first category deals with papers examining exogenous changes to tick size resulting from changes to exchange rules. From the 1990s, the trend toward reduced tick sizes in markets around the world has created dozens of ‘natural experiments’ allowing extensive analysis of the impact of this type of change. The evidences are from Australia (Aitken & Comerton-Forde, 2005). United States (H. J. Ahn, C. Q. Cao, & H. Choe, 1996; Goldstein & Kavajecz, 2000; Jones & Lipson, 2001), Japan (H.-J. Ahn, Cai, Chan, & Hamao, 2007), Singapore (Hameed & Terry, 1998; Lau & McInish, 1995) and Canada (H. Ahn, 1998; Bacidore, 1997). This literature generally reports that lower tick sizes lead to lower spreads, but that the effect on liquidity is mixed. The second category deals with endogenous changes in tick size, which occur as stocks move from one tick size category to another in markets where tick size is a function of price. The findings are similar. The effect of tick size reduction on spreads is positive, as the spreads are reduced when tick size is lower; however, the effect of tick size reduction on trading volume, number of shares, and other market quality factors are different. Numerous studies could be cited here including Bessembinder (2000) for an examination of Nasdaq, Chung *et al.* (2005) for an analysis on liquidity and quote clustering on Kuala Lumpur Stock Exchange, and Cai *et al.* (2008) for an analysis stocks cross tick size threshold on the TSE.

As the New Zealand stock market is inactive compare with other major stock markets around the world, and one of the possible reasons is the high transaction cost, we should think whether the MTS is a constraint on the reduction in spread, and do we need to reduce the MTS in order to eliminate the transaction cost to encourage the participation. Before the reduction, the policy makers should understand the impacts of MTS on the New Zealand stock market. Nonetheless, an enormous volume of empirical research analysis the other markets, no work is addressed the issue for New Zealand market so far. My paper adresses this imbalance. I seek to find out how the MTS influences the stock trading in the New Zealand stock market.

The empirical results from the New Zealand stock markets indicate the current MTS is a binding constraint, especially for the stocks with price above $0.20 and below $10.00. NZX may consider reducing the MTS for stocks with price in that range, or introduce more price level for MTS. A strong evidence shows that there is a relation between the market liquidity and company size. It suggests that the policy makers may think amend MTS rules not only based on the price level, but also the company size.

The rest of the paper is structured as follows. Chapter 2 presents a brief overview of New Zealand stock market and the MTS rules applied. Chapter 3 summaries the existing literature about MTS and market liquidity. Chapter 4 outlines the method, hypothesis and empirical predictions. Chapter 5 discusses the empirical findings. Chapter 6 concludes and discuss implication.

2. Institutional Detail

This section provides a background of the New Zealand stock market studied in my dissertation (section 2.1), and presents an overview of the rules used in New Zealand stock market (section 2.2).

2.1 Background

The New Zealand Exchange (NZX) is the main stock exchange in New Zealand. It is located in Wellington, New Zealand. It contains cash equities, bonds, derivatives, and spot commodities. There were several regional stock exchanges during the gold rush of the 1870s, and they were combined to form one national stock exchange, New Zealand Stock Exchange (NZSE), in 1974. On 31 December 2002, NZSE became a limited liability company. Later on 30 May 2003, New Zealand Stock Exchange Limited formally changed its name to New Zealand Exchange Limited (NZX), and on 3 June 2003 listed its own securities on its main equity market.

NZX operates New Zealand Stock Market (NZSX), New Zealand Alternative Market (NZAX), and New Zealand Debt Market (NZDX). My study focuses on the NZSX. There are 149 stocks listed on NZSX based on the information from NZX website on 28 August 2013. The main index is the NZX 50, which comprises of the 50 largest stocks by free float market capitalization trading on the NZSX. There are other indices, like NZX 20, NZX15, NZX 10, NZX MidCap, and NZX SmallCap.

The normal trading hours for NZSX are from 10am to 4:45pm, Monday to Friday except public holidays. During the normal trading hours, dealers, direct market access (DMA) dealers or a DMA authorized persons may enter, withdraw or amend orders. Clients enter or submit orders into the Trading System by authorizing dealers, DMA dealers or a DMA authorized persons. Investors can use either limit or market orders. The orders shall be matched by the Trading System according to price, then time, priority (NZX Participant Rules 10.14.4). The orders are matched by the best price available in the order book, if there are more than one best, then matched with the “early” order enter the order book. The order book is the list of orders that records the interest of buyers and sellers. A market order is a buy or sell order to be executed immediately at current market price. The market order is automatically filled at the best price available at that point of time. It may split across multiple participants on the other side of the transaction; therefore, there may be different prices. A limit order is an order to buy a security at no more than a specific price, or to sell a security at no less than a specific price. The limit order is only executed within the price constraint. In the New Zealand stock market, limit orders work like market order, which split across multiple transaction. The limit order execution is different from it in other stock markets, for example fill or kill[2] and all or none[3]. Clearing time is around a minute in New Zealand stock market.

2.2 Regulations

The NZX is supported in its role as front-line regulator by the Financial Market Authority (FMA), the statutory regulator of New Zealand's financial markets, although the Securities Commission has no legislative mandate to regulate the NZX.

The NZX has an obligation to operate the equity, debt and futures markets in a fair, transparent, and efficient way. So it regulates listed companies and market participants. The NZX provides Listing Rules governing the behavior of listed companies, Participant Rules and an accreditation programme for market participants, and real-time monitoring and surveillance of trading on its markets. The NZX helps investors to be aware of the risks of investments they are making, the type of the advice they are receiving and the engagements their advisors have for managing their capitals.

[2] Fill or kill (FOK) means fill order completely on the first attempt or canceled out, it is used in Swiss exchange.

[3] All or none (AON) means order must be filled with the entire number of shares specified, or not filled at all, and held on the order book for later execution.

2.2.1 Minimum tick size rules (MTS)

In 2012, the NZX made significant changes in the Listing Rules and the Participant Rules in order to improve its regulatory role. The main change is adaption of MTS.

As a number of other markets, the NZX runs using a tiered tick function. The MTS depends on the price of the stock. NZX Participant Rules states (NZX, 2012):

> *11.9.1 Unless otherwise determined from time to time by NZX, minimum price changes for a Security quoted on the NZSX shall be one cent ($0.01) except:*
>
> *(a) Where the price is less than twenty cents ($0.20), the minimum price change will be one tenth of a cent ($0.001); and*
>
> *(b) For rights, options, warrants, index fund units or other Securities that are dependent on the price of another Security, at the complete discretion of NZX, the minimum price change will be one tenth of a cent ($0.001).*

On the 23rd February 2011 the NZX announced that MTS reduce from $0.01 to $0.005 after 10th March 2011 for five companies (Telecom, Kiwi Income Property Trust, Guinness Peat Group, Fisher & Paykel Appliances and Auckland International Airport). On the 23rd October 2011, the NZX extended the scheme to a further 12 stocks and become effective on the 7th November 2011(Air New Zealand, Infratil, New Zealand Oil & Gas, CDL Investment and AMP NZ Office, Argosy Property Trust, DNZ Property Fund, Goodman Property Trust, Kermadee Property Fund, National Property Trust, Property for Industry, and Vital Healthcare Property Trust). The features of future 12 stocks are either cross-listed or property stocks with price under $2.50. The board of NZX thinks that the MTS reduction benefits the liquidity, as NZX CEO Mark Weldon stated (Krupp, 2011):

> *"…the reduced price steps had a positive impact on liquidity in the selected stocks, which is good news for the companies, for investors and our wider markets. The success of the initiative … has promoted us to introduce the $0.005 price steps for dual listed and New Zealand property sector stocks that under $2.50. We expect to see the same position impact for these stocks too."*

The possible driver in NZX MTS reduction is to make the New Zealand market more attractive for investors under the pressure from Australian markets. Because on the 1st April 2005, ASX has announced stocks under $2.00 may trade at various sub-cent increments. Bryon Burke who is head dealer at Craigs Investment Partners said that (Krupp, 2011):

> *"The driving motivation is probably the arbitrage that goes on between the two markets. Because a security does not trade in the same increments on both bourses is detrimental to New Zealand liquidity".*

In the later Section 3.4, the impact of the MTS reduction in New Zealand stock market is explained in details.

