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The Role of Tick Size in Upstairs Trading and Downstairs Trading*

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This paper examines the impact of reducing the tick size on market-making behavior on The Toronto Stock Exchange. The results indicate a significant decrease in the percentage of trades of fewer than 10,000 shares involving the upstairs traders and a significant increase in the percentage of trades of fewer than 1,000 share involving the designated market makers. Consistent with this finding, the upstairs traders earn significantly lower returns on non-block trades and the designated market markers earn lower returns on trades smaller than 1,000 shares. We conclude the tick size reduction benefits the trading public. *Journal of Economic Literature* Classification Numbers, G20, G24.

Key Words: tick size; upstairs market; market-making.

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I. INTRODUCTION

This paper examines the effect of reducing the tick size on the market-making behavior of two primary liquidity providers on the TSE:[1] the designated market makers and the upstairs traders. The designated market maker, charged with making an orderly market, must provide liquidity to the downstairs market and hence is constrained in his market-making behavior. The upstairs trader[2] works for one of the member firms of the TSE and is free to enter or exit the market at will; his market-making behavior is unconstrained. If a reduction in tick size precipitates a significant reduction in the returns to the upstairs traders and/or the designated market makers, then a significant and possibly asymmetric change in market-making behavior may occur.

We find that the earned returns of both the upstairs traders and the designated market makers significantly decrease with the reduction in tick size on the TSE. We also identify a significant shift in small-sized trades from upstairs traders to designated market makers and suggest that a significant number of orders can no longer be economically filled in the upstairs market. Consequently, a greater percentage of orders are routed to the downstairs market, where the designated market maker is required to participate if there is inadequate liquidity. This shift is concentrated in the trade sizes of less than 1,000 shares. Thus, our study provides important insights into the relation between the upstairs and downstairs markets.

In the next section of the paper, we review the academic literature on tick size. The third section of the paper describes the activities of both the upstairs traders and the designated market makers. The fourth and fifth sections of the paper describe the hypotheses tested and the data and research methods, respectively. The sixth section discusses the test results and the final section presents a summary of our findings and conclusions.

II. BACKGROUND LITERATURE

A. *Tick Size*

Harris (1991, 1994) argues that the traditional tick size of one-eighth of a dollar on North American exchanges reduces the liquidity of securities

[1] Several recent papers examine the impact of reduced tick size on liquidity *per se.* Harris (1994) predicts that a lower tick size makes markets more competitive and liquid. Empirical studies on the AMEX [Ahn *et al.* (1996)] and TSE [Bacidore (1997)], among others, find that spreads are significantly lower after tick sizes are reduced. For a comprehensive review of the issues surrounding decimalization, see Harris (1997).

[2] An upstairs market is present when orders may be matched and executed by member firms prior to being sent to the exchange floor for recording. A detailed description of the upstairs market at the Toronto Stock Exchange is provided in Section III.A.

since bid–ask spreads are higher than they otherwise would be and traders are prevented from transacting directly at particular prices.[3] Ahn *et al.* (1996) examine how the September 1992 reduction in tick size from one-eighth to one-sixteenth for AMEX stocks priced between $1 and $5 affected liquidity. As predicted by Harris (1994), they find that both posted and effective returns decreased. Volume, however, did not increase. Bacidore (1997) reports similar results for a study of stocks listed on the Toronto Stock Exchange following the April 1996 reduction of tick sizes for stocks priced above $3. Both studies suggest that the profits of traders providing liquidity declined because smaller spreads were not offset by larger volumes.[4] However, these studies do not examine the behavior of liquidity providers.

Ahn *et al.* (1998) analyze whether the reduction in tick size on the TSE affected the competition for order flow with U.S. markets. For TSE stocks cross-listed on the NYSE/AMEX, spreads significantly decreased 27% on the TSE but not on the NYSE/AMEX. For TSE stocks cross-listed on the NASDAQ, the spreads declined less on the NASDAQ than on the TSE. Yet there was no shift in order flow from the U.S. markets to the TSE. The authors conclude that the benefits of trading on the NYSE/AMEX exceed the savings in TSE transaction costs.[5]

Concerns raised about reducing the tick size include the expected impact on the profits of market makers and how a change in these profits will affect market liquidity. Grossman and Miller (1988) argue that some mini-

[3] The imposition of minimum price increments changes the distribution of security prices from a continuous form to a discrete form. When a one-eighth tick size is imposed, the tick size, when measured as a percentage of price, will decrease as prices increase. Thus, for very high-price securities, the minimum price increment is generally not as binding as it is for low-price stocks. Harris (1991) finds that, for the highest price securities, there is significant clustering around even eighths as opposed to odd eighths. He argues that the preference of traders to transact at particular price levels is based on a desire to simplify negotiations. The clustering is less significant at lower prices, leading him to conclude that investors would prefer to trade at price increments smaller than those permitted on U.S. exchanges, especially for smaller-priced stocks.

[4] Although the overall trading volume did not change with the introduction of decimalization, there was an increase in order flow to the designated market maker, resulting primarily (as we show later) from decreased activity by upstairs traders.

[5] Canada has five stock exchanges, with the largest market being the TSE. The other Canadian stock exchanges are the Montreal Stock Exchange, Vancouver Stock Exchange, Alberta Stock Exchange, and Winnipeg Stock Exchange. The TSE is the country's largest, with more than 80% of the dollar volume of shares traded. The five exchanges concurrently reduced their tick sizes on April 15, 1996. We investigated whether there was a shift in trading from the TSE to other markets for the securities in our sample. While none of the stocks in our sample is cross-listed on the Vancouver, Alberta or Winnipeg exchanges, 45 of the 60 stocks trading on the TSE over $5 were cross-listed on the Montreal Stock Exchange. We did not find a statistically significant movement in volume between the two exchanges.

mum tick size and a corresponding minimum bid–ask spread are necessary to provide adequate profits to the market makers to ensure that they remain active liquidity providers. Whitcomb (1988) counters this argument by noting that a model by Cohen *et al.* (1981) demonstrates that, even in the absence of a minimum tick size and where market makers are free to exit, liquidity is provided by individuals through limit orders.

III. THE UPSTAIRS MARKET AND DESIGNATED MARKET MAKERS ON THE TSE

A. *The Upstairs Market*[6]

The upstairs market is the purview of TSE member firms and represents an important portion of their operations. We define the upstairs market to mean the trading desks of member firms where the traders seek and match client orders with those of other clients (agency trades) or themselves (principal trades). An upstairs principal trade occurs when the upstairs trader is a client's counter-party. An upstairs agency trade occurs when a trade between two clients of the firm is facilitated. In early 1996, upstairs principal and agency trades accounted for approximately 9% and 7% of all trades, respectively. A third possibility is a nonclient/nonclient trade involving a transfer between two of the brokerage's own accounts or those of its employees. Nonclient/nonclient trades accounted for approximately 1 percent of all trades.

