1997 NASDAQ Reforms and Preferenced Trading

S. Ghon Rhee
University of Hawai^{P}ʻi
2404 Maile Way (C-304)
Honolulu, HI 96822-2282
Tel. No.: (808) 956 2535
E-mail: rheesg@hawaii.edu

and

Ning Tang
University of Hawai^{P}ʻi
2404 Maile Way
Honolulu, HI 96822-2282
Tel. No.: (808) 956 6675
E-mail: ttang@cba.hawaii.edu

Current version: August 2003
First Draft: March 2003

1997 NASDAQ Reforms and Preferenced Trading

Abstract

We demonstrate that the impact of an exogenous shock, such as the 1997 market reforms, on quote competition varies depending on what happens to the levels of preferenced trading. With the significant reduction in the level of preferenced trading, share volume sensitivity to quote competitiveness is expected to increase and the change in share volume is positively related to a market maker's quote competitiveness. However, without a large decline in preferenced trading, the improved competition comes at a price: (i) reduced sensitivity between quote competitiveness and share volume; and (ii) a negative relation between quote competitiveness and the change in share volume. Empirical evidence from the pre- and post-reform periods supports this prediction and reconciles the seemingly conflicting findings of Barclay et al. (1999), Kandel and Marx (1999), and Weston (2000) and those of Chung et al. (2003). We also demonstrate that preferenced trading is responsible for the reduced sensitivity and the negative relation between quote competitiveness and share volume. Consistent with the 'cream skimming' hypothesis, we find that market makers that are more dependent on preferenced trading tend to be associated with stocks characterized by a lower cost of information asymmetry. The pattern of market maker entries and exits is also dictated by the persistent level of preferencing. We observe a net entry of market makers who rely on preferenced trading and a net exit of market makers who rely on quote competition around the NASDAQ market reforms.

1997 NASDAQ Reforms and Preferenced Trading

1. Introduction

The NASDAQ implemented several major market reforms to promote quote competition. Among these reforms, the new order handling rules (OHRs), imposed by the SEC beginning in January 1997, produced the most profound impact on market quality through the mandatory display of customer limit orders and the public dissemination of better prices placed in proprietary trading systems. Barclay et al. (1999) report that quoted and effective spreads narrowed by approximately 30 percent as a result of the change, but that market liquidity was largely unaffected. They also report a significant increase in the number of quote revisions and a significant decrease in the percentage of time a dealer's quote remains on the inside of the spread. Weston (2000) finds that a decline in dealer rents reduces trading costs and the market becomes less concentrated after the reforms. In light of these findings, it was widely perceived that the new OHRs have improved competition among NASDAQ market makers, by promoting quote competition and improving market quality.

Kandel and Marx (1999) predict that a decrease in market makers' profit margins caused by an exogenous shock to quote competition may reduce the practice of payment for order flow. This implies that, the introduction of the new OHRs, should result in a decline in preferenced trading and share volume should be more directly determined by the quote competitiveness of the market maker. They also predict that decreased preferencing should result in an increased number of market makers. They suggest that the net entry by SOES market makers will be greater than the net exit of preferencing market makers. However, Weston (2000) reports only a small increase in the daily number of market makers after the reform and that, after controlling for other factors, the reform results in fewer, not more, market makers. Chung et al. (2003) report that preferenced order flow is on average as high as 80% of the total share volume in a stock four years after the introduction of the new OHRs but prior to the change to decimalization.

Decimalization, which is also projected to considerably reduce preferenced order flow [Chorida and Subramanyam (1995), Kandel and Marx (1999), and Harris (1999)] resulted in only a marginal amount of decline from 80% to 76%. Given the decrease in the number of market makers and a surprisingly high level of preferenced trading on the NASDAQ market, it is possible that the change in order handling rules did not cause a large reduction in preferenced trading as originally envisioned. Even though the minimization of preferenced trading is not the objective of the NASDAQ market reforms, we are left with a troubling question about how a substantial improvement in market quality as documented by Barclay et al. (1999) and the decline in market makers' rents as compiled by Weston (2000) can be explained when preferenced trading remains largely unchanged.

In this paper, we address this question and reconcile the seemingly conflicting findings of Barclay et al. (1999), Kandel and Marx (1999), and Weston (2000) and those of Chung et al. (2003). We do this by investigating the relation between quote competitiveness and the market share of individual market makers on the NASDAQ, but our approach is unique in two important aspects: first, we rely on a *position*-based analysis;[1] and second, we use *relative* (rather than absolute) measures of the key variables of interest to capture quote competitiveness.