In conclusion, NZX is the main stock exchange in New Zealand. They make the market participants rules. The MTS applied in New Zealand is amended in 2012 that makes some exceptions to attract more trades.

3. Literature review

In this section, we introduce operation and obligation of NZX. Also we clarify current MTS rules used by NZX. In this section, we summarize previous studies about MTS and market liquidity. First, we present the fundamental study of tick size and market liquidity (section 3.1). Then, we discuss the tick size change effects based on natural experiments and price movement (section 3.2 and section 3.3). Finally, we review the studies on New Zealand stock market (section 3.4).

3.1 Fundamental study

In a competitive market, a reduction in the MTS will give rise to a reduction in bid-ask spreads, as investors are able to place orders at tighter spreads. The reduction in tick size will be particularly important for stocks where the spread has previously been constrained by the MTS and where the relative tick size is high. However, even stocks that were not constrained by the MTS may also experience a reduction in spread as investors place orders at prices that previously would have been unavailable. The fundamental paper on the effect of tick size on the market quality is by Harris (1994). He suggests that large tick sizes increase execution costs because the tick size constitutes a lower bound for the quotable spread. If the tick size is too large, it would frequently be a binding constraint on the bid-ask spread and thus impose unnecessarily large execution costs on traders. Harris notes that small tick sizes are not without cost, and the zero tick size is not perfect tick size. If the tick size is too small, it may reduce market liquidity because it lowers the cost of front running. That is, small tick sizes may make liquidity providers less willing to provide liquidity because of the high risk of front running. He also argues that a reduction in the MTS could lead to a reduction in liquidity due to raising adverse selection and quote matching.

3.2 Tick size change effects: natural experiments

Changes to stock MTS provide a chance to have natural experiments to analyse the influences of tick size on the market activity worldwide. Empirical research often finds that bid ask spreads and quoted depth decreases after the tick size reduction. Ahn, Cao and Choe (1996), and Goldstein, and Kavajecz's (2000) study present similar conclusions that if the MTS reduce, the bid-ask spread and the quotation size will decrease, and the trading volume will increase in the U.S. Jones and Lipson (2001) also indicate whether the MTS constrains the stock trading or not. Lau and Mclnish (1995) investigate the reduction in MTS in Singapore in 1994, and find it constrains the reduction in the bid-ask spreads, but no obvious evidences to support the change in trading volume. Kurov and Zabotina (2005) argue that when the minimum tick size is binding it indicates that the tick size has been set above its competitive level, and a binding tick size constraint impedes price competition. The decimalization of MTS in Toronto Stock Exchange, from $1/8 to five cents for stock with price between $3.00 to $4.99, and from five cents to one cent for stock with price over $5.00, reduce investors costs, and no significant effect on liquidity as the trading volume does not change and the quoted depths only decreases significantly for stocks traded over $5.00 (Bacidore, 1997). However, Mackinnon and Nemiroff (1999) suggest a significant increase in trading on the Toronto Stock Exchange after decimalization relative to trading in the United States. And increased activity on the Toronto Stock Exchange is consistent with the lower transaction costs. After reduction in tick size on the Toronto Stock Exchange, effective spreads and the fixed cost per share of transacting decline significantly. Therefore, the reduction in MTS benefits investors and helps increasing interexchange competition.

Obviously, the reduction in MTS can lead to reduction in the transaction costs and an improvement in market liquidity. However, an over reduction in MTS is irrational and costly. It is not suitable for all stocks. Stocks with different relative tick size and trading volume are affected differently by a reduction in MTS. The evidence from the Australian Stock Exchange, which is a very comparable market to New Zealand stock market, support that a reduction in the MTS gives rise to a reduction in spreads (Aitken & Comerton-Forde, 2005). Aitken and Comerton-Forde also find that investors are less willing to expose aggressively prices orders due to the reduction in the MTS. This is consistent with the findings by Goldstein & Kavajecz (2000) which investors might be shifting their limit orders to prices further away from the best bid and ask price in order to ensure that they receive an adequate premium for supplying liquidity to the market. For further investigation in Aitken and Comerton-Forde's (2005) study, the results suggest that improvements in liquidity following the decrease in MTS are greatest in high volume stocks. Reducing MTS too much, particularly in low volume stocks with smaller relative tick sizes may even reduce the provision of liquidity. They suggest considering a tick size based on both price and volume rather than a simple price-based. Wu, Krehbiel and Brorsen (Wu, Krehbiel, & Brorsen, 2011) give similar results. The reduction in MTS in 1997 on the New York Stock Exchange (NYSE) increases the effective spreads for transactions of even the smallest size, but the effect of the further reductions in 2001 for high-price and low-volume stocks was not statistically significant as previous. In an analysis of a reduction in tick size on the Tokyo Stock Exchange for stocks priced between 1000 JPY and 3000 JPY, Ahn *et al*. (2007) show that reductions in spreads are greater for stocks with larger tick size reductions and higher trading activity.

3.3 Tick size change effects: movement

The other type of empirical research deals with the change in tick size when stock moves from one tick size category to another. The price clustering, or discrete bid-ask spreads should be considered. The results for this type of research and the results from the natural experiments are similar. In an analysis of securities trading near ten dollars on Nasdaq, small tick sizes result in a decrease of spread. If considering a decrease in quoted depth, trading costs may increase especially for the traders who execute large volume. Small tick sizes may also imply large negotiation costs and thereby delay price discovery (Bessembinder, 2000). Bessembinder suggests that spreads are reduced when tick size is lower, and that this has no adverse selection effect on liquidity. Ke, Jiang and Huang (2004) indicate that the stocks with larger tick size have wider bid-ask spreads, and higher volatility; however, the effect on trading volume is insignificant on Taiwan Stock Exchange. There is a study on market liquidity (spreads and depths) and quote clustering from Kuala Lumpur Stock Exchange. Chung *et al.* (2005) also show that spreads are significantly positively related to inverse price and negatively related to trading volume after controlling for tick size category. That means the stocks with larger tick size have relative wider spreads. Cai *et al.* (2008) show that trading volume, number of shares traded, and average trade size are affected differently based on the study of Tokyo Stock Exchange stocks across the threshold 1000 yen. Also on Tokyo Stock Exchange, Asicoglu, Comerton-Forde and McInish (2010) find that trade size, the number of trades, and price are the most important determinants of whether the minimum tick size is a binding constraint. In fact, trade size and number of trades are more significant determinants of tick size constraint than price. Based on their finding, they suggest that tick size should be set based on trading activity and price, rather than price alone. This is consistent with the suggestion of Aitken and Comerton-Forde (2005). Chung, Kang, Kim (2011) find the strong evidence to support that MTS on high-priced stocks is a binding constraint for bid-ask spreads on the Korea Stock Exchange where the stepwise tock system applied.