In Fig. 1, we provide a flowchart depicting client order flow on the TSE. Clients place orders with brokers, who may hold the orders for as long as 15 min, during which time the upstairs trader attempts to cross the order either as an agent for another client or as a principal against his own inventory.[7] If the order is matched, then it must subsequently be ''crossed'' (recorded) on the exchange floor. If the order is not filled, the order is transmitted to the downstairs market as either an immediately executable limit order, an off-market limit order, or a market order. Upstairs traders generally prefer agency crosses for reasons including the realization of two commissions, reduced holding risk, and fewer administrative handling costs. In principal trades, the upstairs trader earns one commission and hopes to

[6] This section is based on discussions in Harris (1993) and the Ontario Securities Commission Forum Proceedings (1994).

[7] The ability of the upstairs traders to see the order flow in advance of the downstairs market raises the issues of transparency and fragmentation. For an overview of these issues, see Harris (1993). Other papers examining the tradeoffs involved with varying degrees of transparency and fragmentation include Easley and O'Hara (1987), Hamilton (1987), Mendelson (1987), Stoll (1992), and Blume and Marshall (1997).

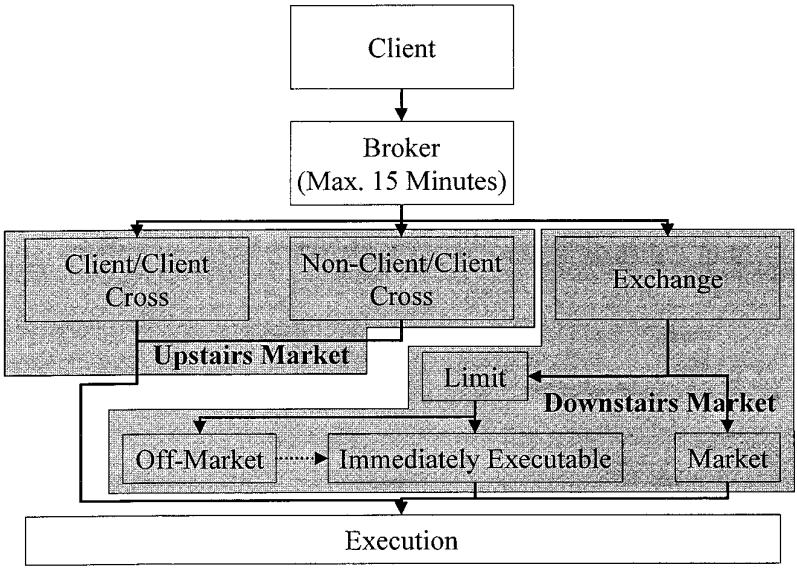

FIG. 1. Client order-flow on the Toronto Stock Exchange. In addition to trades resulting from client order-flow, there are nonclient/nonclient trades. These account for less than 1% of trades. The designated market makers (exchange) and upstairs market traders are the primary liquidity providers.

capture all or part of the spread between the bid and ask prices upon disposal of the inventory position. With a reduction in tick size, the profitability of agency trades is unaffected; however, the spread component of return from principal trades may be affected.

With the reduction of bid–ask spreads, the upstairs trader must determine if all-in costs for principal trades exceed the amount that can be earned given the new bid–ask spread. If *costs* $<$ *\$0.05 plus commissions* per share (the spread for shares valued at more than \$5), then the upstairs trader will continue to operate as before, since market-making will remain profitable. If *costs* $>$ *\$0.05 plus commissions* per share, then the upstairs trader will not trade since the profit motive no longer exists and the orders will be directed to the exchange. In the extreme, the upstairs trader also may exit the agency cross market if there are no longer sufficient trades (agency plus principal) to cover fixed costs. Alternatively if the upstairs trader has a competitive advantage in a certain market segment, for example, large block trades, he may reallocate resources to this activity. A shift in activity from the upstairs market to the downstairs market results in greater liquidity in the downstairs market.

B. *The Designated Market Maker*

A designated market maker (DMM) on the TSE[8] is charged with the responsibility of maintaining the consolidated order book in the downstairs market and with making an orderly market for certain securities.[9] All DMM trades are principal trades, whose spread component of returns will be affected by a reduction in tick size. Unlike other market participants in general, and the upstairs traders in particular, these individuals are required to make trades because of this market-making responsibility; i.e., some trades are nondiscretionary.

On the TSE, immediately tradeable orders (market or limit), at or below a stock's Minimum Guaranteed Fill (MGF) limit, are designated as Market Order System of Trading (MOST) trades. All MOST trades that cannot be filled from the electronic book are filled by computer against the DMM's inventory at the market quote (the DMM cannot exit this market segment[10]). The remaining trades are discretionary.

Another difference between the DMM and the upstairs trader is that the DMM can elect to ''autoparticipate'' in up to 50% of each MOST trade even when there are immediately tradeable limit orders.[11] These trades involve no search costs, and for liquid securities, virtually no holding risks or costs. If a reduction in tick size precipitates additional order flow in trade sizes smaller than the MGF, then the DMM may autoparticipate in greater volume.

IV. HYPOTHESES TESTED

This paper examines how the activities of the upstairs traders and the DMMs have been affected by the switch to decimal trading. In particular, we determine whether the reduction in the tick size has changed the realized returns and the trading behavior of these market participants.

[8] On the TSE, the designated market maker is called the designated registered trader.

[9] This is the role generally filled by the specialist on the NYSE.

[10] To protect themselves against adverse trends in the price, the DMMs can request that the TSE change the size of the MGF. The MGF limit varies both from stock-to-stock and over time, but as a general rule, the greater the average volume and number of trades per day, the higher is the MGF.

[11] The DMM indicates the intention of participating in additional trading activity by inserting a computer flag in the MOST system. The use of this autoparticipation flag by the DMM is binary in nature. If off, the order is filled against immediately tradeable limit orders. If on, 50% of the order is immediately filled against the DMM inventory. An exception to this process occurs if an odd number of shares are at issue. Here, the order is rounded up to the market and down to the DMM. Hence, an order for 700 shares would trade 400 shares against market orders and 300 shares against DMM inventory. This is a major difference from the role of the NYSE specialist who may not participate on the same side of any public order. An analysis of the securities in our study indicates that DMM autoparticipation represents less than 1% of total trading volume, both before and after the tick size reduction.

The first hypothesis is:

(*1*) *A decrease in the tick size lowers the earned returns of both the upstairs trader and the DMM.*

Where bid–ask spreads are constrained by the tick size, a smaller tick size will lead to lower posted and effective bid–ask spreads. If there is a reduction in spreads, the return that the DMMs and upstairs traders realize from providing liquidity will likely be lower. Grossman and Miller (1988) and Chordia and Subrahmanyam (1995) predict the market maker will experience lower profits with smaller trading increments. If this makes some trades unprofitable for the upstairs trader, more trades will be directed to the exchange where the DMM is obligated to facilitate the transactions.

Our second hypothesis is:

(*2*) *A decrease in the tick size leads to a decrease in the activity of upstairs traders and an increase in that of the DMM.*

V. DATA AND RESEARCH METHODS

This study employs the complete TSE equity history files. They are similar to the NYSE TAQ (Trade and Quote) database in that they contain bid, ask, and transactions prices, in addition to volumes offered, wanted, and traded at those prices. The data differ from TAQ in that they allow us to identify whether the buyer or seller in each trade was the DMM for the stock or one of the upstairs traders.

