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The Impact of Tick Size Reduction on NYSE: A Difference-In-Difference Analysis

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Abstract

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In this article, a before-and-after analysis of daily variation in bid-ask spreads, market liquidity, market depth, and Amihud’s Measure is used to research the tick-size reduction on New York Stock Exchange (NYSE) in 1997. In order to eliminate the impact of other possible factors, I assign the trade and quote data from Toronto Stock Exchange (TSX) as a control group. The empirical results show that spreads, which represent the trading costs, declined significantly after the switch, while market liquidity and depth slightly improved. Yet no hasty conclusions can be made for Amihud’s measure, a measurement of the price impact. The results are consistent with my conjecture that, the trading cost will decline, while liquidity of the market improves. In this paper, a “Difference-In-Difference” model and panel data regression is used to estimate these outcomes.

Keywords: Tick Size Reduction; Trading costs; Spreads; Amihud’s measure; Market liquidity; NYSE; TSX; Difference-In-Difference

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I. Introduction

In a financial market, the tick size is the smallest increment by which the price of a financial instrument can move. Different minimum tick rules apply to different markets. Within the United States, for example, the minimum tick for the NASDAQ Stock Market, used to be $1/8 for quotes until June 2, 1997 and in the Chicago Mercantile Exchange's S&P 500 futures contract, the tick size is 0.10 index points. In this article, the market of focus is New York Stock Exchange (NYSE), on which the minimum tick size reduced from $1/8 to $1/16 on June 24, 1997. Hence, I attempt to investigate the impact of this tick size rule change on the behavior of NYSE.

Previous literatures have indicated that an effective method of examining the impact of the change of tick size rule is to inspect the change of bid-ask spread, market liquidity, and market depth. The objective of this paper is to tie these various characteristics of the market together, in order to have a general view that reflects the impact of tick size reduction.

In order to control for other potential factors that might influence the outcome, the dataset includes the stocks that are cross-listed on two different markets: New York Stock Exchange (NYSE) and Toronto Stock Exchange (TSX). Specifically, I choose 97 Canadian companies that were traded both on NYSE and TSX during 1997. Thus those 97 companies traded on TSX are assigned as the control group in the "Difference-In-Difference" model. By such, the model will show a clearer picture of the treatment effect of tick size reduction.

Investigating the tick size reduction provides direct evidence in understanding the costs and benefits of changing the century-old $1/8 fractional pricing system in the stock market. The research hopefully will lead to the finding of an optimal tick size function that will balance the negative and positive effects of tick size reduction.

II. Literature Review

Previous papers investigating the tick size reduction have focused on different stock exchange markets, including NASDAQ, AMEX (American Stock Exchange), and NYSE. These are the three biggest and mostly traded stock markets in the United States. Apart from the studies that focused on the U.S., a few researches set their sights on foreign markets such as Taiwan Stock Exchange and Japan Stock Exchange. Despite the efforts of various researchers in studying different markets, the results they obtained remain largely similar: as the minimum price variation unit, i.e. tick size reduces, quoted spread, effective spread decreases and market depth increase consequentially. Below, I will summarize briefly the contents and conclusions of relevant literatures.

Back to 1994，Christie et al. (1994) investigate the tick size reduction on NASDAQ using the data for the 10 most actively traded firms on the NASDAQ, including Amgen Cisco, Microsoft and etc. Their empirical results show that prior to May 27, 1994, odd-eighth quotes were exceedingly rare for each of these actively traded stocks. However, on May 27 for Amgen, Cisco, and Microsoft and on May 31 for Apple Computer, these companies began to use an increasing proportion of one-eighth spreads, which makes it rise immediately from almost zero to over 50 percent. Most importantly, they find that effective and quoted spreads fell by almost 50 percent following the tick size reduction.