The stock split is a typical example for the stocks move from one tick size category to another. The stock split leads to an immediately change in stock price, hence a firm can split its stock to adjust its tick size. For example, Wu *et al.* (2011) test the effects of stock split on market quality on NYSE. They find that the stock splits decrease both quoted spreads and effective spreads in dollar, but the effect on quoted depth is mixed. For stocks with lower tick size, stock splits increase the quoted depth. For stocks with higher tick size, stock splits decrease quoted depth.

3.4 Studies on New Zealand stock market

While these studies on tick size changes effects has been done for other markets (e.g. Aitken and Comerton-Forde, 2005; Goldstein and Kavajecz, 2000), they provide limit information to New Zealand stock market. There are two studies that focus on New Zealand stock market which are more related to my research (Anderson & Peng, 2013; Nguyen, 2013).

On 23 February 2011 the NZX announced that MTS reduce from \$0.01 to \$0.005 after 10th March 2011 for five companies in an attempt to increase New Zealand stock market liquidity. Later on the 23rd October 2011, the NZX extended the scheme to a further 12 stocks and become effective on the 7th November 2011. Based on the minimum tick size rule changes, Anderson and Peng (2013), and Nguyen (2013) use the event study to examine the impact of tick size change on liquidity. They analyze trading activity by measuring quoted and effective spreads, volume, depth, composite liquidity, and bind-constraint probability. They both find the reduction in minimum tick size would result in a smaller bid-ask spread, and also reduction in depth. Overall, the impact of reduction minimum tick size on New Zealand stock market liquidity is mixed. So it is difficult to conclude whether the eligible NZX stock is more liquid or less liquid.

3.4.1 Anderson and Peng study

Anderson and Peng (2013) examine various respects of liquidity before and after the reduction in minimum tick size for the 17 eligible stocks and control stocks that have similar liquidity characteristics with the eligible stocks. There are five aspects of liquidity being tested – quoted spread, effective spread, volume, depth, and bind-constraint probability. They find significant evidence to support that both bid-ask spread and depth for eligible after the introduction of half-cent.

Anderson and Peng (2013) also test the explanatory variables of liquidity changes following the reduction in the minimum tick size. The liquidity is measured by quoted spread percentage, volume, depth, market liquidity (ratio of dollar depth to quoted spread), and Amihud illiquidity ratio (2002). Amihud illiquidity ratio is ratio of absolute daily return to the daily dollar volume. The dependent variable is the natural log of the post-period divided by pre-period liquidity measure. The explanatory variables include the natural log of the average pre-period stock price, market capitalization, the bind-constraint probability, and the standard deviation of daily returns. There is a significant negative relationship between binding-constraint probability and change in quoted spread percentage. It suggests that the quoted bid-ask spread have larger decrease if stocks have higher probability of trades at minimum tick size. The relation between changes in depth and binding-constraint probability is negative, as well as the relation between changes in market liquidity and binding-constraint probability. It indicates that high binding-constraint probability stocks experience the greater decline in depth; however, total liquidity decrease more rapidly for stocks with higher bind-constraint probability. This is consistent with prior studies (Chung, Charoenwong, and Ding, 2004; Hsieh, Chung and Lin, 2008).

Then they examine the liquidity change based on size and binding-constraint probability. The results show that there is very significant negative relation between dollar depth and bind-constraint probability, and stocks with higher probability experience greater declines. It supports the previous test result. The strong evidence indicates that the quoted spread percentage of stocks with high bind-constraint probability. Therefore, the market liquidity declines for high bind-constraint probability portfolio, and increases for low bind-constraint probability portfolio.

3.4.2 Dr. Nhutt Nguyen study

This study examines the impact of a reduction in the minimum tick size from cents to half-cent on stock liquidity and market efficiency for the eligible stocks. The five liquidity measures they used are time-weighted quoted bid-ask spread, value-weight effective spread, depth in dollar value, number of shares, and composite liquidity. The composite liquidity measure is the percentage quoted spread divided by the dollar market depth. They also analyze the depth in the limit order book before and after the reduction. Then they test the order flow by percentage domestic volume. Later, they test whether the market efficiency increases or decreases after the minimum tick size reduction.

Both the graphs and empirical results suggest that there is a significant decline in the quoted spread and effective spread for the first five stocks, and for the twelve stocks there is no significant pattern in the quoted spread, and significant decrease in effective spread. Overall, the liquidity has improved after introduction of cents to half-cent. The five-stock experience greater benefit of lower bid-ask spread than the twelve-stock as the five-stock is more liquid. Both the volume depth and dollar depth decline after the reduction for five-stock and twelve-stock. The result of overall effect on liquidity suggests only the twelve stocks are more liquid. There is no strong evidence to support the cumulative volume (dollar) depth is different after the minimum tick size reduction for five-stock group. For the twelve-stock group, both cumulative volume depth and cumulative dollar depth decrease significantly.

Krupp (2011) suggests that the reason for NZX introduces the tick size reduction is they want to capture a greater market share of total order flow. Hence, Nguyen(2013) analyze the order flow for seven cross-listed stocks on the Australian stock market by using NZX volume divided by the total of NZX volume and ASX volume. The result is mixed. Only the percentage domestic volume of Auckland International Airport, and Fisher and Paykel Appliances show significant increase due to the reduction. The percentage domestic volume of NZ Oil and Gas shows significant decrease after the minimum tick size reduction. As the sample is quite small, it is hard to conclude the impact of minimum tick size reduction on order flow.

For the market efficiency, the coefficients for lagged order imbalance are significant for all sample and control group. And the coefficient of the interaction term between lagged order imbalance and the tick size dummy variable is negative. It suggests that the predictability of return is lower, and the market is more efficient post-reduction.

4. Hypotheses and methodology

In last chapter, we discussed the empirical research about MTS and market liquidity. Harris (1994) points that the MTS may be the spread binding constraint. Later, either the evidence from natural experiments or price movement shows that a reduction in the MTS shall led to a reduction in bid-ask spread, and therefore the execution cost. The effect on market depth is different for each market. However, the effect on market liquidity is varied. We cannot conclude the MTS reduction can raise the market liquidity or decrease the market liquidity, because there is a trade-off between the bid-ask spread and depth, which are indicators of market liquidity. The New Zealand stock market studies are based on the change of MTS rules in February and October 2011. The change is subject to only 17 stocks in total, not the whole market. My study can fill this gap because I will examine the whole New Zealand stock market to expose the impact of MTS on market liquidity.

This section develops the key hypotheses tested in my dissertation around the impact of MTS on the liquidity of the New Zealand stock market. First, I can test whether current MTS is a binding constraint or not (section 4.1). Secondly, the relation between MTS and stock characteristics will be tested (section 4.2). Finally, the causality of each liquidity determinants will be examined (section 4.3).

4.1 Binding constraint

Previous literature has discussed that large MTS increases transaction cost, and small MTS may reduce market liquidity. Sometimes, a large MTS would be a binding constraint on the bid ask spread, therefore, large execution cost (Harris, 1994). Although using the tiered tick regime based on stock price, the level of constraint is variable across the stocks (Asicoglu, Comerton-Forde and McInish, 2010; Cai, Hamao and Ho, 2008; Chung, Kang and Kim, 2010). Aitken and Comerton-Forde (2005), and Asicoglu *etc.* (2010) suggest the considering a tick size based on both price and other factors. Therefore,

H_1: The current MTS is a constraint in the reduction in spreads for the stocks with price below and above \$0.20.