We use intraday quote and trade data for common equities to test the impact of the change in tick size over the 14 weeks before and the 14 weeks after the reduction in TSE tick sizes on April 15, 1996. The choice of these 14-week periods is arbitrary and represents a trade-off between ensuring an adequate number of observations for statistical purposes and restricting the length of the event window to ensure that the general market conditions and individual security characteristics (e.g., company size) related to liquidity are held constant.[12]

The reduction in tick size on the TSE affects securities priced above $3. For stocks trading above $5, the trading increment decreased from $0.125 to $0.05. For stocks trading between $3 and $5, the trading increment decreased from 5 cents to 1 cent. Below $3, the trading increments did not change. This allows us to construct a control sample (stocks trading below

[12] In an earlier version of this study, we report results (available upon request) based upon an examination of the 7 weeks before and the 7 weeks after April 15, 1996. Our results are robust to the length of the study period.

$3) and two test samples (stocks trading above $5 and stocks trading in the $3 to $5 range). By comparing changes in the test samples relative to the control sample, we eliminate the impact of systematic effects other than those attributable to a reduction in tick size.

Although the reduction in tick size resulted in an 80% decline in the minimum spreads for stocks priced between $3 and $5, there are too few securities (under 15) from which to draw reliable statistical inferences. The small number of stocks in this category is mainly the result of the requirement that securities used in this study remain within the same price level before and after the change to decimal trading. Unfortunately for the $3 to $5 category, the price volatility of many of the securities resulted in their either (1) dropping to less than $3 where there is no change in tick size, or (2) rising above the $5 level where they are subject to a 5-cent minimum spread. Thus, these securities are eliminated from further analysis.

We selected the most liquid stocks by choosing those securities with the lowest effective spread over the 14-week period from the 28th through 15th weeks prior to April 15, 1996. Testing is restricted to the most liquid stocks because such stocks are the most likely to be constrained by a minimum tick size.[13] In this study, the 30 most liquid stocks trading above $5 are examined and compared to a control group of the 30 most liquid stocks trading between $1 and $3.[14] Because the return and activity measures for this control group did not significantly change, the results for the control group are not reported.[15] To verify the robustness of our results, we also examined the next 30 most liquid securities trading over $5.

For each stock, measures of the profitability of and the participation by designated market makers and upstairs traders are estimated. The profitability of the DMM and upstairs trader is measured by the realized returns of the trades they participate in as principals. Upstairs agency crosses are excluded since the profitability of crosses is unaffected by a reduction in tick size.

The DMM and upstairs trader realize a return from two sources. First,

[13] The bid–ask spread of the 30 most liquid stocks priced above $5 was close to 12.5 cents before the reduction in the tick size. For most other stocks listed on the TSE, the normal spread was at least 25 cents. We also performed the analysis using securities ranked on the dollar value of shares traded and obtained highly comparable results (available upon request).

[14] Firms with stock prices below $1 are excluded, since such companies are more likely to be thinly traded. This would create excessive noise in the control sample of stocks.

[15] The use of stocks under $3 as a control sample can be criticized. First, the under-$3 stocks tend to be from smaller, less actively traded companies than the over-$5 stocks. This potential error is reduced by the fact that over 300 common share issues on the TSE are priced between $1 and $3 and sampling only the 30 most liquid of these securities ensures that very illiquid securities are not included. It also is possible that the under-$3 stocks may be affected by spillover effects; e.g., if the change in regulation lowers the cost of program trading, trading in all stocks may increase.

they profit from increases in the equilibrium price of a stock from the time of purchase to time of sale. Second, they profit as market makers when they buy a stock below its equilibrium price and sell it above its equilibrium price. Thus, we decompose the realized return into the holding period return and the earned return. The realized return (RR) over the 14-week period equals the percentage increase from the average purchase price to the average sale price, i.e.,

$$\mathrm{RR} = \left[\frac{\dfrac{1}{\sum_{t=1}^{N} \mathrm{SV}_t} (\mathrm{SP}_t \times \mathrm{SV}_t) - \dfrac{1}{\sum_{t=1}^{N} \mathrm{PV}_t} (\mathrm{PP}_t \times \mathrm{PV}_t)}{\dfrac{1}{\sum_{t=1}^{N} \mathrm{PV}_t} (\mathrm{PP}_t \times \mathrm{PV}_t)} \right], \tag{1}$$

where

SP_t = The price of the shares sold by market maker of interest in trade t.
PP_t = The price of the shares purchased by market maker of interest in trade t.
SV_t = The volume of shares sold by market maker of interest in trade t.
PV_t = The volume of shares purchased by market maker of interest in trade t.
N = The total number of trades involving market maker of interest during 14-week period.

Using the mean of the bid and ask prices as a proxy for the equilibrium price, the holding period return is calculated as the percentage increase (decrease) in the volume-weighted equilibrium price at the time of the purchase(s), to the volume-weighted equilibrium price at the time of the sale(s). That is,

$$\mathrm{HPR} = \left[\frac{\dfrac{1}{\sum_{t=1}^{N} \mathrm{SV}_t} \sum_{t=1}^{N} \left(\dfrac{A_t + B_t}{2} \times \mathrm{SV}_t \right) - \dfrac{1}{\sum_{t=1}^{N} \mathrm{PV}_t} \sum_{t=1}^{N} \left(\dfrac{A_t + B_t}{2} \times \mathrm{PV}_t \right)}{\dfrac{1}{\sum_{t=1}^{N} \mathrm{PV}_t} \sum_{t=1}^{N} \left(\dfrac{A_t + B_t}{2} \times \mathrm{PV}_t \right)} \right], \tag{2}$$

where

A_t = The ask price at the time of trade t.
B_t = The bid price at the time of trade t.
SV_t = The volume of shares sold by market maker of interest in trade t.
PV_t = The volume of shares purchased by market maker of interest in trade t.
N = The total number of trades involving the market maker of interest during the 14-week period.

To estimate the profits from market-making activities exclusively, we measure the earned return by subtracting the holding period return from the realized return. In computing the earned return, the above calculations assume that the level of inventory of a stock held at the beginning and end of the 14-week period is unchanged.[16] We made this assumption since we do not have data on the exact opening and closing inventory positions of the DMM and upstairs traders.[17] This method of estimating earned returns should produce a measure approximately equal to the effective spread of Lee *et al*. (1993), Christie and Schultz (1994), Christie *et al*. (1994) and Huang and Stoll (1996a, 1996b), who measure the effective spread as twice the absolute amount of the difference between the trade price and the mean of the bid and ask prices.[18] Finally, the percentages of trades in which

[16] We find strong support for the assumption of unchanged inventory levels for the DMM and less support for the upstairs traders. In particular, as a percentage of the number of shares bought, the average absolute differences between the number of shares bought and sold are 3.09 and 5.42% for the DMM for the 14-week periods before and after the lowering of tick size, respectively. For the upstairs traders, the comparable average absolute values are 59.09% and 53.91%, respectively. However, if we do not use absolute values, the average differences between buys and sells are much smaller and are not statistically significantly different from zero. This indicates that while the inventory holdings may have changed for individual securities, there was no overall increase or decrease in holdings across all 30 securities. Thus, while there may be some noise in the calculation of the upstairs traders' returns for individual securities resulting from changes in inventory levels, the measurement of average return across 30 securities should be affected less because of the absence of any systematic shifts in inventory levels.