Later in 1995, Hee-Joon Ahn et al. (1995) take the argument a step further and focused on another major American stock market, AMEX (American Stock Exchange). In their paper *Tick size, spread, and volume*, Hee-Joon Ahn et al examine the impact of the change in the minimum price variation using extensive variables such as effective spread, quoted spread, transaction costs, trading volume and market depth. They focus their analysis on AMEX stocks traded at prices between $1 and $5 affected by the new tick-size rule, effective September 3, 1992. The model they used is cross-sectional analysis: they chose 3 months before September 3, 1992 and 3 months after the tick size reduction. The empirical results present direct evidence on the impact of reducing tick size on transaction costs and trading activity. The evidence shows that a substantial reduction in both quoted and effective spreads follow the reduction in tick-size from $1/8 to $1/16. However, the rule change affects neither trading volume nor market depth.

In 1997, Angel's paper (1997), investigating the behavior of NYSE, shows the counteractive effect of tick size reduction. Angel provides the indirect evidence on minimum tick size reduction. He finds that a wider tick enhances liquidity by reducing bargaining and processing costs. Nevertheless, a wider tick size also increases the minimum quoted bid-ask spread. He also suggests that the optimal tick size for a particular firm might be a function of its risk, market size, and the proportion of informed trader. He argues that the optimal stock price level for a given tick size balances the positive and negative impact of tick size on spreads, depth, and liquidity.

However, unlike Angel, Bollen et al. (1998), also examining the behavior of NYSE, provides direct evidence that both bid-ask spreads and market depth at the prevailing bid-ask quotes have fallen after tick size reduction. They use the trade and quote data from NYSE of 20 trading days prior to the switch to $1/16 and 20 trading days after the switch. In their research paper, they compare measures of trading volume, bid-ask spreads, market depth, and market quality of pre-20 days and post-20 days. As a result, they not only come to the conclusion that bid-ask spread fell but also show that investor's trading costs have dropped overall. Apart from the declining measures that previous studies also find out, they also indicate that the largest gains were experienced for low price shares and for small trade size.

Moving yet another step forward, Goldstein et al. (1998) find that limit order book spreads (i.e., the spread between the highest buy order and the lowest sell order) actually increased and depth at the best prices on the limit order book declined after the reduction. Similar to the empirical results of Bollen's paper, Goldstein et al. observe the effect of tick size reduction on different characteristics of the market. They state that overall the cumulative effect of the changes in the limit order book and NYSE floor member behavior has reduced the cost for small market orders but increased the cost for larger market orders. The effect of the minimum tick size reduction is sensitive to the trade size and the trading frequency of each stock.

Taking a different research direction is Roger D. Huang (2000), who compares the behavior of two stock exchange markets: New York Stock Exchange and London Stock Exchange. In his paper, he argues that microstructure characteristics are not independent of market structure. Huang investigates two markets with distinct market structures: New York Stock Exchange, an auction market, and London Stock Exchange, a dealer market. An auction market is a market in which buyers and sellers enter competitive bids and offers, respectively, at the same time. Then matching bids and offers are paired together and the orders are executed. Whereas a dealer market is a market where dealers are assigned for specific securities. The dealers create liquid markets by purchasing and selling against personal inventory. According to the results of Huang's paper, a minimum tick is required in an auction market to encourage liquidity provision.

Without a minimum tick, a limit order can cheaply step ahead of another limit order or a dealer quote, which makes it easy to avoid time priority. Yet dealer markets have less need for a minimum tick. Huang suggests that the tick size rule is different and dependent on the different structure each market has.

Furthermore, Chung et al. (2001) analyze the data of NASDAQ stocks from Trade and Quote (TAQ) Database. Their research focuses on the time periods before and after February 4, 1997, when tick size rule on NASDAQ changed again. Their paper generalizes the findings of Christie et al. (1994), who focus on the 10 most actively traded stocks on NASDAQ. Chung et al. find that bid-ask spreads declined significantly after the introduction of the new order handling rules and the extent of the decline is particularly large during midday. They utilize the inventory and information models of the spread to explain the results and underscore that market structure has a significant effect on trading costs.