The stocks are divided into different groups by price level. The numbers of times stock price crossed regime of the six groups for each stock are counted, and the average quoted spread and effective spread are calculated. The quoted spread is defined as the differences between the lowest ask price and highest bid price. The percentage quoted spread is calculated as:

$$\text{percentage quoted spread} = \frac{2\left(Ask_{j,t} - Bid_{j,t}\right)}{\left(Ask_{j,t} + Bid_{j,t}\right)} \times 100$$

The effective spread is defined as twice the differences between the actual execution price and the midpoint of prevailing market quote at the time of order entry. The percentage effective spread is calculated as:

$$\text{percentage effective spread} = \frac{\left|2 \times trade\ price - \frac{Ask_{j,t} + Bid_{j,t}}{2}\right|}{\frac{Ask_{j,t} + Bid_{j,t}}{2}} \times 100$$

where $Ask_{j,t}$ and $Bid_{j,t}$ represent the best ask and bid price for stock j at time t.

Then we calculate the binding constraint probability (BCP). The BCP is the proportion of closing quoted spreads The table and graph can be constructed by summarizing the average spreads in dollar based on the number of times crossings occurred and based on duration, the number of days stock prices remain in one category. This method is first used by Harris (1994) and developed by Cai *et al.* (2008).

To notice that the results may be biased, as the number of stocks traded in New Zealand market is small, the small sample size and relatively low trading activity, the tests used lack the power to reject the null hypothesis. However, the results still can give a rough suggestion that whether the current MTS is a binding constraint for each price level, volume level, and market capitalization level. If the BCP of single group is larger than the BCP of whole market, then it suggests there is a binding constraint. I would expect a drop in the average spreads when stock price are above $0.20 compare with stock price are below $0.20. Also, I would expect to see a larger reduction in average spreads from crossing events with longer duration, because a longer duration indicates the change in tick size is permanent, or less likely to be reversed. For the graph, if the frequency decreases as the spread increases, it means that the MTS is truly a constraint on reduction in spreads.

4.2 MTS and stock characteristics

As we discussed in previous chapter, there is a relationship between MTS and each stock characteristics - trading volume, trade size, number of trades, depth, market capitalization. Asicoglu, Comerton-Forde and McInish (2010) find that there is a significant relationship between MTS and trade size, the number of trades, and price. Therefore,

> *H_2: there is a significant relationship between MTS and trading volume, trade size, number of trades, depth, market capitalization.*

The stocks move from one price level to another, hence, the MTS changes. The changes will be captured to measure the impacts of tick size on the spreads by regression model. The discrete spread model of Harris (1994) estimates the expected reduction in spreads that can result from a decrease in tick size. His model is estimated by using intraday stock quotation spread frequencies. The following empirical research is modified his model. The spread is one aspect of market liquidity. It represents a transaction costs for investors entering and existing a position. There are two types of spread. One is quoted spread, which is a good indicator of execution cost for small size orders. The other one is effective spread that includes price movement and market impact from order itself. These two types of spreads are both used in this study, the calculations of percentage quoted spread and percentage effective spread are introduced in section 4.1.

Based on previous literature, I estimate the following regressions.

$$SPREAD_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it};$$

$$PROMTS_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it};$$

$$DEPTT_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it};$$

where IP_{it} stands for the inverse average trade price for stock *i* at time *t*; TV_{it} stands for the daily trading volume for stock *i* at time *t*; NT_{it} stands for the number of trades for stock *i* at time *t*; CAP_{it} stands for the market capitalization for stock *i* at time *t*; $DEPTH_{it}$ stands for the depth at the best bid and ask price available immediately prior to each trade in dollar value; $SPREAD_{it}$ stands for the average of the difference between the ask and bid price, in my case, I use quoted spread percentage and effective spread percentage; $PROMTS_{it}$ stands for the proportion of time that the spread equals the MTS for stock *i* at time *t*, $PROMTS_{it}$ is as same as BCP; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below \$0.20, \$0.20 - \$0.99, \$1.00 - \$4.99, \$5.00 - \$9.99, above \$10.00, respectively; ε is the error term.

PROMTS proportion is used by Chung and Charoenwong (2002), and Asicoglu, Comerton-Forde and McInish (2010). From an economic perspective, we expect higher priced stocks to have a higher absolute spread, SPREAD, and, consequently, lower levels of constraint PROMTS. The estimated coefficients (i.e., β_6 through β_{10}) for the dummy variables measure the difference in the relative spread or depth between the stocks with different price level. Hence, by looking at the sign and statistical significance of β_5 through β_{10}, we can determine whether stocks with larger relative tick sizes have larger spreads or larger depths. I would expect to see, stocks exhibit more frequent changes in the best quotes, have more depth, higher spreads and are more frequently constrained by the minimum tick size in the relative high tick size category.

The result can suggest us the relation between the MTS and stock characteristics. Consequently, we know how strong the MTS and the variables correlated, especially the depth. The market depth is the other aspect of market liquidity. It refers to the size of order needed to move the market for a given amount in general. The depth in dollar is calculated as the average of the bid depth times bid price and ask depth times ask price. The deeper the market is, the more liquid the market is.

5. Data selection

I obtain intraday transaction data for all New Zealand Stock Exchange (NZSX) listed stocks from the Reuters database maintained by the Securities Industry Research Centre of Asia Pacific (SIRCA). The market capitalization data are acquired from Datastream. The studying period is six months from October 2012 to March 2013. There are 122 normal trading days in the period, which exclude Labour Day, Christmas (3 days) and New Year (3 days). I obtain details of bid and ask price, and also trade size of every individual trade. We also obtain details of every change in the bid and ask price, and depth for the best two price steps. There are 178 securities traded in NZSX between the studying periods. The stocks are removed from the sample if the stock price does not trade during the study period, or the stock is delisted or taken over by others in NZSX. Therefore, there are 135 stocks left.

The stocks are divided into two groups basically. One is stocks with price less than $0.20, the other one is stocks with price equal and greater than $0.20. The stocks in the group with price equal and greater than $0.20 are split into four small groups by the price between $0.20 to $0.99, the price between $1.00 to $4.99, the price between $5.00 to $9.99, and the price above $10.00. There are 17 exceptions due to the MTS rules changes in March 2011 and November 2011. They are in one category. However, in my sample there are 16 in total as Fisher and Paykel Appliance was took over by Haier before October 2012. The numbers of stocks in the four groups with price greater than $0.20 are nearly equal. As stated above, the firms with stocks traded above $10.00 are in the financial industry. Due to the unique feature of financial industry, I will consider the results for group with stock price above $10.00 separately.

The following trading variables are calculated for each stock for each day: TV, the trading volume; NT, the number of trades; CAP, the market capitalization; IP, the inverse stock price; DEPTH, the average of depth in dollar at the best bid and ask price; SPREAD, the mean of the difference between the ask and bid price, which are quoted spread and effective spread;

PROMTS, the proportion of time that the spread equals the minimum tick size. PROMTS is used by Chung and Charoenwong (2002) and Ascioglu *et al.* (2010). The descriptive statistics of the trading variables for stocks trading in each tick size categories should be reported and compare the differences between six groups.

6. Empirical Results

In this section, I present the empirical results for each hypotheses. First section is summary and descriptive statistics (section 6.1). Then, the regression model is examined (section 6.2). The last section is cause effect of stock characteristics (section 6.3).