[17] Porter and Weaver (1997) assume there is a zero opening inventory in calculating TSE traders' profits and estimate ending inventory by the level of purchases less sales. Faced with the same data limitations as this study, they estimate profits by the change in the trader's cash position over a one-month holding period, plus any amount paid or received upon reversal of the estimated ending inventory position. Their method of calculating profit does not remove any holding period gains or losses.

[18] For example, under our method a DMM who purchased 1,000 shares at $10, 2,000 shares at $10.05, and 2,000 shares at $10.10 would have a volume-weighted purchase price of $10.06. If these shares were subsequently sold in two equal transactions at $10.15 and $10.20, then the volume-weighted sale price would be $10.175 and the realized return 1.143%. Assuming that at the time of sale, the bid–ask quotes were at the 5-cent minimum tick and the buy (sell) prices were equal to the bid (ask) prices, then the volume-weighted mean of the bid-

the DMM participates and the upstairs traders act as principals and agents are calculated.

Because different market makers may have competitive advantages in various market segments, we also stratify the samples by trade size. In each sample, we divide trades into three categories: less than 1,000 shares, greater than or equal to 1,000 shares and less than or equal to 10,000 shares, and greater than 10,000 shares. All measures of profitability and activity are calculated for each stock in both samples of securities for each trade category over the 14-week periods before and after April 15, 1996. The increases (decreases) in profitability and activity measures from before to after are then determined. Finally, *t*-statistics are computed to test whether the means of the changes across the securities in each trade category are significantly different from zero.

VI. RESULTS

We commence by examining the overall effect of the reduction in tick size on the TSE as a whole. Previous research on the impact of the reduction in the tick size [e.g., Ahn *et al*. (1996), Bacidore (1997)] has focused on liquidity. We also test for changes in liquidity with measures including quoted bid-ask spreads, size of quotes and volume. As shown in Tables 1 through 3, our results are similar to those reported earlier in that bid–ask spreads narrow, quote sizes at the market are reduced, and volume is unaffected relative to the control group.

Table 1 presents the time-weighted bid–ask spreads and the size of the quoted volume of the sample groups from before to after the change to decimalization. Spreads and quoted volume decreased significantly (1% level) for the groups subject to the changes in the minimum tick size. The control group actually experienced a marginally significant (10% level) increase in spreads without a change in the quoted volume. With the exception of quoted spread and the number of trades, the control group exhibited no statistically significant shifts from before to after April 15, 1996. Thus, statistics for the control group are only reported in Tables 1 and 3.

In Table 2, we present the mean effective spreads (in cents) of the first and second 30 most liquid securities priced at more than \$5 and the 30 most liquid securities, during the 14 weeks before and after April 15, 1996,

ask price for purchases (sales) would be \$10.085 (\$10.15). Thus, the holding period return is 0.645% and the earned return equals 0.498%, i.e., 1.143% less 0.645%. Based on the calculation most commonly used in the literature, the effective spread here would be 5 cents, which as a percentage of the volume-weighted purchase price is 0.497%. Thus, our calculation of earned return approximates that of the effective spread.

TABLE 1
Impact of Reduction in Tick Size on Quoted Bid–Ask Spreads and Size of Offered Quotes on Most Liquid Securities on the Toronto Stock Exchange

	Bid–ask spread in cents			Total quoted volume (bid and ask) in $ thousands		
Price range	Before	After	Difference	Before	After	Difference in the log of quoted volume
30 most liquid stocks	13.7	7.3	−6.3	464	202	−0.4
>$5	[0.2]	[0.6]	(−16.6)***	[54]	[25]	(−23.1)***
Next 30 most liquid	15.0	9.3	−5.7	230	119	−0.3
stocks >$5	[0.2]	[0.3]	(−26.0)***	[25]	[127]	(−12.5)***
30 most liquid stocks	6.0	6.4	0.4	11	11	0.00
>$1 and <$3	[0.4]	[0.4]	(2.0)*	[1]	[9]	(0.0)

Note. The table shows the mean of the time-weighted bid–ask spreads and the size of the quoted volume (bid volume plus ask volume) of the first and second 30 most liquid securities priced over $5 and the 30 most liquid securities priced between $1 and $3, over the 14-week period before and after April 15, 1996, on the Toronto Stock Exchange. For each stock, the time-weighted bid–ask spread is calculated by summing the difference between the bid and ask quotes multiplied by the percentage of time over the 14-week period that the spread remains in effect. A similar calculation is performed to determine the time-weighted average of the quoted volumes at the bid and ask prices, which are then summed. This table also exhibits the difference in the logarithm of the quoted volume that equals the increase (decrease) in the quoted volume from the 14-week period before to after April 15, 1996. The most liquid securities are identified by ranking stocks by the effective spread over the period 28 to 15 weeks prior to April 15, 1996. The figures in brackets [ ] under columns titled ''Before'' and ''After'' are standard errors of the mean. The figures in parentheses ( ) under the columns titled ''Difference'' and ''Difference in the log of quoted volume'' are *t*-statistics. One, two, and three asterisks indicate significance at the 10, 5, and 1% levels, respectively

for transactions involving DMMs and upstairs traders. As expected, the effective spreads of principal trades of both types of market makers declined significantly (at the 1% level) as a result of decimalization. Further, it is clear that the effect is consistent across trade size.

In Table 3, we show the mean number of trades and the mean dollar volume of shares traded for the same two groups of securities trading at more than $5. When examined over all trade sizes, we find that in general the number of trades generally declined as did the dollar volume of the shares traded. Of interest is the significant reduction in the number of trades for securities priced between $1 and $3, while the traded dollar volume remained unchanged. We find the result is driven solely by changes involving 1,000 to 10,000 shares. The difference in logs (adjusting for scale) for this group is −0.1, which is significant at the 1% level (*t*-statistic is −2.6).