When a market maker deals multiple stocks, he is said to have a position in each of the stocks. Quote competitiveness varies across these positions even though the same market maker manages these positions. These differences may be attributed to individual stock characteristics as well as the capital constraints facing the individual market maker. Quote competition may be higher in some stocks than in others and, as a result, market share in each of the positions may differ for the same market maker. A market maker taking a position in a more competitive stock may be forced to quote more aggressively than in a less competitive stock. Even without the differences in stocks characteristics, capital constraints may cause a market maker to behave

[1] Although the term "position" has not been widely used in academic literature, it is a common term used by NASDAQ.

differently in each of his positions. A position-based analysis brings out critical aspects which may have been overlooked in the examination of the relation between share volume and quote competitiveness. Therefore, regarding each position as an independent entity allows for a more exacting analysis.[2]

The use of relative rather than absolute measures is critically important when analyzing the change in market share in response to the change in quote competitiveness. Many previous studies have introduced such variables as quote revision frequency and different versions of spreads to investigate quote competitiveness. Quote aggressiveness and competitiveness are used interchangeably in the past studies. In this paper, we distinguish quote competitiveness from quote aggressiveness. Suppose all positions have the same level of quote aggressiveness as measured by the number of quote revision of 100 times a day at the beginning of the period. If one position exhibits an increase of 10 times a day in the frequency of quote revision, while the average change of all positions is an increase of 20 times a day. This means that the absolute measure of quote aggressiveness increases 10% for this position and 20% for all positions, but, relatively speaking, the competitive strength of this position has weakened due to a greater improvement in quote aggressiveness by its competitors. In this example, the quote competitiveness of this positions after the change is captured by a relative measure of 0.92 (=1.1/1.2), which correctly indicates the deterioration in its quote competitiveness. This relative change should be accounted for when we evaluate the changes in market share of that particular position.[3] The absolute measure of quote aggressiveness fails to indicate the relative change of a position vis-à-vis other positions and serves as a poor proxy of quote competitiveness, whereas the relative measure of quote aggressiveness captures the change in quote competitiveness. In the

[2] The position-based analysis has been used in previous studies of quoting behavior [Ellis et al. (2002), Chung et al. (2003), and Chung et al. (2002)].

[3] In contrast, the relative measure greater than unity implies the improvement in quote competitiveness for this particular market maker's position.

rest of this paper, quote competitiveness is always measured by the relative quote aggressiveness.[4]

In the presence of preferenced trading, the market is effectively comprised of two parts: the quote competition segment and the preferencing segment. We demonstrate that quote competition can intensify and market quality can improve in the quote competition segment after an exogenous shock even if preferenced trading activities do not decline. Using a graphical analysis, we demonstrate that with or without a large decline in preferenced trading, an exogenous shock may lead to more aggressive quoting in the quote competition segment; however, the structure of quote competition may differ substantially. Two sharp contradictions highlight the differences: (i) with [without] a large decline in preferenced trading, increased quote competitiveness is accompanied by an increase [decrease] of share volume sensitivity to quote competitiveness; (ii) for market makers who compete primarily through quotes, there is a positive [negative] relation between quote competitiveness and the change in share volume when the level of preferenced trading is substantially reduced [sustained]. Hence, no conflicts exist between a sustained high level of preferencing and improved quote competition. Quote competition can be improved as long as quote competition is present. However, without a large decline in preferenced trading, the improved competition comes at a price: (i) a reduced sensitivity between quote competitiveness and share volume; and (ii) a negative relation between quote competitiveness and the change in share volume.

Our empirical evidence supports these predictions. First, a positive relation is observed between quote competitiveness and share volume; however, share volume becomes less sensitive

[4] Since a quote competitiveness variable is a relative measure standardized using mean across all observations, the mean of a quote competitiveness variable is always equal to 1. Quote competitiveness and the change in quote competitiveness, therefore, can be interpreted in a percentage term. For example, if quote competitiveness changed from 1.02 to 0.95, it declined from 2% above the mean [=100(1.02-1)%] to 5% below the mean [=100(0.95-1)%], and the total magnitude of the change is -7% [=100(0.95-1.02)%] of the mean.

to quote competitiveness after the NASDAQ market reforms.[5] Second, for market makers who are competing for order flow primarily through quotes, the change in share volume is negatively related to their quote competitiveness. These two pieces of evidence are consistent with very little change in preferenced trading after the introduction of the OHRs, as reported by Chung et al. (2003). Further investigation reveals that market makers who are more likely to rely on preferenced trading [quote competition] improve their quote competitiveness by the least [greatest] degree and gain [lose] share volume on average, while overall quote aggressiveness improves across the market and quote competition intensifies. Third, we examine the relation between the cost of asymmetric information and a position's probability of relying on preferencing trading. We find that positions that are more dependent on preferenced trading tend to be associated with stocks with low asymmetric information costs. This finding is consistent with Easley et al.'s (1996a) "cream skimming" hypothesis and supports our conjecture that preferenced trading is responsible for the decreased sensitivity between quote competitiveness and share volume; and for the negative correlation between share volume change and quote competitiveness.

Utilizing the relation between information asymmetry costs and the probability a position is more dependent upon preferenced trading, we examine the pattern of entries and exits that occurred around the NASDAQ market reforms. We find that there is a net exit for positions that compete on quotes, while there is a net entry for positions that rely on preferencing. This entry and exit pattern is consistent with the scenario in which quote competition intensifies but the level of preferenced trading remains at very high level.

[5] The positive relation between share volume and quote competitiveness is consistent with previous empirical findings. Chung et al. (2002), using NASADAQ proprietary data, find that quote aggressiveness affects dealer's market share even in the presence of preferencing. Klock and McCormick (2002) report a positive correlation between quote aggressiveness and share volume using the data prior to the 1997 market reforms. Bessembinder (2003) shows that the probability of a trade execution on NYSE, NASDAQ, and five regional exchanges increases when the market posts competitive quotes.