6.1 Descriptive statistics and BCP

Table 1: Summary statistics for sample stocks and each group based on stock price

	Stock Price	Trading Volume	Number of Trades	Market Capitalisation	Quoted Spread%	Effective Spread %	Depth	PROMTS
Panel A: Whole Sample								
Mean	$3.40	477,534	29.24	$1,233,443	3.12%	2.79%	33652.67	0.1250714
Standard Deviation	$5.26	3,485,707	71.22	$4,542,036	12.12%	11.53%	50163.82	0.2915368
Minimum	$0.01	1	0.00	$124	0.04%	0.00%	30	0
Maximum	$39.00	209,000,000	2002.00	$37,100,000	200.00%	206.67%	900300.7	1
Panel B: New MTS rules eligible stocks								
Mean	$1.31	1,556,499	63.63	$857,761	0.77%	0.72%	86226.83	0.0325403
Standard Deviation	$0.64	4,628,644	104.91	$1,442,555	1.49%	1.42%	89919.66	0.1223264
Minimum	$0.42	120	0.00	$1,425	0.18%	0.00%	1137.475	0
Maximum	$2.95	113,000,000	961.00	$4,179,468	51.23%	49.59%	900300.7	1
Panel C: Stocks with price less than $0.20								
Mean	$0.09	163,002	3.36	$5,764	13.32%	11.82%	6707.837	0.0838039
Standard Deviation	$0.06	339,371	7.54	$4,889	26.07%	24.34%	7120.877	0.254315
Minimum	$0.01	100	0.00	$2,669	0.58%	0.00%	30	0
Maximum	$0.20	3,791,141	215.00	$27,551	200.00%	206.67%	77194.79	1
Panel D: Stocks with price between $0.20 to $0.99								
Mean	$0.53	309,662	10.01	$179,710	5.34%	4.66%	36571.63	0.1333197
Standard Deviation	$0.21	3,313,365	22.13	$332,122	13.35%	12.63%	55918.5	0.3253955
Minimum	$0.20	2	0.00	$124	0.15%	0.00%	405.6	0
Maximum	$1.00	159,000,000	410.00	$1,264,833	200.00%	206.67%	519790.2	1
Panel E: Stocks with price between $1.00 to $4.99								
Mean	$2.66	301,905	28.25	$461,012	1.87%	1.72%	23645.13	0.1970446
Standard Deviation	$1.06	3,150,007	71.14	$2,136,993	9.31%	9.12%	22215.01	0.3454851
Minimum	$1.00	1	0.00	$124	0.04%	0.00%	234.515	0
Maximum	$4.99	209,000,000	2002.00	$37,100,000	200.00%	200.00%	297975	1
Panel F: Stocks with price between $5.00 to $9.99								
Mean	$6.55	471,564	42.16	$4,958,043	1.40%	1.20%	23045.02	0.0602023
Standard Deviation	$1.32	4,634,637	87.70	$9,785,207	7.73%	7.65%	21118.63	0.1926474
Minimum	$5.00	60	0.00	$6,252	0.12%	0.00%	335.68	0
Maximum	$9.70	188,000,000	870.00	$37,100,000	200.00%	200.00%	406321.8	1
Panel G: Stocks with price greater than $10.00								
Mean	$20.65	88,341	20.34	$1,016,237	2.04%	1.86%	23771.21	0.0276657
Standard Deviation	$10.19	142,938	28.68	$614,454	13.79%	13.68%	13852.59	0.089345
Minimum	$10.00	50	0.00	$692	0.11%	0.00%	2166	0
Maximum	$39.00	788,293	513.00	$1,897,469	200.00%	200.00%	114062.4	0.6666667

This table contains summary statistics of the stock characteristics, stock price, trading volume, number of trades, and market capitalization. These variables are calculated based on the average daily closing value. Quoted spread percentage, effective spread percentage and depth are calculated from intraday data. PROMTS is the proportion that quoted spread equal MTS.

Table 1 shows descriptive statistics for panel data set of sample stocks and stocks grouped by price. Regarding the trading volume, the 16 new MTS rules applied stocks are much higher than full sample, as the average trading volume for new MTS rules eligible stocks is 1556499 that is three times the full sample trading volume (477534). The trading volume for the other groups is lower than the full sample, especially stocks with price less than $0.20 and stock price greater than $10.00. The mean daily trading volume for these two groups are 163002 and 88341, respectively. The result of number of trades shows same trend as the trading volume. That means investors trade less if the stock price is less than $0.20 or stock price is greater than $10.00. The quoted spread percentage and effective spread percentage are higher for stock with price less than $0.20. Comparing them, 13.32% and 11.82%, with the mean quoted spread percentage and effective spread percentage for full sample are 3.12% and 2.79%, respectively. Depth is the average of the best bid price times bid depth and quoted ask price times ask depth. The depth of new MTS rules eligible stocks is 86226.83 that is more than the depth of full sample and the other groups. The lowest depth is for the stocks with price less than $0.20, which is only 6707.84.

PROMTS is the proportion of spread equal to MTS, it is as same as BCP. The mean BCP for all stocks is the 0.1251. The BCP of new MTS rules eligibe stocks is 0.0325 that is much lower than the full sample. It means that MTS is not a binding constraint for the stocks applied the new MTS rules. The BCP for stocks traded between $0.20 and $0.99, and stocks traded betweem $1.00 and $4.99 are 0.1333 and 0.1970, respectively. They are higher than 0.1251. This means the current MTS rules, the MTS is $0.01, for stocks trades above $0.20 and lower than $5.00 is a binding contraint. The BCP for stock with price greater than $10.00 is lower than 0.1251. It is not consistent with my prediction in section 4.1, which is the higher the stock price is, the larger the BCP is. I think the reason for this is the industry of stocks with price greater than $10.00 is financial. As I stated above, the financial industry is not always shown same empirical results as others.

6.2 Regression model

6.2.1 Spread and stock characteristics – Panel data

Table 2 presents the quoted spread regression results by using the panel data set, and Table 3 presents the effective spread regression results by using the panel data set. The following model is estimated:

$$SPREAD_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it};$$

Table 2: Quoted spread and stock characteristics – Panel data

QuotedSpread	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
LTV	-.0016786	.0007205	-2.33	0.020	-.0030909	-.0002664
NoTrades	-4.44e-07	.0000181	-0.02	0.980	-.0000359	.000035
MarketCap	-4.91e-10	8.52e-10	-0.58	0.564	-2.16e-09	1.18e-09
IP	.0009671	.0004451	2.17	0.030	.0000947	.0018395
D1_new	-.013993	.0118134	-1.18	0.236	-.0371469	.009161
D2_less02	.0298084	.0143859	2.07	0.038	.0016125	.0580042
D3_02to099	.0222882	.0087143	2.56	0.011	.0052085	.0393678
D4_1to499	.0058326	.0062517	0.93	0.351	-.0064205	.0180856
_cons	.0408259	.0094688	4.31	0.000	.0222674	.0593844
sigma_u	.03215821					
sigma_e	.07493913					
rho	.15551081	(fraction of variance due to u_i)				

$SPREAD_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it}$, where IP_{it} stands for the inversed average trade price for stock *i* at time *t*; TV_{it} stands for the daily trading volume for stock *i* at time *t*; NT_{it} stands for the number of trades for stock *i* at time *t*; CAP_{it} stands for the market capitalization for stock *i* at time *t*; $SPREAD_{it}$ stands for the average of the difference between the ask and bid price, in this case, I use quoted spread percentage; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below \$0.20, \$0.20 - \$0.99, \$1.00 - \$4.99, \$5.00 - \$9.99, above \$10.00, respectively; ε is the error term. To assess the robustness of our results, I estimate the model after omit the groups with price between \$5.00 and \$9.99, and price greater than \$10.00.