TABLE 2
Impact of Reduction in Tick Size on Effective Spreads for Trades Involving the Designated Market Makers and Upstairs Traders on the Toronto Stock Exchange

Panel A: Effective spread of principal trades of designated market makers and upstairs traders

Price range	Designated market makers			Upstairs traders		
	Before	After	Difference	Before	After	Difference
30 most liquid stocks >$5	11.3	6.0	−5.3	12.9	6.7	−6.2
	[0.1]	[0.4]	(−13.5)***	[0.1]	[0.5]	(−14.1)***
Next 30 most liquid stocks >$5	11.7	7.9	−3.8	13.4	8.2	−5.2
	[0.2]	[0.4]	(−13.1)***	[0.1]	[0.3]	(−18.8)***

Panel B: Effective spread of trades of designated market makers grouped by trade size (x)

Price range	x < 1,000 shares			1,000 shares ≤ x ≤ 10,000 shares			10,000 shares < x		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
30 most liquid stocks >$5	11.6	6.2	−5.5	9.6	4.8	−4.8	Not applicable due to an insufficient number of observations (≤15)		
	[0.1]	[0.4]	(−14.9)***	[0.2]	[0.4]	(−10.2)***			
Next 30 most liquid stocks >$5	12.0	8.1	−3.9	10.0	6.7	−3.4			
	[0.2]	[0.4]	(−13.2)***	[0.6]	[0.4]	(−5.7)***			
Panel C: Effective spread of principal trades of upstairs traders grouped by trade size (x)									
30 most liquid stocks >$5	13.0	7.0	−6.1	12.8	6.6	−6.2	12.3	5.9	−6.4
	[0.1]	[0.5]	(−12.7)***	[0.1]	[0.5]	(−11.5)***	[0.3]	[0.2]	(−36.1)***
Next 30 most liquid stocks >$5	13.7	8.5	−5.2	13.3	8.6	−4.7	12.8	7.2	−5.6
	[0.2]	[0.4]	(−16.7)***	[0.2]	[0.6]	(−7.5)***	[0.6]	[0.3]	(−10.0)***

Note. This table shows the mean effective spreads in cents of the first and second 30 most liquid securities priced above $5 during the 14 weeks of trading before and after April 15, 1996, on the Toronto Stock Exchange. For each stock, the effective spread is calculated as two times the absolute difference between the transaction price and the mean of the bid and ask quotes. The most liquid securities were identified by ranking stocks by effective spread over the period 28 to 15 weeks prior to April 15, 1996. The figures in brackets [ ] under the columns entitled "Before" and "After" are standard errors of the mean. The figures in parentheses ( ) under the columns entitled "Difference" are t-statistics. One, two, and three asterisks indicate significance at the 10, 5, and 1% levels, respectively.

TABLE 3
Impact of Reduction in Tick Size on Volume of Most Liquid Securities on the Toronto Stock Exchange

Price range	Number of trades			Dollar volume of shares traded in millions		
	Before	After	Difference in logs	Before	After	Difference in log of dollar volume
Panel A: All trades sizes						
30 most liquid stocks >$5	12,610 [1,243]	10,517 [1,164]	−0.10 (−5.3)***	629 [117]	555 [105]	−0.06 (−2.6)**
Next 30 most liquid stocks >$5	8,326 [1,420]	5,900 [887]	−0.14 (−7.6)***	519 [128]	389 [88]	−0.08 (−2.3)**
30 most liquid stocks priced between $1 and $3	1,212 [207]	976 [162]	−0.08 (−2.3)***	6 [2]	5 [1]	−0.05 (−0.9)
Panel B: Trade size less than 1,000 shares						
30 most liquid stocks >$5	9,671 [961]	7,968 [960]	−0.12 (−5.7)***	65 [10]	58 [9]	−0.07 (−3.7)***
Next 30 most liquid stocks >$5	6,168 [1,146]	4,226 [710]	−0.15 (−8.5)***	53 [11]	40 [7]	−0.11 (−4.7)***
Panel C: Trade size between 1,000 and 10,000 shares						
30 most liquid stocks >$5	2,480 [312]	2,178 [238]	−0.05 (−2.4)**	164 [37]	150 [30]	−0.03 (−1.2)
Next 30 most liquid stocks >$5	1,904 [342]	1,485 [230]	−0.09 (−4.2)***	164 [50]	126 [34]	−0.07 (−3.0)***
Panel D: Trade size greater than 10,000 shares						
30 most liquid stocks >$5	459 [73]	371 [57]	−0.11 (−4.9)***	401 [75]	347 [64]	−0.08 (−2.4)**
Next 30 most liquid stocks >$5	254 [52]	188 [36]	−0.12 (−3.0)***	301 [70]	224 [49]	−0.08 (−1.3)

Note. The table shows the mean number of trades and the mean dollar volume of shares traded for the first and second groups of 30 most liquid securities priced above $5 and the 30 most liquid securities priced between $1 and $3 over the 14-week period before and after April 15, 1996, on the Toronto Stock Exchange. The most liquid securities are identified by ranking stocks by the effective spread traded over the period 28 to 15 weeks prior to April 15, 1996. This table also exhibits the difference in the log of the volume statistics from before to after April 15, 1996. The figures in brackets [ ] under the columns entitled, ''Before'' and ''After,'' are standard errors of the mean. The figures in parentheses ( ) under the columns entitled Difference in logs and Difference in log of dollar volume are *t*-statistics. One, two, and three asterisks indicate significance at the 10, 5, and 1% levels, respectively.

Changes in all other categories are not significantly different from zero. As a result, the control group statistics for Panels B through D are not shown.

We next examine the activity levels of the DMMs and upstairs traders. Table 4 reports the impact reducing the tick size has on the percentage of trades in which the DMM and upstairs traders participate. Examining Panel A, we find that there has been a statistically significant decrease in both principal and agency trades of the upstairs traders for the 30 most liquid shares priced at more than $5, and a similar decline in the next 30 most liquid securities. For the DMM, there was a statistically significant increase in trades. More precisely, for the 30 most liquid securities, the upstairs trader participated in 9.0% of trades as principal before decimalization and 7.5% of trades after decimalization. The percentage of upstairs agency trades declined from 7.5 to 5.3%. In addition, there also was a decline from 0.88 to 0.72% in nonclient/nonclient crosses arranged by the upstairs traders. All of these reductions were significant at the 1% level. Hence, an additional 3.8% of all orders were executed in the downstairs market either as trades on the exchange between clients and/or nonclients of different firms, or as trades involving the DMM. The percentage of trades involving the DMM increased by 4.1% for the 30 most liquid securities. Similarly, for the second group of most liquid stocks priced at more than $5, there was a decrease of 1.3% in upstairs trades, while there was a 3.3% increase in DMM activity.

Closer examination of the trading by size of trade reveals three distinct results. First, for trades under 1,000 shares, the significant decrease in activity by the upstairs traders was partially offset by a significant increase in DMM activity. Second, the activities of the upstairs trader in trades of 1,000 to 10,000 shares declined. Since there is no corresponding increase in DMM activity in this trade size range, this activity appears to have shifted to the downstairs market. Finally, the upstairs traders participated in significantly more trades as principal or agent in both categories of securities trading in excess of $5 for transactions involving 10,000 or more shares. This latter point is consistent with anecdotal evidence related to the authors that after decimalization many upstairs traders redeployed efforts and personnel into block trading.