Although our theory does not predict how a persistent level of preferenced trading would affect dealers' rents after an exogenous shock, we believe that a decrease in dealers' rents can coexist with the sustained high level of preferenced trading. Intensified quote competition leads to smaller spreads and lower dealers' rents in the quote competition segment. The smaller spreads and lowered rents affect the entire market and every transaction with the 'best execution' rule in place. That is, profit margin decreases in the quote competition segment and influences the entire market because of the 'best execution' rule even though the quote competition segment of the market is small in its magnitude and the level of preferenced trading is high. This suggests that decline in preferenced trading is not required for a reduction in dealers' rents. Hence, Weston's (2001) findings do not conflict with ours.

The rest of the paper is organized as follows: In Section 2, we demonstrate how an exogenous shock affects the structure of quote competition both with and without a reduction in preferenced trading activities. We show that an exogenous shock could increase quote competition without a substantial decline in preferenced trading. We derive two testable hypotheses from the above demonstration. In Section 3, we describe the data used in the study. In Section 4, we present the results of the tests of the two hypotheses. In Section 5, we investigate whether preferenced trading is responsible for our findings in the previous section. In Section 6, we present our summary and the conclusions.

2. The Relation between Share Volume and Quote Competition

2.1. The Relation between Share Volume and Quote Competitiveness with and without Reduction in Preferenced Trading

In a competitive market where no preferenced trading exists, volume is allocated solely based on quote competitiveness. RN in Figure 1 denotes the share volume as a function of quote competitiveness in such a market. Point R is not located at the origin because there is a minimum level of quote competitiveness needed to attract the first order. Point N is the maximum quote competitiveness necessary for obtaining all orders. In the presence of preferenced trading, the

market is effectively comprised of two segments, a quote competition segment and a preferencing segment. The share volume curve is different in the two segments. In Figure 1, PQ denotes the level of preferenced trading. The area above PQ is the quote competition segment and the shaded portion below PQ is the preferencing segment. In the quote competition segment, share volume is still allocated according to quote competitiveness and the share volume curve AM in this segment is similar to the share volume curve RN under perfect competition. However, point A is closer to the y-axis and point M is to the left of point N such that both the minimum and maximum levels of quote competitiveness, in the presence of preferenced trading, are smaller than in a perfectly competitive market. In the preferenced trading segment, the share volume curve should be negatively correlated to quote competitiveness since preferencing discourages quote competition. The more preferenced volume a market maker receives the less aggressive he needs to be. Subsequently, the volume curve in the preferencing segment is the negatively sloped curve, PL.

We assume that quote competitiveness is positively related to non-preferenced share volume. The best execution rule may obscure the positive relation because this rule means that orders be executed at the inside even if the orders are routed to dealers who are not posting the best prices.[6] This concern may be valid only if brokers are willing to pay the costs of searching for the best prices before routing their orders.[7]

[6] Macey and O'Hara (1997) provide an excellent discussion of best execution. How to measure best execution is a complicated issue, which is beyond the scope of this paper. We adopt the simplest definition of best execution which is to find the best available price. This definition does not alter the positive relation between quote competitiveness and share volume.

[7] Two possibilities are feasible for an order to be non-preferenced: (i) no preferenced arrangements exist; or (ii) the broker can not rely on preferenced arrangements because the order does not meet the stipulated requirements in preferencing agreement. In both cases, the best trading strategy is to route the order to the dealer posting the best prices. If not, the broker will incur search cost and the timely execution at the best prices may not be achieved. As long as brokers are not willing to incur search costs, the positive relation should remain intact despite the best execution rule.

The slope of the share volume curve AM in the quote competition segment is flatter than that of the RN curve. Since the slope of the share volume curve measures the degree of sensitivity of share volume to quote competitiveness, a flatter slope implies that there is less sensitivity between share volume and quote competitiveness in the presence of preferenced trading. Market makers simply have lower incentives to compete on quotes when orders can be obtained through preferencing arrangements. The vertical distance between AM and PQ is the volume obtainable by quote competitiveness. This distance may also be interpreted as the maximum volume loss if a market maker decides to totally forego quote competition. The vertical distance between PL and the x-axis denotes preferenced volume. Figure 1 implies that the higher the proportion of volume from preferencing, the less competitiveness that position needs to be. Hence, as a position increases its proportion of preferenced trading the importance of quote competition diminishes.

[Insert Figure 1]

2.2. The Impact of External Shock on Preferenced Trading and Quote Competition

When an exogenous shock impacts quote competition without reducing the preferenced trading activity, the share volume curve in the quote competition segment of the market will shift to the right, while PL will remain unchanged, as illustrated in Figure 2. Suppose the exogenous shock is powerful enough to drive point M to N. If every position is affected equally, AM shifts to the parallel line BN. Since the level of preferenced trading volume, PQ, is not affected by this exogenous shock, a position which was less aggressive prior to the shock will face less pressure to remain competitive after the shock. This happens because the vertical distance between AM and PQ (or the maximum loss in share volume for giving up quote competition) decreases as we move down the AM curve. More importantly, the volume loss as the percentage of total share volume, caused by intensified quote competition, decreases as we move down the AM curve. The market maker whose position is located on the lower portion of the AM curve not only has

less incentive to compete through quote competition but also has less incentive to react to the impact from the exogenous shock if the level of preferenced trading remains unchanged. As a result, the AM curve will not shift to the parallel BN curve. Instead, a new share volume curve, CN, emerges. The CN curve will be located between AM and BN, with a slope less than that of AM. The distance between AM and CN denotes the lost volume resulting from quote competition. For the positions plotted along the upper portion of the AM curve, more aggressive quoting only leads to a greater loss in share volume in the quote competition segment of the market, as indicated by the greater distance between AM and CN.