Table 3: Effective spread and stock characteristics – Panel data

EffectiveS~d	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
LTV	-.0023394	.0006872	-3.40	0.001	-.0036864	-.0009925
NoTrades	5.03e-06	.0000173	0.29	0.771	-.0000289	.000039
MarketCap	-3.76e-10	7.67e-10	-0.49	0.624	-1.88e-09	1.13e-09
IP	.0012616	.0004098	3.08	0.002	.0004585	.0020647
D1_new	-.009442	.0106841	-0.88	0.377	-.0303825	.0114984
D2_less02	.0182325	.0133408	1.37	0.172	-.007915	.04438
D3_02to099	.0196452	.0080554	2.44	0.015	.003857	.0354335
D4_1to499	.0059573	.0058418	1.02	0.308	-.0054925	.017407
_cons	.0439558	.0088675	4.96	0.000	.0265759	.0613357
sigma_u	.02880529					
sigma_e	.07197241					
rho	.13806589	(fraction of variance due to u_i)				

$SPREAD_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it}$, where IP_{it} stands for the inversed average trade price for stock *i* at time *t*; TV_{it} stands for the daily trading volume for stock *i* at time *t*; NT_{it} stands for the number of trades for stock *i* at time *t*; CAP_{it} stands for the market capitalization for stock *i* at time *t*; $SPREAD_{it}$ stands for the average of the difference between the ask and bid price, in this case, I use effective spread percentage; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below $0.20, $0.20 - $0.99, $1.00 - $4.99, $5.00 - $9.99, above $10.00, respectively; ε is the error term. To assess the robustness of our results, I estimate the model after omit the groups with price between $5.00 and $9.99, and price greater than $10.00.

The random effects model is used. Because the daily market capitalization is not changed frequently as the other variables. If we use the fixed effects model, the market capitalization is shown as omitted variable in STATA. The random effects model is also used for following panel data regression models.

IP is an important variable, it first used by Harris (1994). Harris (1994) finds that there is a strong positive correlation between inverse price and spread, and MTS is a binding constraint on the spread of low-price stocks. In table 2 and table 3, the first column shows that there is a positive relation between spread and inverse price (IP) as the positive coefficients with p-value is less than 0.05. It is a consistent result with Harris's finding. It presents the low-price stocks are binding by MTS. This is consistent with BCP results in section 6.1. For trading volume, there is negative relationship with spread; and the relation is strong, as the p-value is less than 0.05 that means the coefficient of trading volume is significantly different from zero. The relationship between spread and market capitalization is insignificant negative as the p-value is much greater than 0.05. It indicates the large companies stocks trade at narrow spread. The coefficient of stock with price less than $0.99 (include group less than $0.20 and between $0.20 and $0.99) is positive and significant. It means that the spread for the stocks in this group is limited by MTS. It is consistent with BCP result. The relationship between spread and new rules applied stocks is not significant. It means the new MTS is not binding constraint for these stocks.

6.2.2 Spread and stock characteristics – Cross sectional data

In this section, the spread regression is run by cross sectional data regardless of the time differences.

Table 4: Quoted spread and stock characteristics – Cross sectional data

Source	SS	df	MS
Model	.100502168	10	.010050217
Residual	.088360284	75	.001178137
Total	.188862452	85	.002221911

Number of obs =	86
F(10, 75) =	8.53
Prob > F =	0.0000
R-squared =	0.5321
Adj R-squared =	0.4698
Root MSE =	.03432

QuotedSpread	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LTV	-.0167153	.0028549	-5.85	0.000	-.0224026	-.0110281
NoTrades	.0002324	.0001021	2.28	0.026	.0000291	.0004357
MarketCap	1.34e-09	9.66e-10	1.39	0.168	-5.79e-10	3.27e-09
IP	.0015247	.000607	2.51	0.014	.0003155	.0027339
D1_new	.0313692	.038151	0.82	0.414	-.0446315	.1073699
D2_less02	.0840589	.0402586	2.09	0.040	.0038595	.1642582
D3_02to099	.0578125	.0363972	1.59	0.116	-.0146945	.1303195
D4_1to499	.028095	.0346678	0.81	0.420	-.0409668	.0971568
D5_5to999	-.0047487	.0318628	-0.15	0.882	-.0682226	.0587251
D6_greater10	.0068144	.0370634	0.18	0.855	-.0670197	.0806485
_cons	.1805336	.0425291	4.24	0.000	.0958114	.2652559

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$SPREAD_i = \alpha + \beta_1 NT_i + \beta_2 TV_i + \beta_3 CAP_i + \beta_4 IP_i + \beta_5 D_1 + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \beta_9 D_5 + \beta_{10} D_6 + \varepsilon_i$; where IP_i stands for the inversed average trade price for stock *i*; TV_{it} stands for the daily trading volume for stock *i*; NT_i

stands for the number of trades for stock *i*; CAP_i stands for the market capitalization for stock *i*; $SPREAD_i$ stands for the average of the difference between the ask and bid price, in this case, I use quoted spread percentage; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below $0.20, $0.20 - $0.99, $1.00 - $4.99, $5.00 - $9.99, above $10.00, respectively; ε is the error term. To assess the robustness of our results, I estimate the model after omit the groups with price between $5.00 and $9.99, and price greater than $10.00.

Table 5: Effective spread and stock characteristics – Cross sectional data

Source	SS	df	MS
Model	.074647417	10	.007464742
Residual	.071747537	75	.000956634
Total	.146394954	85	.001722294

Number of obs =	86
F(10, 75) =	7.80
Prob > F =	0.0000
R-squared =	0.5099
Adj R-squared =	0.4446
Root MSE =	.03093

EffectiveS~d	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LTV	-.0151868	.0025726	-5.90	0.000	-.0203116	-.010062
NoTrades	.0002137	.000092	2.32	0.023	.0000305	.0003969
MarketCap	1.22e-09	8.70e-10	1.40	0.165	-5.12e-10	2.95e-09
IP	.0013065	.0005469	2.39	0.019	.0002169	.002396
D1_new	.0298175	.034378	0.87	0.389	-.038667	.0983021
D2_less02	.0660863	.0362772	1.82	0.072	-.0061817	.1383542
D3_02to099	.0539409	.0327977	1.64	0.104	-.0113954	.1192772
D4_1to499	.0269829	.0312393	0.86	0.390	-.035249	.0892148
D5_5to999	-.0041533	.0287117	-0.14	0.885	-.0613499	.0530433
D6_greater10	.0073909	.033398	0.22	0.825	-.0591414	.0739231
_cons	.1627935	.0383231	4.25	0.000	.08645	.2391371

$SPREAD_i = \alpha + \beta_1 NT_i + \beta_2 TV_i + \beta_3 CAP_i + \beta_4 IP_i + \beta_5 D_1 + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \beta_9 D_5 + \beta_{10} D_6 + \varepsilon_i$; where IP_i stands for the inversed average trade price for stock *i*; TV_{it} stands for the daily trading volume for stock *i*; NT_i stands for the number of trades for stock *i*; CAP_i stands for the market capitalization for stock *i*; $SPREAD_i$ stands for the average of the difference between the ask and bid price, in this case, I use effective spread percentage; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below $0.20, $0.20 - $0.99, $1.00 - $4.99, $5.00 - $9.99, above $10.00, respectively; ε is the error term. To assess the robustness of our results, I estimate the model after omit the groups with price between $5.00 and $9.99, and price greater than $10.00.