Apart from the previous papers that examine the change of behavior on the U.S. stock exchange markets after tick size reduction, the paper by Tzung-Yuan Hsieh et al.(2008) stands out. In fact, they focus on the Taiwan Stock Market, an emerging order-driven market, and inspect the impact of tick-size reduction on the market liquidity. Tzung-Yuan Hsieh et al. extract intraday transaction and quote data from TEJ (Taiwan Economics Journal). Their results show that the bid-ask spread, market depth, market liquidity, and binding-constraint probability decrease following the tick-size reduction and the declines are larger for low-priced or low-risk stocks.

Though previous papers have performed comprehensive studies on tick size, examining its impact on market quality such as market liquidity, bid-ask spread, and etc., they do not manage to eliminate other possible factors that might affect the outcomes. Hence to account for the effect of some potential “noisy” elements, I use a control group of stocks from Toronto Stock Exchange (TSX). In1997, there are 97 Canadian companies that were cross-listed on both NYSE and TSX. Then, by adding the control group into the “Difference-In-Difference” model, the analysis will indicate particularly the treatment effect of the tick size rule change. In the following Data and Methodology section, I will elaborate on the models in detail.

III. Data and Methodology

i. Data source

The trade and quote data are obtained from Datastream (Thomson Reuters) Equity Section. I selected all the Canadian companies, a total of 97, that were traded both on the Toronto Stock Exchange and New York Stock Exchange. The time periods include two months before and after the reduction, from April 24, 1997 to August 24, 1997, excluding weekends when both markets were close. The dataset includes information on firm code, exchange market, name of the firm, SEDOL code, ISIN code, delist status, dead status, close price of that particular day, open price, ask or high price, bid or low price, number of ordinary shares that represent the capital of the company, volume traded for the stock on that specific day, the volume unit, value, value unit, total return index, sector of the company, and LocalCode. Yet here the data types of interest are firmcode, close price, open price, ask price, bid price, volume, and volume unit. The reason is that firmcode will be served as the identifier and the time-invariant factor in the panel data regression. For the ask price, bid price and etc., they are important elements to calculate the dependent variables.

In addition, before performing the regression analysis on these data, a few modifications are needed. The first modification is to convert the prices in Canadian Dollars into U.S. dollars. Using the currency data released by Board of Governors of the Federal Reserve System, the close price, open price, ask price and bid price of the stocks traded on TSX are converted to U.S. dollars by the ratio of: Canadian Dollars to 1 U.S. Dollar = 1.3857. The second modification I make is to eliminate the outliers in the dependent variables. Given the fact that the dataset includes 97 Canadian companies cross-listed both on NYSE and TSX for approximately four months, the data renders huge variability. Therefore the existence of outliers would badly cloud the regression results. Hence, to better take full use of the data, I drop the data that lie below the 1^{st} and above the99^{th} percentiles of the dataset for each dependent variable (which will be stated clearly in the following section): QPS(quoted percentage spread), EPS(effective percentage spread), DD(dollar depth), ML(market liquidity), and AM(Amihud's measure), respectively. Thus, I keep the data in same unit and eliminate the possible impacts that might be brought up by these outliers.

ii. Measures

Several measure variables are to be examined in order to investigate the impact of tick size reduction. First of all I will examine the effect of tick size reduction on trading costs, which are usually measured by bid-ask spread. This is given the fact that bid-ask spread measures the implicit cost of trading and captures the price of liquidity, thus the trading costs. Hence the first two dependent variables employed here are: quoted percentage spread (denoted ass QPS), and effective percentage spread(denoted as EPS). To be more specific, the difference between these two measures will be stated in definition and in formula. The quoted spread basically captures the difference between ask-price ($Ask_{i,t}$) and bid-price ($Bid_{i,t}$). For small orders, quoted spread is a good indication of the trading cost for a trade. While for large orders, however, it may not fully represent the cost. Here, the effective spread better captures the cost of an order by including both price movement and market impact. The percentage spread is used here, instead of the dollar spread, to illustrate that the spread differ by the level of share price. The two measures are calculated using the following formulas.