Table 5 decomposes realized returns of the DMM into holding period returns and earned returns. The earned return is significantly lower for all trades and for trades under 1,000 shares as shown in Panels A and B, respectively. For both the first and second 30 most liquid stocks priced at more than $5, the decreases in earned returns are significant at the 5% level. The average earned return of the DMM per trade for the 30 most liquid stocks falls approximately 45% from 0.3 to 0.2% with the decrease in tick size. However, the percentage of total trades involving the DMMs increased by approximately 20% from 18.8 to 22.9% (Table 4, Panel A). Insufficient observations ($\leq$15 firms) exist to test for statistical significance

TABLE 4
Impact of Reduction in Tick Size on Percentage of Trades in Which the Designated Market Maker and Upstairs Traders Participate

Panel A: Percentage of trades according to participant

	Designated market maker trades			Principal upstairs trades			Agency upstairs trades		
Price range	Before	After	Difference	Before	After	Difference	Before	After	Difference
30 most liquid stocks >$5	18.8 [1.4, 12,610]	22.9 [1.5, 10,519]	4.1 (5.5)***	9.0 [0.6, 12,610]	7.5 [0.5, 10,519]	−1.5 (−5.1)***	7.5 [0.5, 12,610]	5.3 [0.3, 10,519]	−2.2 (−8.8)***
Next 30 most liquid stocks >$5	20.9 [1.6, 8326]	24.2 [2.0, 5900]	3.3 (2.9)***	6.9 [0.4, 8326]	6.8 [0.5, 5900]	−0.1 (−0.2)	5.9 [0.4, 8326]	4.7 [0.3, 5900]	−1.2 (−4.1)***

Panel B: Percentage of trades in which the designated market maker participates grouped by trade size (x)

	$x < 1{,}000$ shares			$1{,}000 \text{ shares} \leq x \leq 10{,}000$ shares			$10{,}000 \text{ shares} < x$		
Price range	Before	After	Difference	Before	After	Difference	Before	After	Difference
30 most liquid stocks >$5	20.5 [1.4, 9671]	26.5 [1.6, 7968]	5.9 (7.9)***	15.6 [1.9, 9671]	15.6 [1.8, 7968]	0.1 (0.1)	1.8 [0.6, 7968]	1.2 [0.4, 7968]	−0.6 (−1.1)
Next 30 most liquid stocks >$5	23.5 [1.7, 6168]	28.2 [2.2, 4226]	4.7 (3.4)***	14.8 [1.8, 6168]	15.1 [1.7, 4226]	0.3 (0.4)	1.0 [0.4, 6168]	1.1 [0.5, 4226]	0.1 (0.2)

Panel C: Percentage of trades in which the upstairs trader participates as a principal grouped by trade size

	$x < 1{,}000$ shares			$1{,}000 \text{ shares} \leq x \leq 10{,}000$ shares			$10{,}000 \text{ shares} < x$		
Price range	Before	After	Difference	Before	After	Difference	Before	After	Difference
30 most liquid stocks >$5	8.0 [0.6, 2480]	6.1 [0.5, 2178]	−1.9 (−5.8)***	9.7 [0.7, 2480]	8.2 [0.8, 2178]	−1.5 (−3.4)***	32.5 [1.3, 2480]	36.4 [1.7, 2178]	4.0 (3.1)***
Next 30 most liquid stocks >$5	5.4 [0.3, 1904]	4.9 [0.4, 1484]	−0.5 (−2.1)***	8.2 [0.5, 1904]	7.7 [0.8, 1484]	−0.5 (−0.9)	34.0 [2.1, 1904]	42.3 [2.3, 1484]	8.3 (3.0)***

Panel D: Percentage of trades in which the upstairs trader participates as an agent (client/client crosses) grouped by trade size

	$x < 1{,}000$ shares			$1{,}000 \text{ shares} \leq x \leq 10{,}000$ shares			$10{,}000 \text{ shares} < x$		
Price range	Before	After	Difference	Before	After	Difference	Before	After	Difference
30 most liquid stocks >$5	7.8 [0.5, 459]	5.2 [0.3, 371]	−2.6 (−10.0)***	4.5 [0.5, 459]	3.1 [0.3, 371]	−1.4 (−5.0)***	20.4 [2.2, 459]	23.8 [3.0, 371]	3.4 (2.9)***
Next 30 most liquid stocks >$5	5.7 [0.5, 254]	4.2 [0.3, 188]	−1.5 (−5.0)***	4.0 [0.4, 254]	3.3 [0.3, 188]	−0.7 (−2.1)***	26.7 [3.3, 254]	30.1 [3.3, 188]	3.4 (2.0)***

Note. This table shows the percentage of trades involving either the designated market maker or the upstairs trader as either a principal or agent. The figures indicate the mean percentage of trades during the 14 weeks before and after April 15, 1996 for the first and second 30 most liquid securities priced over $5 on the Toronto Stock Exchange. The most liquid securities are identified by ranking stocks by the effective spread over the period 28 to 15 weeks prior to April 15, 1996. The first and second figures in brackets [ ] under the columns entitled "Before" and "After" are standard errors of the mean and the average number of trades, respectively. The figures in parentheses ( ) under the columns entitled "Difference" are *t*-statistics. One, two, and three asterisks indicate significance at the 10, 5, and 1% levels, respectively.

TABLE 5
Decomposition of Realized Returns of Designated Market Maker

Price range	Realized return (%)			Holding period return (%)			Earned returns (%)		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
Panel A: All trade sizes									
30 most liquid stocks >$5	0.1 [0.1, 2371]	0.1 [0.1, 2413]	−0.0 (−0.1)	−0.2 [0.1, 2372]	−0.0 [0.1, 2413]	0.1 (0.9)	0.3 [0.0, 2372]	0.2 [0.0, 2413]	−0.1 (−5.6)***
Next 30 most liquid stocks >$5	0.2 [0.1, 1736]	0.1 [0.1, 1427]	−0.1 (−1.1)	−0.0 [0.1, 1736]	−0.1 [0.1, 1427]	−0.0 (−0.3)	0.3 [0.0, 1736]	0.2 [0.0, 1427]	−0.1 (−2.6)**
Panel B: Trades < 1,000 shares									
30 most liquid stocks >$5	−0.1 [0.2, 1984]	−0.1 [0.1, 2108]	0.0 (0.2)	−0.7 [0.2, 1984]	−0.3 [0.1, 2108]	0.3 (1.5)	0.6 [0.1, 1984]	0.3 [0.0, 2108]	−0.3 (−8.7)***
Next 30 most liquid stocks >$5	0.1 [0.2, 1448]	0.0 [0.2, 1191]	−0.1 (−0.5)	−0.3 [0.2, 1448]	−0.3 [0.23, 1191]	0.1 (0.3)	0.5 [0.1, 1448]	0.3 [0.0, 1191]	−0.2 (−5.2)***
Panel C: Trades between 1,000 and 10,000 shares									
30 most liquid stocks >$5	0.4 [0.2, 386]	0.3 [0.2, 340]	−0.0 (−0.1)	0.3 [0.2, 386]	0.3 [0.2, 340]	0.0 (0.0)	0.1 [0.0, 386]	0.1 [0.0, 340]	−0.0 (−1.4)
Next 30 most liquid stocks >$5	0.6 [0.2, 281]	0.3 [0.2, 224]	−0.3 (−1.0)	0.5 [0.2, 281]	0.2 [0.2, 224]	−0.3 (−1.0)	0.1 [0.0, 281]	0.1 [0.0, 224]	−0.0 (−0.7)

Note. The table decomposes the realized return of securities into the holding period return and the earned return. The realized return is calculated as the volume-weighted selling price, less the volume-weighted purchase price, divided by the volume-weighted purchase price. The holding period return is calculated as the volume-weighted mean of the bid and ask quotes, at the time of sale, less the volume-weighted mean of the bid and ask quotes, at the time of purchase, divided by the volume-weighted mean of bid and ask quotes, at the time of purchase. The earned return equals the realized return less holding period return. Insufficient observations exist to examine trades in excess of 10,000 shares. The first and second figures in brackets [ ] under the columns entitled "Before" and "After" are standard errors of the mean and the average number of trades, respectively. The figures in parentheses ( ) under the columns entitled "Difference" are *t*-statistics. Two and three asterisks represent significance at the 5 and 1% levels, respectively.

of the DMM returns for trades in excess of 10,000 shares. Thus, we conclude that the earned returns of the DMMs were reduced with the reduction in tick size.