Table 4 presents the quoted spread regression results by using the cross sectional data set, and Table 5 presents the effective spread regression results by using the cross sectional data set. The following model is estimated:

$$SPREAD_i = \alpha + \beta_1 NT_i + \beta_2 TV_i + \beta_3 CAP_i + \beta_4 IP_i + \beta_5 D_1 + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \beta_9 D_5 + \beta_{10} D_6 + \varepsilon_i;$$

Compare this equation with the equation used in section 6.2.1, there is no time concern. The time is not considered if we use the cross section regression. The cross sectional data is without regard to difference in time. I calculate average figures of each stock characteristics of each over the six months.

R-squared for the quoted spread regression is 0.5321, which is higher than the R-squared for the effective spread regression (0.5099). It indicates that the quoted spread model is more appropriate to use, although 0.5321 is not very close to 1. There is a significantly negative relationship between spread and trading volume. It indicates that the stocks traded in high volume are usually with low spread. This is consistent with the results of panel data. The p-value of number of trades is less than 0.05, thus the coefficient of number of trades is significant positive. It means the more the number of trades is, the higher the spread is. This result is not supported by the panel data that show insignificant evidence. There is no significant evidence to support relationship between spread and market capitalization. The coefficient of IP is significant and positive. The MTS is a bind constraint for the low price stocks. It is similar to the results of IP in section 6.2.1 and Harris's finding (1994). For each price group, the p-value for stocks traded less than \$0.20 is 0.04 in quoted spread regression. It means the MTS is a binding constrain for the stocks traded less than 0.20.

6.2.3 Depth and stock characteristics – Panel data

Table 6 presents the depth regression results. The following model is estimated:

$$DEPTT_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it};$$

Table 6: Depth and stock characteristics – Panel data

LDepth	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
LTV	.1068332	.0056243	18.99	0.000	.0958098	.1178566
NoTrades	.0000776	.0001391	0.56	0.577	-.0001951	.0003503
MarketCap	-3.73e-09	1.02e-08	-0.37	0.714	-2.37e-08	1.63e-08
IP	-.0017065	.0043539	-0.39	0.695	-.0102401	.0068271
D1_new	.8960444	.1367769	6.55	0.000	.6279666	1.164122
D2_less02	-.6629155	.132519	-5.00	0.000	-.9226481	-.403183
D3_02to099	-.2463227	.0815458	-3.02	0.003	-.4061495	-.086496
D4_1to499	-.2095793	.0543863	-3.85	0.000	-.3161744	-.1029841
_cons	8.682335	.086036	100.92	0.000	8.513707	8.850963
sigma_u	.39353458					
sigma_e	.56734446					
rho	.32484473	(fraction of variance due to u_i)				

$DEPTT_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it}$, where IP_{it} stands for the inversed average trade price for stock *i* at time *t*; TV_{it} stands for the daily trading volume for stock *i* at time *t*; NT_{it} stands for the number of trades for stock *i* at time *t*; CAP_{it} stands for the market capitalization for stock *i* at time *t*; $DEPTH_{it}$ stands for the depth at the best bid and ask price available immediately prior to each trade in dollar value; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below \$0.20, \$0.20 - \$0.99, \$1.00 - \$4.99, \$5.00 - \$9.99, above \$10.00, respectively; ε is the error term. To assess the robustness of our results, I estimate the model after omit the groups with price between \$5.00 and \$9.99, and price greater than \$10.00.

As I stated in previous section, IP is important. Harris (1994) finds that depth is positively related to inverse price, as well as trading volume. However, in the New Zealand stock market, my results show that there is insignificantly negative relation between depth and inverse price as the p-value is 0.695. For the trading volume, the result is consistent with Harris that is significantly positive. The larger the trading volume is, the deeper the depth is. And the coefficients of each dummy show that there is significant influence on depth. Hence, investors in New Zealand stock market usually quote greater depths for stocks with larger tick sizes. It is consistent with the findings of prior studies in other markets, which an increase in quoted depth often follows an increase in tick size. The coefficient of market capitalization and number of trades are insignificant, no strong evidence to support that there is relation with depth.

6.2.4 Depth and stock characteristics – Cross sectional data

Table 7 presents the depth regression results by using the cross sectional data set. The following model is estimated:

$$DEPTH_i = \alpha + \beta_1 NT_i + \beta_2 TV_i + \beta_3 CAP_i + \beta_4 IP_i + \beta_5 D_1 + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \beta_9 D_5 + \beta_{10} D_6 + \varepsilon_i;$$

This model is regardless of the difference in time.

Table 7 Depth and stock characteristics – Cross sectional data

Source	SS	df	MS
Model	45.5410543	10	4.55410543
Residual	14.6981834	75	.195975779
Total	60.2392377	85	.708696914

Number of obs	86
F(10, 75)	23.24
Prob > F	0.0000
R-squared	0.7560
Adj R-squared	0.7235
Root MSE	.44269

LDepth	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LTV	.2918134	.036821	7.93	0.000	.2184623	.3651646
NoTrades	-.0011759	.0013162	-0.89	0.374	-.0037979	.0014461
MarketCap	-2.98e-08	1.25e-08	-2.40	0.019	-5.46e-08	-5.03e-09
IP	-.0120392	.0078284	-1.54	0.128	-.0276343	.0035558
D1_new	.5767302	.4920502	1.17	0.245	-.403484	1.556944
D2_less02	-1.149474	.5192332	-2.21	0.030	-2.18384	-.1151084
D3_02to099	-.3970285	.4694306	-0.85	0.400	-1.332182	.5381251
D4_1to499	-.1236873	.4471257	-0.28	0.783	-1.014407	.7670328
D5_5to999	.1966468	.4109478	0.48	0.634	-.6220032	1.015297
D6_greater10	.3770409	.478023	0.79	0.433	-.5752297	1.329311
_cons	6.755607	.5485157	12.32	0.000	5.662907	7.848306

$DEPTT_i = \alpha + \beta_1 NT_i + \beta_2 TV_i + \beta_3 CAP_i + \beta_4 IP_i + \beta_5 D_1 + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \beta_9 D_5 + \beta_{10} D_6 + \varepsilon_i$, where IP_i stands for the inversed average trade price for stock *i*; TV_i stands for the daily trading volume for stock *i*; NT_i stands for the number of trades for stock *i*; CAP_i stands for the market capitalization for stock *i*; $DEPTH_i$ stands for the average depth at the best bid and ask price available immediately prior to each trade in dollar value; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below $0.20, $0.20 - $0.99, $1.00 - $4.99, $5.00 - $9.99, above $10.00, respectively; ε is the error term. To assess the robustness of our results, I estimate the model after omit the groups with price between $5.00 and $9.99, and price greater than $10.00.

The R-squared is 0.5491 that is nearly middle of 0 and 1. It is fair to use this model to describe the data. The relation between trading volume and depth is significant and positive. That is consistent with previous studies. The p-value of market capitalization is 0.019 that is less than 0.05. It indicates the relative small companies trade more depth. There is strong evidence to show that the MTS is a binding constraint of stocks trade less than $0.20 as significant relation with depth.