Midpoint: $M_{i,t} = \frac{Bid_{i,t}+Ask_{i,t}}{2}$,

Quoted Percentage Spread: $QPS_{i,t} = \frac{Ask_{i,t}- Bid_{i,t}}{M_{i,t}}$,

Effective Percentage Spread: $EPS_{i,t} = \frac{2*|Price_{i,t}- M_{i,t}|}{M_{i,t}}$,

where i indicates the ith company among the 97, which is identified by the company code; t indicates the date on which the stock is traded.

The next set of variables is to measure market liquidity and depth. Dollar depth (denoted as the variable DD) comprises the sum of the number of shares times their respective prices at both the bid and ask price. Here with the product of dollar depth of each security, I can calculate the market liquidity (denoted as the variable ML), by taking the ratio of dollar depth to quoted spread. The formulas used to calculate dollar depth and market liquidity are stated as follows:

Dollar Depth: $DD_{i,t} = Number\_of\_Shares_{i,t} * (Ask_{i,t} + Bid_{i,t})$

Market Liquidity: $ML_{i,t} = \frac{DD_{i,t}}{Ask_{i,t}-Bid_{i,t}}$

Last but not the least, it is helpful to examine the change of price impact following the tick size reduction. Here I use the Amihud's (Illiquidity) Measure (denoted as AM) to estimate the price impact. Amihud (2002) proposes a proxy of price impact, based on the Kyle's Model (1985), which is estimated by the absolute price change on a particular day divided by the absolute order flow on the same day. The following formula shows exactly how to calculate the Amihud's

Measure:

Amihud's Meausre: $AM_{i,t} = \frac{|r_{i,t}|}{dvol_{i,t}}$

Where $r_{i,t}$ stands for the daily return of the stock. In practice it is substituted as the $Price_{i,t} - Price_{i,t-1}$. $dvol_{i,t}$ stands for the dollar volume.

iii. Difference-In-Difference Model

Following the introduction of dependent variables/measures in the previous section is the explanation of the basic model used in this paper. Here I use the "Difference-In-Difference" model since such model is often used to examine the treatment effect of a policy change. The main idea of the "Difference-In-Difference" model can be illustrated using the table below. In the pre-period, that is the 2 months before the tick-size reduction, neither the NYSE group nor the TSX group went through a policy change. Yet in the post-period, the tick size on NYSE fell from $1/8 to $1/16 whereas the tick size on TSX remained the same. Therefore for the investigation of the effect of the tick size rule change, the following table of outcome averages is applied.

	Pre-period	Post-period
NYSE	a	b
TSX	c	d

The average effect of the tick size change is (b–a) – (d–c), which is the (difference in measures for NYSE between pre-period and post-period) – (difference in measures for TSX between periods).

In order to use this method, it is necessary to generate two binary indicators with respect to different markets and the time periods. Firstly, regarding the two markets, the dummy variable, denoted as the variable nyse is created as follows:

nyse= $\begin{cases} 0, & if\ TSX\ (Toronto\ Stock\ Exchange) \\ 1, & if\ NYSE\ (New\ Yotk\ Stock\ Exchange) \end{cases}$

Secondly concerning the pre-change period and post-change period, I create the binary indicator: treatment period (denoted as the variable post). It is defined as follows:

post = $\begin{cases} 0, & if\ it\ is\ two\ months\ before\ the\ reduction \\ 1, & if\ it\ is\ two\ months\ after\ the\ reduction \end{cases}$

Besides these two binary indicators: nyse and post, an interaction term is needed in order to find if the effect of changing the minimum price variance from $1/8 to $1/16 has any impact on the already existing difference between stocks cross-listed on NYSE and TSX. The interaction term nysepost is defined as follows:

nysepost = nyse * post, which represents the interaction between the binary indicator for nyse and the binary indicator for post-period.