[Insert Figure 2]

With the exogenous shock causing the level of preferenced trading to decline, the CN curve will no longer accurately describe the relation between share volume and quote competitiveness in the quote competition segment of the market. In the preferencing segment, PL will also shift due to decreased preferencing activity. Figure 3 contains a graphic illustration of the case in which the exogenous shock causes a substantial decline in the level of preferenced trading. This decline causes the AM curve to shift to BN if we assume all the positions are equally affected and further assume the decline in preferencing affects preferenced order flow of every position proportionally to make PL shift to a parallel line P"L". Positions are affected unevenly by the external shock depending upon the positions' locations on the AM curve prior to the shock, As the level of preferenced trading decreases and the preferencing level moves away from the original level PL, positions located on the lower portion of the AM curve lose an increasingly larger proportion of their total share volume. Because these positions are more sensitive to the level of preferenced trading than positions located in the upper portion of the AM curve, a new share volume curve A"N emerges in the quote competition segment. The slope of this new curve is greater than that of the original curve AM. The distance between AM and A"N indicates how much share volume a position loses in the quote competition segment of the market

after the shock if the position maintains quote competitiveness. The amount of share volume loss is negatively related with quote competitiveness as we move up the A"N curve.

[Insert Figure 3]

2.3. Testable Hypotheses

From our discussion of the two scenarios illustrated in Figures 2 and 3, a contrast between the two scenarios emerges. In Scenario I, an external shock affects the level of preferenced trading only slightly, the share volume curve in the quote competition segment of the market shifts to the right but the new share volume curve will have a flatter slope which implies a lesser sensitivity of share volume to quote competitiveness. In this first scenario, the more competitive positions will experience a greater share volume loss in the quote competition segment unless market makers change their quote competitiveness substantially. In Scenario II, an external shock causes the level of preferenced trading to decline and the share volume curve in the quote competition segment shifts to the right. The new share volume curve has a steeper slope which implies a greater sensitivity of share volume to quote competitiveness. In this second scenario, the less competitive positions experience a greater share volume loss in the quote competition segment unless market makers change their level of quote competitiveness. Table 1 summarizes the differences between the two scenarios.

[Insert Table 1]

Without a substantial decline in the level of preferenced trading, two testable hypotheses, consistent with Scenario I, are useful in investigating the quoting behavior of NASDAQ market makers:

H_1: *The sensitivity between share volume and quote competitiveness decreases after the 1997 market reforms.*

H_2: *For positions that compete for order flow primarily through quote competition, a negative relation is expected between quote competitiveness and the change in share volume.*

The declining sensitivity of share volume to quote competitiveness predicted by the first hypothesis is readily explained by the sustained level of preferenced trading. If the relation between quote competitiveness and preferenced share volume does not change in the preferencing segment, the net impact will be a declining sensitivity of total share volume to quote competitiveness for the whole market. The negative relation predicted by the second hypothesis is not surprising when preferenced trading remains at a high level. With a sustained preferencing level, quote competitiveness and the change in non-preferenced share volume are negatively related. However, the change in volume in the quote competition segment is not the total change in volume, and we do not have access to the segmented data required to estimate the changes in preferenced trading volume and in quote-competition-based volume for each of the sample positions. For this reason, we test for negative relation using the change in total share volume but with selected positions that compete for order flow primarily through quote competition. For those positions, the change in total share volume should approximate the change in share volume from quote competition.

3. Data Description

The OHRs were instituted in phases, rather than in a single, one step, market-wide change. Our data includes 100 stocks that were brought under the new OHRs in the first two batches. One batch began trading under the new rules on January 20, 1997 and the other on February 10, 1997. The market makers' quotes, quote size, and inside quotes are from the NASDAQ. Quote data from November 1, 1996 through January 19, 1997, for the first waves of stocks, are pooled with quote data from November 1, 1996 through February 9, 1997, for the second wave of stocks, as the pre-reform quote data. Quote data from January 21, 1997 to

February 28, 1997, for the first wave of stocks, are pooled with the quote data from February 11, 1997 to February 28, 1997, for the second wave of stocks, as the post-reform quote data. The share volume data is obtained from the NASDAQ Monthly Activity Report. This monthly publication reports total share volume and block share volume for each market maker in each stock. Total share volume in the last quarter of 1996 is considered as pre-reform share volume and total share volume from March 1997 to May 1997 is considered as post-reform share volume.