In Table 6, we present similar estimates for the returns of the upstairs trader acting as principal. No significant difference in earned returns is found for either sample of shares trading in sizes in excess of 10,000 shares. Accordingly, we do not present these results. However, for the other two trade size categories, the estimates of the earned returns decline significantly at the 1% level for the upstairs traders. For all trades changes in earned returns were significantly negative at the 5% level.[19]

An implicit assumption in Tables 5 and 6 is that the average holding periods are constant in the postdecimalization period relative to the predecimalization period. The potential impact of a change in the number of market orders versus limit orders becomes important since the time-to-execution of an off-market limit order is intrinsically longer than the time-to-execution of a market order. If a shift to market orders occurs in the postdecimalization period because there is less incentive to beat the spread, each trade in which the market maker participates will take a shorter time to reverse in the market; i.e., the market maker's holding period decreases.[20] Even if the holding period returns do not change between the two periods, the market maker is accepting less holding period risk with no change in return. To investigate this possibility, we compute the average time between reversing principal trades for the DMM and upstairs traders for the pre- and postdecimalization periods. A reversing trade is defined as the first principal buy (sell) by a market maker following a principal sell (buy) regardless of trade volume. Our results are presented in Table 7, where we find no statistical difference in the mean reversal time for the DMM. For the upstairs traders, the average reversing time increases. This finding of higher holding period risk, with no greater holding period return, does not offset the decreases in earned returns reported above. Thus, there is less incentive for the upstairs traders to trade.

[19] As further verification of the reduced profitability, we compared the 1995 and 1997 annual reports of the nine publicly listed firms involved in market making on the TSE and tried to extract the revenues from market making in equities. Midland Walwyn Inc. had the most specific disclosure of profits in this area of market making. Under the category 'Principal Transactions: Equity Trading,' the firm's revenues declined from $28.1 million to $6.8 million from 1995 to 1997. The other firms had broader categories for trading revenues that included such items as income from commodities, debt securities, and precious metal contracts. Of the nine firms, four experienced a decrease and five experienced an increase in trading revenues over the two-year period.

[20] As pointed out by a reviewer, a shift in the volume of shares traded also may affect the holding period. That is, if trading volume decreases and the market maker's inventory of securities does not decrease proportionally, the inventory turnover will fall and the holding period will increase. For the purposes of this study, we assume that the ratio of inventory to trading volume is not affected by level of trading.

TABLE 6
Decomposition of Realized Returns of Upstairs Trading

Price range	Realized return (%)			Holding period return (%)			Earned return (%)		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
All trade sizes									
30 most liquid stocks >$5	0.1 [0.1, 1139]	−0.2 [0.4, 789]	−0.3 (−0.5)	−0.1 [0.5, 1139]	−0.3 [0.4, 789]	−0.2 (−0.3)	0.2 [0.0, 1139]	0.1 [0.0, 789]	−0.1 (−2.1)**
Next 30 most liquid stocks >$5	0.6 [0.7, 572]	0.6 [0.3, 401]	0.0 (0.0)	0.4 [0.7, 572]	0.5 [0.3, 401]	0.2 (0.2)	0.3 [0.1, 572]	0.1 [0.0, 401]	−0.1 (−2.3)**
Trades < 1,00 shares									
30 most liquid stocks >$5	0.2 [0.5, 773]	−1.0 [0.5, 789]	−1.2 (−1.9)*	−0.4 [0.5, 773]	−1.3 [0.5, 489]	−0.9 (−1.5)	0.6 [0.1, 773]	0.3 [0.0, 489]	−0.3 (−9.4)***
Next 30 most liquid stocks >$5	−0.3 [0.3, 333]	−0.8 [0.3, 208]	−0.5 (−1.1)	−0.8 [0.3, 333]	−1.2 [0.4, 208]	−0.4 (−0.7)	0.5 [0.1, 333]	0.3 [0.0, 208]	−0.2 (−7.1)***
Trades between 1,000 and 10,000 shares									
30 most liquid stocks >$5	0.6 [0.6, 241]	−0.7 [0.3, 179]	−1.3 (−1.6)	0.1 [0.6, 241]	−0.9 [0.3, 179]	−1.0 (−1.3)	0.5 [0.1, 241]	0.2 [0.0, 179]	−0.3 (−6.6)***
Next 30 most liquid stocks >$5	−0.3 [0.4, 156]	−0.3 [0.3, 224]	−0.0 (−0.0)	−0.8 [0.4, 156]	−0.6 [0.3, 224]	0.1 (0.3)	0.5 [0.1, 156]	0.3 [0.0, 224]	−0.2 (−3.9)***

Note. The table decomposes the realized return of securities into the holding period return and the earned return. The realized return is calculated as the volume-weighted selling price less the volume-weighted purchase price, divided by the volume-weighted purchase price. The holding period return is calculated as the volume-weighted mean of the bid and ask quotes at the time of sale, less the volume-weighted mean of the bid and ask quotes at the time of purchase, divided by the volume-weighted mean of bid and ask quotes, at the time of purchase. The earned return equals the realized return less holding period return. Trades in excess of 10,000 shares do not exhibit any statistical significance. The first and second figures in brackets [ ] under the columns entitled "Before" and "After" are standard errors of the mean and the average number of trades, respectively. The figures in parentheses ( ) under the columns entitled "Difference" are *t*-statistics. One, two and three asterisks represent significance at the 10, 5, and 1% levels, respectively.

TABLE 7
Impact of Change in Tick Size on Mean Time between Reversing Trades

	Designated registered trader			Upstairs principal		
	Before	After	Difference	Before	After	Difference
30 most liquid stocks >$5	0.77 [0.0, 2372]	0.75 [0.1, 2413]	−0.02 (−0.3)	2.30 [0.5, 1139]	3.95 [1.3, 789]	1.65 (1.8)*
Next 30 most liquid stocks >$5	1.59 [0.3, 1736]	2.26 [0.6, 1427]	0.67 (1.1)	4.24 [0.8, 572]	6.23 [1.3, 401]	2.00 (3.7)***

Note. This table shows the impact of the change of tick size on the mean time in hours between trade reversals for both the designated market maker and the upstairs trader for principal trades. A reversing trade is defined as the first principal buy (sell) by a market maker following a principal sell (buy) regardless of trade volume. The first and second figures in brackets [ ] under the column entitled "Before" and "After" are standard errors of the mean and the average number of trades. The figures in parentheses ( ) under the column entitled "Differences" are *t*-statistics. One and three asterisks represent significance at the 10 and 1% levels, respectively.