Therefore the basic model used to estimate dependent variables is as follows :

Y= $\beta_0 + \beta_1 * nysepost + \beta_2 * nyse + \beta_3 * post + \varepsilon$, where β_1 is the treatment effect. In this model, Y represents the different measures: QPS (quoted percentage spread), EPS (effective percentage spread), DD (dollar depth), ML(market liquidity) and AM (Amihud's Measure). ε represents the error term in this regression model.

iv. Hypotheses

Before running the regression, several hypotheses are to be made on the effect of tick size reduction on each of the dependent variables. First of all, considering the bid-ask spread measure, I hypothesize that the reduction in minimum tick size will reduce relative quoted spreads. The reasoning behind this hypothesis is that a smaller minimum increment in which prices can change reduces the difference between bid prices and ask prices. Therefore the bid-ask spread is expected to decrease. Consequently, the trading cost, measured by the bid-ask spread, should also diminish.

Moreover, a smaller trading cost will encourage the market makers to participate more in the market and thus increase the competition among the market makers. Hence the market liquidity, in contrary to transaction costs, improves. Additionally, market depth, defined as size of an order needed to move the market a given amount, is positively related to market liquidity. As a result, the more liquidity a market has, the deeper the market is. Therefore given a smaller tick size, a greater market depth is also within expectations. Moreover for a market that has greater market depth, the price impact of each stock will decrease. Thus the Amihud's measure is expected to be smaller after the change.

To summarize, for the regression model, I expect the coefficients β_1 for quoted percentage spread (QPS) and effective percentage spread (EPS) to be negative. And the coefficient β_1 for market liquidity (ML) and dollar depth (DD) will be positive, indicating an improving liquidity and depth. Lastly the coefficient measuring the price impact, the Amihud's measure, is anticipated to be negative.

IV. Empirical results

i. Descriptive Statistics

As mentioned above, the basic framework of my analysis is to compare the measures of transaction cost, market liquidity, market depth and price impact in the trading days of two month before the switch of tick size from \$1/8 to \$1/16 with two month after that. In addition, to control for other factors that might cloud the impact of tick size, a "Difference-In-Difference" model, holding TSX stocks as the control group, is used.

Before looking at the regression results, first I will analyze the basic descriptive statistics summarizing the mean, standard deviation, minimum, and maximum of stocks on NYSE. The main focus among these basic descriptive statistics is the mean of each measure, for that mean value captures a larger portion of information of the impact than standard deviation, minimum value and maximum value. As can be seen in Table I, while inspecting the QPS, EPS, I can notice the average values for these measures both decrease for post-change period. In detail, the pre-tick-size-reduction mean for QPS is 0.0217764 and the mean for post-change period is 0.0217115. The average value falls by, though not much, 6.49E-05 and 0.298%. Next for the effective percentage spread, which has the pre-change mean 0.0148 and post-change mean 0.0137, has the net change of -0.00106 and percentage difference -7.18%. Not only these differences satisfy with the aforementioned hypothesis, but also the mean values of effective and quoted spread agree with the fact that effective spread is always smaller than quoted spread.