For a stock to remain in our sample, the stock must have: (i) quote and transaction data in each month during the period from November 1996 to February 1997; (ii) share volume data for at least two months in the last quarter of 1996; and (iii) share volume data for at least two months during the period from March 1997 to May 1997. Ninety seven stocks meet this criterion. A total of 2,376 positions are associated with the 97 stocks. Share volume and quote data are available for 2,024 positions in both the pre- and post-reform periods with 352 positions missing either share volume data or quote data, or both, which makes calculating changes in share volume and/or changes in quote competitiveness for these positions impossible. Since the analyses in this study focus on the relation between changes in quote competitiveness and changes in share volume, we confine our analyses to the 2,024 positions in Sections 4 and 5. We re-visit the 352 positions in Section 5.4, however, to examine the question of net entry and exit of market makers which has been addressed by Weston (2000).

4. Empirical Findings

4.1. Descriptive Statistics

Table 2 presents the equally-weighted quote aggressiveness (as measured by absolute measures) and corresponding quote competitiveness (as measured by relative measures), position volume, stock volume, and the Herfindahl-Hirshman index (HHI) for the pre- and post-reform periods. The five quote aggressiveness variables include: (i) duration; (ii) percentage spreads; (iii) the number of quotes that are on the inside per day, which is referred to as "inside quotes";

(iv) the number of quotes that improve the inside spread per day, which is referred to as "inside improvements"; and (v) depth on the inside. Relative measures of quote aggressiveness variables represent a position's quote aggressiveness variable divided by the average quote aggressiveness of all positions in the same stock.[8] In this study, we use relative duration as the primary variable, while the remaining four variables are used to demonstrate the robustness of the test results.

The first column in Table 2 presents absolute measures of quote aggressiveness and the changes in quote aggressiveness before and after the NASDAQ market reforms for 2,024 positions to facilitate the comparison with the results documented by Barclay et al. (1999) and Weston (2000). Duration declines from 170 to 133; percentage spreads decrease from 2.16 to 2.05; inside quotes increase from 24.12 to 33.57; inside improvements increase from 4.07 to 4.49; and depth decreases from 9.99 to 9.83.[9] These changes are consistent with Barclay et al. (1999) and Weston (2000), who document improved quote aggressiveness and intensified quote competition.

The changes in average quote aggressiveness, however, do not present a complete and precise picture of how positions reacted to the NASDAQ market reforms. To make our point, we sort the 2,024 positions into four quartiles on the basis of the changes in absolute measure of duration. The first quartile's average change is -104, followed by the second quartile with -51 and the third quartile with -21. In contrast, the fourth quartile exhibits an increase of 30 in absolute duration. For most of the positions, absolute duration declines, but the magnitude of the decline differs from one group to another. For the other four absolute measures, the range of the changes across the different quartiles is fairly large: from -0.47 to 0.16 for percentage spreads, from -0.94 to 21.55 for inside quotes, and from -1.32 to 2.35 for inside improvements, and from -0.67 to 0.57 for market depth.

[8] Relative measures are reported in parentheses.

[9] The decline in depth is expected because limit orders tend to have smaller depth than quotes from market makers. Hence, the display of limit orders negatively affects the depth on the inside.

The relative measures that assess quote competitiveness draw a different picture. The absolute and relative durations contradict in the third quartile, where changes in both measures are highly significant but with opposite signs: a decrease of 21 minutes in absolute duration, indicating decreased quote aggressiveness but an increase of 0.07 in relative duration, indicating improved quote competitiveness. Similar patterns are observed when the other four absolute and relative measures are compared. For the first quartile, for example, the absolute measure of inside quotes exhibit an insignificant change, whereas the relative measure of inside quotes show a significant decline after the market reforms. For the same quartile, the absolute measure of depth shows a significant change while the change in relative depth is not significant. The absolute measures of quote aggressiveness variables simply indicate the direction and magnitude of changes over time, while quote competitiveness as measured by relative measures illustrate changes in quote aggressiveness relative to their competitors, i.e., change in quote competitiveness. It is obvious from Table 2, both the sign and the magnitude of changes in quote competitiveness could be very different from those of changes in quote aggressiveness.

For positions volume, we report both absolute position volume and relative positions volume (in the parenthesis). Relative positions volume is the absolute position volume as a percentage of total volume in the corresponding stock. The relative positions volume can be regarded as a measure of a market maker's market share of volume in a stock. Absolute position volume exhibits a significant increase for each of the four quartiles, while relative position volume in general has declined with different degrees of statistical significance. In this paper, we use the relative position volume when measuring a position's share volume.

In Table 2, we also report average stock volume and the HHI over our sample of 97 stocks. These two variables are used in various regressions to control for the volume effect as well as the market concentration effect. Consistent with the increase in absolute position volume, the total trading volume in each of sample stock increases by 27.8 million shares. The HHI

exhibits an average decline of 214, which is consistent with the decline in relative position volume. This suggests that each position on average controls a smaller portion of the total volume of a stock in support of the findings of Weston (2000). The average HHI is smaller than that reported by Weston (2000) because we use a stock's total volume in the calculation, while Weston uses total volume by market makers. HHI calculated using stock total volume reflects market concentration more accurately.