6.2.5 PROMTS and stock characteristics – Panel data

Table 8: PROMTS and stock characteristics – Panel data

PROMTS	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
LTV	.0087235	.0014722	5.93	0.000	.0058381	.0116089
NoTrades	-3.33e-06	.0000373	-0.09	0.929	-.0000765	.0000698
MarketCap	-1.28e-09	6.04e-09	-0.21	0.833	-1.31e-08	1.06e-08
IP	.0109147	.0013483	8.10	0.000	.0082722	.0135573
D1_new	-.1149845	.0784398	-1.47	0.143	-.2687237	.0387546
D2_less02	-.1744997	.0392342	-4.45	0.000	-.2513973	-.097602
D3_02to099	.0053674	.0246157	0.22	0.827	-.0428785	.0536133
D4_1to499	.029669	.0159527	1.86	0.063	-.0015977	.0609356
_cons	.0380141	.0348759	1.09	0.276	-.0303413	.1063695
sigma_u	.23861572					
sigma_e	.1522882					
rho	.71057108	(fraction of variance due to u_i)				

$PROMTS_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it}$; where IP_{it} stands for the inversed average trade price for stock *i* at time *t*; TV_{it} stands for the daily trading volume for stock *i* at time *t*; NT_{it} stands for the number of trades for stock *i* at time *t*; CAP_{it} stands for the market capitalization for stock *i* at time *t*; $PROMTS_{it}$ stands for the proportion of time that the spread equals the MTS for stock *i* at time *t*, $PROMTS_{it}$ is as same as BCP; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below $0.20, $0.20 - $0.99, $1.00 - $4.99, $5.00 - $9.99, above $10.00, respectively; ε is the error term. To assess the robustness of our results, I estimate the model after omit the groups with price between $5.00 and $9.99, and price greater than $10.00.

Table 8 presents the PROMTS regression ran by panel data. The following model is estimated:

$$PROMTS_{it} = \alpha + \beta_1 NT_{it} + \beta_2 TV_{it} + \beta_3 CAP_{it} + \beta_4 IP_{it} + \beta_5 D_{1t} + \beta_6 D_{2t} + \beta_7 D_{3t} + \beta_8 D_{4t} + \beta_9 D_{5t} + \beta_{10} D_{6t} + \varepsilon_{it};$$

where $PROMTS_{it}$ stands for the proportion of time that the spread equals the MTS for stock *i* at time *t*. The relationship between trading volume and PROMTS is positively and significant. The more the trading volume is, the more frequent the spread equal to MTS. The inverse price is also strongly positive correlated with PROMTS as the p-value is 0. That indicates that the low price stock is more likely binding by MTS. The regression results show that number of trades and market capitalization have no influence on the PROMTS as the p-value close 1o 0. The coefficients of groups with stocks trade less $0.20 are negative and significant. It shows that stocks with price less than $0.20 are likely to trade at the MTS, which is $0.001.

6.2.6 PROMTS and stock characteristics – Cross sectional data

Table 9: PROMTS and stock characteristics – Cross sectional data

Source	SS	df	MS
Model	1.69849143	10	.169849143
Residual	4.0864772	75	.054486363
Total	5.78496863	85	.068058454

Number of obs =	86
F(10, 75) =	3.12
Prob > F =	0.0022
R-squared =	0.2936
Adj R-squared =	0.1994
Root MSE =	.23342

PROMTS	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LTV	.056309	.019415	2.90	0.005	.0176323	.0949858
NoTrades	-.0000341	.000694	-0.05	0.961	-.0014167	.0013484
MarketCap	-4.14e-09	6.57e-09	-0.63	0.530	-1.72e-08	8.94e-09
IP	.0053015	.0041278	1.28	0.203	-.0029215	.0135245
D1_new	.2131175	.2594491	0.82	0.414	-.3037316	.7299665
D2_less02	.3039765	.2737822	1.11	0.270	-.2414256	.8493785
D3_02to099	.4388762	.2475221	1.77	0.080	-.0542132	.9319656
D4_1to499	.511013	.2357612	2.17	0.033	.0413526	.9806734
D5_5to999	.3752819	.2166852	1.73	0.087	-.0563772	.8069411
D6_greater10	.4063736	.2520528	1.61	0.111	-.0957413	.9084884
_cons	-.9347535	.2892223	-3.23	0.002	-1.510914	-.3585931

$PROMTS_i = \alpha + \beta_1 NT_i + \beta_2 TV_i + \beta_3 CAP_i + \beta_4 IP_i + \beta_5 D_1 + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \beta_9 D_5 + \beta_{10} D_6 + \varepsilon_i$; where IP_i stands for the inversed average trade price for stock *i*; TV_i stands for the daily trading volume for stock *i*; NT_i stands for the number of trades for stock *i*; CAP_i stands for the market capitalization for stock *i*; $PROMTS_i$ stands for the proportion of time that the spread equals the MTS for stock *i*, $PROMTS_i$ is as same as BCP; D stands for the dummy variables for the six groups where the new MTS rules applied, and stock price is below $0.20, $0.20 - $0.99, $1.00 - $4.99, $5.00 - $9.99, above $10.00, respectively; ε is the error term. To assess the robustness of our results, I estimate the model after omit the groups with price between $5.00 and $9.99, and price greater than $10.00.

Table 8 presents the PROMTS regression ran by panel data. The following model is estimated:

$$PROMTS_i = \alpha + \beta_1 NT_i + \beta_2 TV_i + \beta_3 CAP_i + \beta_4 IP_i + \beta_5 D_1 + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \beta_9 D_5 + \beta_{10} D_6 + \varepsilon_i$$

This is regardless of the diferences in time. The R-Squared is 0.2936, which is not much close to 1. It means this PROMTS regression is not very appropiate. But the R-squared is nor very small, so there is still some power to explain. As previous findings, the trading volume has significantly positive relationship with PROMTS. It presents that the stock with large trading volume is more likely traded at MTS. It is interesting to notice that the coefficient of stocks with price between \$1.00 to \$4.99 is positive and significant when we use cross sectional data. However, there is no clear evidences show this relation in the other regression. This significantly positive relationship means the stocks in this group is limited by MTS. This results is consistent with the descriptive statistic result.

The empirical results are mixed. But there are still strong evidences show that the current MTS is a binding constraint and trading volume is corrolated with spread and depth.

7. Conclusion

As there are already a massive amount of research on the effects of the MTS on stock market from stock marker around the world, this paper is to fill the blank on literature where is not study on the topic about the impacts of the MTS in New Zealand stock market. It is a new topic in New Zealand. The purpose of this paper is to test the impact of MTS on New Zealand stock market liquidity. The results can give a better understanding on the New Zealand stock market to all market participants. We know the relation between tick size and spread and depth these are two aspects of market liquidity. The empirical results show the current MTS is a binding constraint for stocks with price less than $0.20. The trading volume is strongly positive correlated with proportion of spread equal to MTS. However, the relationship with market capitalization is weak. That is consistent with prior studies.

More and more stock markets decide to reduce the MTS based on the price even the trading activity. This change suggests that the stock market managements believe that there is a merit in the reduction. It can make the market more competitive. The regulators in New Zealand may think you reduce the MTS as well. Depend on the results from this paper, I can make a suggestion that to introduce more price category to make the MTS rules more precisely or to reduce the current MTS. The alternative method is to combine the price level and trading volume to make MTS rules.

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