Apart from the spread measures, the measures concerning dollar depth, market liquidity and the price impact are also of importance. As mentioned in the last section of hypotheses, as tick sizes reduced from $1/8 to $1/6 on June 24th, 1997, the dollar depth, market liquidity are expected to increase whereas the measure for price impact: Amihud's measure is anticipated to decrease. From Table I, the descriptive statistics on the three measures suggest that dollar depth changes in the direction as expected, whereas market liquidity and Amihud's measure show a different direction of change. In detail, the pre-period mean of dollar depth is 7645509 and the post-period mean of dollar depth is 8175108. Clearly 8175108 is larger than 7645509 by 529599. Also from Table I, we are also able to see that the mean increases by 6.93%. For market liquidity, the average values for the two months before the reduction and the two months after is 3.09E+07 and 2.97E+07, respectively. This shows that the market liquidity actually reduces by -3.88%. Furthermore, the average value of the Amihud's measure before the rule change is 0.000132 and the mean after that is 7.19E-05. The AM variable, as expected, decreases by 40%. Yet for now, it is not sufficient to say that the price impact decreases according to the mean value. I will still need to look at the regression results to confirm the previous hypothesis.

ii. Company Fixed Effects

As stated above in the methodology section, the "Difference-In-Difference" model is used to analyze the outcome. Apart from the "Difference-In-Difference" model, another technique employed here is regression with regards to panel data. For this data set, which includes four months of trade and quote data of 97 Canadian companies cross-listed both on NYSE and TSX, I will observe the same subjects (the behavior of each of 97 companies) for multiple time periods. Therefore the panel data technique is applied here to control for fixed-effects, which is the firm code, a numerical representative of each company in this model. Adding this numerical representative to the "Difference-In-Difference" regression model accounts for any company-specific, time-invariant factor. Therefore with these two techniques in hand, the treatment effect of tick size rule change on NYSE can be analyzed.

A. Spread and Trading Costs

As can be seen from Table II, the regression analysis indicates that QPS will have the following relationship with the binary indicators regarding different markets and time periods.

QPS = 0.0211909-0.0015969*nysepost+0.0007744*nyse+0.0014735*post

Though the change is relative small, it still shows that the quoted percentage spread on NYSE, compared to that on TSX, decreases due to the tick size reduction. The p-value of the nysepost coefficient is 0.004, which is obviously smaller than the significance level of 0.05. It suggests that the coefficient is effective in explaining the treatment effect of tick size rule change on QPS. However, as can also be noticed, the coefficient is relatively small: 0.0015969. When comparing the coefficient to the mean value of the quoted percentage spread, one can inspect that it only takes 7.3% of the average. Such small proportion of the average indicates a not so big change between the pre-period and post period of tick size reduction. Additionally the R-squared between for this test is 0.226, which suggests that the regression of panel data with fixed effect can explain 22.6% of the change.

Then I will analyze the effect percentage spread, which better captures the cost of an order by including both price movement and market impact and is of same importance to measure trading cost. The model for effective percentage spread is as follows, respectively.

EPS = 0.013235 -0.0015419*nysepost+ 0.0018174*nyse+ 0.0004085*post

This model not only suggests a decreasing effective percentage spread, but also indicates that the coefficient for EPS is significant, suggested by the 0.002 p-value, smaller than the 5% confidence level. Similar to the analysis for quoted percentage spread, I will also look at the comparison between the coefficient and the average value for effective percentage spread to get a comprehensive economic interpretation. The ratio of this coefficient 0.0015419 to the mean value of pre-EPS is 10.42% and 11.22% for post-EPS. Both ratios show a relatively small change. Hereby I can come to the conclusion that the treatment effect of tick size does affect the effective percentage spread, though with a small amount of change. Therefore, with the analysis of the two measures of spread, a summary can be made that both effective and quoted percentage spread decreases in a statistically significant way. Furthermore, the spread measures are in fact used to estimate the trading cost, a falling cost can also be expected following the tick size reduction, though the amount of change is relatively small.