[Insert Table 2]

4.2. The Post-Reform Changes in the Sensitivity of Share Volume to Quote Competitiveness

Under the first hypothesis, we test whether the sensitivity of share volume to quote competitiveness decreases after the NASDAQ market reforms. With preferenced trading remaining largely unchanged, as documented by Chung et al. (2003), the slope of the share volume curve in the quote competition segment becomes flatter in the post-reform period which suggests a lower sensitivity of share volume to quote competitiveness in this part of the market. If the relation between quote competitiveness and share volume does not change in the preferencing segment, the quote sensitivity to share volume for the whole market declines. The following regression model is used to test this prediction.

$$RPV_{ij} = a_0 + a_1 QC_{ij} + a_2 D_{ij} + a_3 (QC_{ij} * D_{ij}) + a_4 SV_j + a_5 H_j + \varepsilon_{ij}, \quad (1)$$

where, each of the variables is defined for position *i* and stock *j* as shown below:

RPV = relative position share volume;

QC = quote competitiveness as measured by relative quote aggressiveness;

SV = natural log of trading volume of individual stock;

H = HHI in thousands; and

D = a dummy variable, which is assigned 1 if the observation belongs to the post-reform period and 0 otherwise.

In addition to the positions-based quote competitiveness (QC), we introduce two stock-based control variables, SV and H. The log of stock volume (SV) is used to control for the volume effect.[10] In stocks with high volume, positions may have a lower RPV for two reasons: (i) the same RPV means a greater volume in absolute magnitude, which forces market makers to secure more resources; and (ii) competition for order flow may be more intense. For these reasons, average RPV in high volume stocks tends to be smaller than in low volume stocks. The HHI is included because market concentration can also affect the relative position share volume (RPV) [Klock and McCormick (2002)]. In stocks where a few market makers dominate the market, RPV tends to be much higher for dominant market makers and tends to be much lower for other market makers.

The estimated coefficient of QC measures the sensitivity of share volume to quote competitiveness in the pre-reform period and the coefficient, a_3, of the interaction terms (QC*D) measures the change in the sensitivity in the post-reform period. If the market rewards competitive quotes with higher volume, a_1 should be positive for quote competitiveness as measured by relative duration, relative inside quotes, relative inside improvements, and relative depth. When relative spreads are used as a proxy for quote competitiveness, a_1 should be negative because smaller spreads imply greater quote competitiveness. When examining the first hypothesis, we are primarily interested in the estimated coefficient for the interaction term. A positive a_3 means the sensitivity of RPV to QC increases after the reform, while a negative a_3 suggests decline in the sensitivity when QC is measured by relative duration, relative competitive quotes, relative inside improvements, and relative depth. However, the signs should be reversed with relative spreads measuring quote competitiveness. With very little decline in the level of preferenced trading, we expect a negative a_3 with relative duration, relative inside quotes, relative

[10] Smith (1998) observes the effects of the OHR changes and 16ths on the trading characteristics of stocks with different levels of liquidity.

inside improvements, and relative depth as by QC and a positive a_3 with the relative spreads as QC.

Regression results are reported in Table 3. In Panel A, we report regression results using relative duration, which is the primary variable measuring quote competitiveness. In Panel B, we report regression results using four other measures of quote competitiveness including: relative spreads, relative inside quotes, relative inside improvements, and relative depth to ascertain the robustness of the results.

As summarized in Panel A, the estimated coefficient for relative duration is positive and significant in all regressions. The coefficient estimated for the interaction term is negative in support of the prediction under the first hypothesis, indicating that the slope of the share volume curve becomes flatter in the post-reform period. This is consistent with a sustained preferencing level after the market reforms. The significant and negative coefficient for stock share volume is consistent with our conjecture that the greater the stock volume the more difficult it is for a position to obtain the same percentage of that stock's volume. The coefficient for HHI is positive and significant and also consistent with our prediction that RPV should be larger in stocks with concentrated volume.

In Panel B, we report the regression results when the remaining four relative measures are used as proxies for quote competitiveness. All the regression results are consistent with the results in Panel A when the relative duration is used. The estimated coefficient for relative spreads is significantly negative and the estimated coefficient for the interactive term is significant and positive. The signs of estimated coefficients when relative spread is introduced are expected because relative spread, when measuring quote competitiveness, has a negative correlation with all other quote competitiveness measures.

[Insert Table 3]

4.3. The Relation between Quote Competitiveness and Post-Reform Decline in Share Volume

The test of the second hypothesis requires a careful sorting of sample positions because this hypothesis applies only to positions that compete for order flow through aggressive quoting. For positions that secure order flow mainly through non-quote competition, intensified quote competition will not produce a negative relation between quote competitiveness and change in relative position volume. Unfortunately, we do not have access to the data necessary to differentiate the positions that are more likely to rely on quote competition and the positions that are more likely to rely on preferenced trading. Therefore, we proceed with sorting of sample positions as discussed below.

As Figures 2 and 3 illustrate, if a position relies more heavily on quote competition, an exogenous shock should lead to a substantial decline in the position's volume even if its quote competitiveness remains unchanged. It is possible that the position's volume would decline even if its quote competitiveness increased substantially. Consequently, if a position's quote competitiveness improves or remains unchanged while the position's volume decreases, this position may be perceived as relying on quote competition for order flow. In contrast, if a position's quote competitiveness deteriorates or remains unchanged while its volume increases, that position may be perceived as relying on a non-quote competition strategy such as preferenced trading.