Table 8 examines the question of whether the decrease in upstairs trading had an uneven effect on industry participants. The table suggests that those brokerage firms most heavily involved in upstairs trading were the most likely to lose market share in the handling of trades of the most liquid securities on the TSE. The top four brokerage firms, with 34.84 to 42.95% of their trading handled upstairs in the predecimalization period, collectively lost 7.07% of the total trading volume of the 30 most liquid TSE-listed securities priced at more than $5.

Finally, we conducted a number of robustness tests (available upon request) to ensure that the findings were not the result of outliers or other phenomena. We examined the data on a week-by-week basis to examine if any cross-sectional factors changed over time (excluding the switch to decimalization itself). We found the earned return declines by roughly 50% at the time of decimalization. Concomitant with this event are an immediate decline in upstairs principal participation and earned returns, an increase in DMM participation, and generally unchanged trading volume.

We also conducted our tests on a company-by-company basis for the 30 most liquid securities trading at more than $5. For nearly every company, we find results similar to those reported in Tables 4 through 8. The results are not attributable to outliers.

VII. CONCLUSIONS

On April 15, 1996, the Toronto Stock Exchange reduced the tick size for stocks priced at more than $5 from $0.125 to 5 cents. This paper examines the effect of this reduction in tick size on the returns and behavior of the

TABLE 8
Impact of Change in Tick Size on Trading by Brokerage Firms Ranked by Upstairs Trading Activity

Rank of brokerage firm based on percentage of trading in upstairs market	Percentage of dollar volume traded by firm handled as upstairs trades (14 weeks before April 15, 1996)	Percentage of total trading handled by brokerage firm		
		14 weeks before April 15, 1996	14 weeks after April 15, 1996	Increase (decrease)
1	42.95	10.71	7.87	−2.84
2	37.46	4.18	3.59	−0.59
3	37.35	12.40	9.90	−2.50
4	34.84	8.05	6.91	−1.14
5	31.95	9.97	10.52	0.56
6	30.10	11.43	12.43	1.00
7	27.60	4.94	4.13	−0.81
8	26.84	1.97	3.43	1.46
9	22.55	1.61	1.93	0.32
10	21.47	5.65	7.21	1.56
11	19.84	6.66	7.47	0.82
12	19.75	2.20	2.06	−0.15
13	19.27	2.21	1.53	−0.68
14	14.79	0.91	1.60	0.70
15	13.67	1.38	1.01	−0.37
16	12.48	1.93	1.72	−0.21
17	10.84	0.12	0.05	−0.07
18	9.88	3.13	3.49	0.36
19	8.20	0.04	0.03	−0.01
20	7.39	0.84	0.84	0.00
21	5.54	0.44	0.33	−0.11
22	5.05	0.02	0.02	0.00
23	4.80	0.54	0.23	−0.31
24	4.22	0.29	0.42	0.13
25	2.83	0.13	0.12	−0.01

Note. This table shows the impact of the change in tick size on the percentage of total trading of the 30 most liquid TSE securities priced above $5 handled by the 25 brokerage firms most active in upstairs trading (agency and principal). The ranking of brokerage firms is based on trading statistics over the 14-week period ending April 15, 1996.

designated market maker and the upstairs traders. We hypothesize that the reduction in tick size will lead to (1) a reduction in earned returns to both the DMM and upstairs traders due to a reduction in effective spreads for principal trades; and (2) a decrease in the activity of upstairs traders and an increase in the activity of the DMM due to asymmetric market-making constraints.

Our results show that in the postdecimalization period, earned returns are generally lower for both the DMMs and the upstairs traders. Specifically, we find that DMMs earn significantly lower returns for transactions involving less than 1,000 shares for securities priced at more than $5. Upstairs

traders earn significantly lower returns on trades of less than 10,000 shares in the priced more than $5 category.

Because the DMM is charged with making an orderly and continuous market, trades executed by the DMM are without execution cost; i.e., the TSE does not charge a fee for DMM trading but does charge for upstairs traders' trades. We note that on May 1, 1996, the TSE reduced the trading fee charged to the upstairs traders by 50% after numerous complaints were registered over the imposition of lower tick sizes. We conjecture that this was done to ensure the upstairs traders' participation in making a continuous and liquid market. In addition, the MGFs were lowered for the most liquid securities during April 1996, after negotiation between the DMMs and the TSE. Smaller MGFs reduce the impact of adverse movements in price on the DMMs and may serve to offset partially their lower realized returns in market making.

Our results support the hypothesis that a shift in activity occurred because there is a significant increase in DMM participation in trades of less than 1,000 shares and a corresponding decrease in participation by the upstairs traders. This shifting of trades from the upstairs dealer market to the downstairs auction market reduces market fragmentation and increases market transparency. Who benefits from increased market transparency and reduced market fragmentation is subject to considerable debate. Pagano and Röell (1996) use several stylized trading models with different degrees of transparency in an auction versus dealer market context and find that greater transparency generates lower trading costs for uninformed traders on average, but not necessarily for every size of trade.[21] Assuming that uninformed traders prefer small trade sizes, our findings are consistent with those conclusions.

Our results could be interpreted as suggesting that further reduction in the tick size would lead to additional reduction in earned returns and, thus, additional benefits to the trading public. However, it does not necessarily follow that additional reductions in the tick size are beneficial, since the impact is not necessarily linear. Angel (1997) discusses several reasons for an optimal nonzero tick size. Referencing Harris (1991), he points out that a nonzero tick simplifies a trader's information set, reducing the time spent bargaining and the potential for costly errors. He goes on to argue that a nonzero tick not only enforces the time and price priority in the limit book, but also provides an incentive for investors to submit limit orders, thereby increasing potential liquidity. A positive spread also improves liquidity by

[21] Using the Easley and O'Hara (1987) model, Pagano and Röell illustrate that if the optimal strategy of an insider differs from the auction to the dealer market, the liquidity of the auction market may no longer be unambiguously greater for all noise traders. This is precisely the situation on the TSE between the upstairs (dealer) market and the downstairs (auction) market.

providing incentives for dealers to make markets, although some of the gain in liquidity will be offset by higher transaction costs to the investors. Angel concludes that the optimal tick size represents a trade-off between the benefits of a nonzero tick and the costs that a tick imposes. Our results reinforce this point, by emphasizing that the reduction in dealer returns was not a result of a reduction in overall volume.

The paper's results are bolstered by the fact that there are no significant corresponding shifts in the return and activity measures for the control group of the 30 most liquid stocks priced between \$1 and \$3. Thus, the significant changes in the sample of stocks priced at more than \$5 are not due to other systematic changes, but can be attributed to the reduction in tick size. Our empirical findings support the argument that returns earned by liquidity providers are lowered by the reduction in tick size.

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