B. Market Depth and Market Liquidity

In this section, I will look at the measures of market liquidity and market depth. Both of these two measures are expected to increase given the fact that the trading costs are lower than before. Therefore two models regarding dollar depth and market liquidity are summarized, respectively:

DD = 1.31E+07+ 2.16E+05*nyespost -6023460*nyse+ 330177.2*post

ML = 6.43E+07+ 4712276*nysepost -3.67E+07*nyse -5203151*post

Both models show that the treatment effect of tick size results in higher dollar depth and market liquidity. However as can be seen in Table II, the p-values for the coefficient of interest are 0.670 and 0.095 for DD and ML, respectively. Both p-values are larger than the significant level of 5%. Yet if the model is estimated with a 90% confidence interval, then the coefficient for ML, which has the p-value of 0.095, becomes significant in accounting for its growth. Apart from the statistical way of analyzing the model, I am more interested in looking at the change in economic way. Hence by comparing the coefficient with the aforementioned mean value of market liquidity: 3.09E+07, it is observed that 4712276 merely accounts for 15.25% of the mean. Similar to the results from quoted percentage spread and effective percentage spread, the proportion of increase is comparatively slight. In addition, the R-squared between for these two regressions are relative low. Particularly for ML with a significant coefficient, the R-squared between is 0.7%. Hence from these two models, the outcomes can be summarized that though market depth and market liquidity improve after the tick size rule change, the treatment effect, compared to the control group in TSX is not statistically efficient.

C. Price Impact

Lastly, I estimate the change of price impact that results from a smaller tick size. The model from the regression analysis is:

AM = 8.49E-05+ 4.74E-06*nysepost+ 5.86E-05*nyse-5.42E-05*post

The model shows a slight increase of the Amihud's measure. This result does not match with my conjecture that the price impact should decrease. Moreover the p-value for the coefficient of nysepost is relatively large: 0.894, which indicates its statistical insignificance. Hence from our model I cannot make any conclusion about the change of the price impact due to the tick size reduction.

V. Conclusion, limitations and extensions

i. Conclusions

In this paper, the trade and quote data are obtained for 97 Canadian companies that were cross-listed on NYSE and TSX during 1997. Two months before and after June 24^{th}, 1997 are chosen to investigate the impact of tick size reduction. In order to control for other possible factors that might cloud the impact, the stock data on TSX are employed as the control group and the "Difference-In-Difference" model is used. The "DID" model makes it possible to see the treatment effect of tick size rule change on NYSE clearly. The regression outcome shows that the trading cost, measured by quoted percentage spread and effective percentage spread falls because of a smaller tick size. Also I find out that market liquidity increases after the change, as anticipated, though the amount of change for both the spread and the liquidity is comparatively small. However no hasty conclusion of treatment effect on market depth and price impact, estimated by Amihud's measure can be made, because of their relatively large p-values. Consequently a conclusion is achieved that trading costs decrease and market liquidity improves because of a smaller tick size. The extent of reduction of trading costs and that of increase of liquidity is relatively slight. Such fact suggests that changing tick size from $1/8 to $1/16 is not enough to improve the behavior of NYSE, which is probably why the tick size rule changed again from $1/16 to decimal, 2001. Yet no summaries should be made on the change of market depth and price impact.

ii. Limitations

One of the limitations about this paper is that the dataset only includes 97 companies, since there was only a limited amount of companies that were cross-listed in 1997. The disadvantage of such selection is whether the 97 companies can represent the behavior of the whole market. Can the result of this paper be generalized to every company traded on NYSE? Another limitation is that right on April 23, 1997, TSX became a floorless and electronic trading environment. A question is proposed if such change will have any impact on the outcome of this paper.

iii. Extensions

Further issues that can be investigated on include comparing the tick size reduction in 1997 with the decimalization of tick size in 2001. By such comparison, since more companies become cross-listed, a larger dataset will be available to investigate on the impact. Additionally decimalization is a larger change than the switch from $1/8 to $1/16. Whether decimalization will generate different results from the outcome in this paper is worth researching. Moreover, estimating the outcomes with respect to different industries can also shed light on if a different tick size rule should be applied accordingly.