We use the above logic to classify all positions into one of the three groups as follows. We first sort sample positions into three categories based on the magnitude of the changes in quote competitiveness. For example, when we use relative duration, we identify the positions with an increase of 0.2 or more in relative duration (20% increase relative to the mean) and place

these positions in the TOP category.[11] The positions with a decline of 0.2 or more (20% decline relative to the mean) are placed in the BOTTOM category; the rest of the positions are assigned to the MIDDLE category.[12] Each of the three categories is then subcategorized as having either an increased or decreased share volume. As a result, a total of six subcategories exist. In the final step, we consolidate the six subcategories into three groups depending on the relation between the changes in quote competitiveness and the changes in share volume. Figure 4 illustrates the steps of creating three groups.

[Insert Figure 4]

Group 1 is characterized by no significant improvement in quote competitiveness but with a share volume increase; Group 2 is characterized by the co-movement of changes in quote competitiveness and changes in share volume; and Group 3 is characterized by no significant deterioration in quote competitiveness but with a share volume decline. For Group 1 positions, share volume increases without an improvement in quote competitiveness. It is obvious that market makers in these positions do not rely on competitive quotes to attract order flow. In contrast, intensified quote competition among market makers may be the underlying reason why Group 3 positions lose share volume despite of no significant deterioration in quote competitiveness. Market makers holding Group 2 positions that gain [lose] volume as their quote competitiveness increases [decreases], must either be more [less] aggressive than the average in

[11] The mean of a relative measure across all positions in the same stock should always equal to one. Any amount of change in a relative measure therefore can be interpreted as percentage change relative to the mean. This interpretation allows us to correctly compare the magnitude of changes in a relative measure from different levels. For example, an increase of relative duration from 0.40 to 0.50 will be regarded as an equal improvement of increase from 1.10 to 1.20, a 0.1 or 10% increase relative to the mean. If we use percentage change, the two increases become 25% [=(0.5-0.4)/0.4] and 9% [=(1.2-1.1)/1.1], which exaggerates the magnitude of increase from 0.4 to 0.5.

[12] The same sorting rules are imposed as we use different measures of quote competitiveness, except for relative spread. When relative spread is used, the 0.2 and -0.2 cutoff points result in very large difference in the number of observation among the final three subgroups. To deal with this problem, we used 0.1 and -0.1 cutoff points, which give us a relatively balanced number of observations in each subgroup.

relative terms, or relying more heavily on preferenced trading. This is an empirical question to be resolved.

Group 3 is the ideal candidate to test the second hypothesis. In the following regression, we introduce two dummy variables, G1 and G2, which signify Group 1 and Group 2, respectively, while Group 3 serves as the reference group.

$$\Delta RPV_{ij} = a_0 + a_1 QC_{ij} + a_2 \Delta QC_{ij} + a_3 SV_j + a_4 \Delta SV_j + a_5 H_j + a_6 \Delta H_j + a_7 G1_{ij} + a_8 G2_{ij} + a_9 (G1_{ij} * QC_{ij}) + a_{10} (G2_{ij} * QC_{ij}) + e_{ij} \quad (2)$$

where, definitions of all variables have been introduced in equation (1), subscripts *i* and *j* refer to position and stock, respectively, and the prefix Δ denotes the changes in the particular variable which follows. As in equation (1), we retain two stock-based control variables, SV and H, along with ΔSV and ΔH to control for the stock volume effect and the market concentration effect. In addition to the two dummy variables, G1 and G2, we also introduce two interaction terms to examine how the group classification affects the relation between pre-reform quote competitiveness and post-reform declines in position share volume. A negative coefficient for QC supports the second hypothesis when quote competitiveness is proxied by the four relative measures: durations, inside quotes, inside improvements, and depth. A positive coefficient supports the hypothesis when relative spread is used as the proxy for quote competitiveness.

In Panel A of Table 4 we present the results of regressions where relative duration is used as the proxy for quote competitiveness. In Panel B we summarize the results when quote competitiveness is measured by four other relative measures. Panel A finds that the estimated coefficients for relative duration and the change in relative duration are all negative and significant, suggesting that the result supports the prediction of the second hypothesis.[13] The coefficients for the change in quote competitiveness are positive and significant but in much smaller magnitude. This finding suggests that the greater the improvement in quote

[13] Regressions in both panels use observations before the reform. When the after reform observations are used, the regression results are very similar to the results reported in Table 4.

competitiveness, the larger the gain in share volume. However, the magnitude of the impact on share volume from improved quote competitiveness is very low when compared to other factors.

The different magnitudes of estimated coefficients for the two interaction terms are interesting and informative. First, we observe that the coefficients of 4.85 estimated for Group 1 is positive and large enough to reverse the sign of the coefficient of -2.95 estimated for Group 3's QC. When testing the null hypothesis that the sum of the two coefficients is equal to zero, the F-value is 28.97, which is highly significant and allow us to reject the null hypothesis. This implies that Group 1 gains share volume even though its positions do not exhibit any significant improvement in quote competitiveness. We suspect that preferenced trading is responsible for this and will revisit this question in the latter part of this study. In contrast, the coefficients of 2.28 estimated for interaction term for Group 2 is positive but not large enough to reverse the sign of the coefficient estimated for Group 3's QC. For the null hypothesis that the sum of the two coefficients is equal to zero, the F-value is 3.25, which is significant at 10% level.