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Table I: Descriptive statistics summarizing the daily average of quoted percentage spread, effective percentage spread, dollar depth, market liquidity, Amihud's measure of the 97 Canadian companies cross-listed on NYSE and TSX during 1997. The Pre- statistics refer to the two months of trading days before June 24th, 1997 and the Post- statistics refer to the two months of trading days after June 24th, 1997. Since I focus on the impact of tick size change on NYSE, here I would only inspect the behavior of stocks on NYSE.

Panel A: Quoted Percentage Spread

	Mean	Std. Dev.	Min	Max
pre	0.0217764	0.014213	0.0005139	0.1064426
post	0.0217115	0.0147512	0.000656	0.0963391
Difference	-6.49E-05	0.0005382	0.0001421	-0.0101035
%Difference	-0.002980291	0.037866742	0.27651294	-0.094919703

Panel B: Effective Percentage Spread

	Mean	Std. Dev.	Min	Max
pre	0.0148024	0.0123658	0	0.0671264
post	0.01374	0.0118671	0	0.0665951
Difference	-0.0010624	-0.0004987	0	-0.0005313
%Difference	-0.071772145	-0.040328972	0	-0.007914919

Panel C: Dollar Depth

	Mean	Std. Dev.	Min	Max
pre	7645509	1.47E+07	1376	1.08E+08
post	8175108	1.59E+07	3618.78	1.07E+08
Difference	529599	1200000	2242.78	-1000000
%Difference	0.069269293	0.081632653	1.629927326	-0.009259259

Panel D: Market Liquidity

	Mean	Std. Dev.	Min	Max
pre	3.09E+07	6.47E+07	11466.67	6.41E+08
post	2.97E+07	6.04E+07	42600	5.92E+08
Difference	-1.20E+06	-4.30E+06	3.11E+04	-4.90E+07
%Difference	-3.88E-02	-6.65E-02	2.72E+00	-7.64E-02

Panel E: Amihud's Measure

	Mean	Std. Dev.	Min	Max
pre	0.000132	0.0006522	2.00E-09	0.0173958
post	0.0000791	0.000343	1.00E-09	0.005
Difference	-0.0000529	-0.0003092	-0.000000001	-0.0123958
%Difference	-0.400757576	-0.474087703	-0.5	-0.7125743

Table II: Regression result statistics summarizing the coefficients for each of the independent variables: nysepost, nyse. The dependent variables include the quoted percentage spread, effective percentage spread, dollar depth, market liquidity, Amihud's measure of the 97 Canadian companies cross-listed on NYSE and TSX during 1997. The Pre- statistics refer to the two months of trading days before June 24th, 1997 and the Post- statistics refer to the two months of trading days after June 24th, 1997. Since besides the sign of the coefficient, I would also like to know the statistical significance of the dependent variable and the usefulness of the test, I also include the p-value for the coefficient of the interaction term: nysepost and R-sq for the whole regression test.

Dependent Variable (Y）	β_0	β_1	β_2	β_3	P-value for β_1	R-sq within	R-sq between	R-sq overall
QPS	0.0211909	-0.001597	0.0007744	0.0014735	0.004	0.002	0.226	0.001
	(.0002683)	(.0005617)	(.000412)	(.0003754)				
EPS	0.013235	-0.001542	0.0018174	0.0004085	0.002	0.003	0.019	0.002
	(.0002409)	(.0005043)	(.0003699)	(.000337)				
DD	1.31E+07	2.16E+05	-6023460	330177.2	0.670	0.058	0.004	0.019
	(242550.5)	(507815.1)	(372410.4)	(339326.4)				
ML	6.43E+07	4712276	-3.67E+07	-5203151	0.095	0.064	0.007	0.032
	(1347917)	(2822063)	(2069583)	(1885726)				
AM	0.0000849	4.74E-06	0.0000586	-5.42E-05	0.894	0.002	0.014	0.001
	(.0000152)	(.0000315)	(.0000228)	(.0000214)				