The results shown in Panel B are consistent with those in Panel A. The overall results support the second hypothesis and confirm that the more competitive positions before the market reforms lose more in the quote competition segment of the market than other positions that are less aggressive. This result holds even if the market maker maintains the same level of quote competitiveness after the reform. We attribute this unusual finding to the high level of preferenced trading that persisted following the 1997 NASDAQ market reforms.

[Insert Table 4]

5. An Additional Test of the "Cream-Skimming" Hypothesis

5.1. Test Design

In the previous section, the first hypothesis test presents evidence that the slope of the share volume curve is flatter in the post-reform period than in the pre-reform period. This indicates a declining sensitivity of share volume to quote competitiveness. The second

hypothesis test produce evidence that some subsets of the sample positions gained market share even though their quote competitiveness either declined substantially or changed very little. We interpret this evidence as an indication that preferenced trading overrides quote competition.

However, our interpretation still remains conjectural because we do not have access to the NASDAQ proprietary data that would allow us to estimate the magnitude of preferenced trading in each of the sample positions. Hence, the main purpose of this section is to provide direct evidence in support of preferenced trading playing a critical role in the quoting behavior of NASDAQ market makers using the "cream-skimming" hypothesis of Easley, Kiefer, and O'Hara (1996a) and the sorting hypothesis proposed by Battalio and Holden (2001).[14]

Using a sample of stocks employed in purchased order flow, Easley et al. (1996a) demonstrate that the information content of orders differs across trading locales. The probability of informed trades on the New York Stock Exchange is approximately 44% higher than on the Cincinnati Stock Exchange. They attribute this difference to the "cream-skimming" of orders.[15] Battalio and Holden (2001) argue that purchasers and internalizers use externally verifiable characteristics to sort orders based on the likelihood of information content. Their theoretical model relaxes the assumption of anonymous trading and allows market makers to observe any externally verifiable characteristics of the trader or order to identify which orders are most likely to be coming from informed investors. Hence, the sorting hypothesis of Battalio and Holder (2001) implies that preference-dependent positions should be more concentrated in stocks that

[14] Battalio and Holden's (2001) sorting hypothesis is a broader concept than Easley et al.'s (1996a) cream-skimming hypothesis because previous theoretical models of Easley et al. (1996a) as well as of Glosten (1991), Chordia and Subrahmanyam (1995), are built on the anonymous trading assumption. By relaxing this assumption, Battalio and Holden (2001) is able to reconcile the controversy between Battalio (1997) and Easley et al. (1996a). Battalio (1997) argues payment for order flow and internalization are the result of cost competition while Easley et al. (1996a) suggest that they are the result of cream-skimming.

[15] Chorida and Subramahmanyam (1995), Lin, Sanger, and Booth (1995), and Bessembinder and Kaufman (1997) also report that non-NYSE trades of New York listed stocks convey very little or no information.

have a lower asymmetric information cost. It is also true under Easley et al.'s (1996a) cream-skimming hypothesis that purchased order flow will have the lowest information asymmetry cost.

We proceed in two stages. First, we highlight the disparate impact of the OHRs on the three groups introduced in the previous section. The exogenous shock has distinct effects on the three groups studied, implying unique dynamic relations between quote competitiveness and share volume. Group 1 positions are of special interest because they represent the group which is seemingly most heavily reliant on preferenced trading. If preferenced trading or purchased order flow is the main reason for this aberration in the relation between share volume and quote competitiveness, we expect the degree of information asymmetry to be lowest among the positions in the first group. A priori we are not certain whether Group 2 or Group 3 will have a lower degree of information asymmetry. This is an empirical question which we address with a logit regression, discussed below. Second, we revisit the cream skimming hypothesis or the sorting hypothesis in the context of a logit regression framework to ascertain the role of preferenced trading across group positions characterized by various degrees of information asymmetry.

5.2. Disparate Impact of OHRs on Quote Competitiveness and Share Volume

In Table 5, we report the changes in quote competitiveness and changes in relative share volume for the three groups of positions. Our purpose is to demonstrate the disparate impact of the OHRs on positions' quote competitiveness and share volume. Since Group 1 positions are perceived as being more dependent on preferenced trading and Group 3 positions are more dependent on quote competition, we expect Group 3 positions to display the greatest improvement in every quote competitiveness measure accompanied by the smallest increase in share volume, while Group 1 positions should display the smallest improvement in quote competitiveness accompanied by the largest increase in share volume. We report the changes

when relative duration is used for the purpose of sorting positions into three groups.[16] The 0.2 and -0.2 cutoff points in relative duration give us a balanced number of positions in the three groups. Group 1 has 616 positions, Group 2 has 662 positions and there are 746 positions in Group 3.

Group 1 positions, the positions most strongly influenced by preferenced trading, exhibit either the smallest improvement or the largest deterioration in quote competitiveness among the three groups except for change in depth, while significantly gaining volume. The increase in relative volume averages 179 basis points. In contrast, Group 3 positions, which are perceived to rely most heavily on quote competition, exhibit the greatest improvement or the least amount of deterioration in quote competitiveness except for the change in relative depth in all cases. Group 3 also has a significant loss in volume. The loss in relative volume averages 217 basis points. Although Group 3 positions have a larger decline in depth than Group 1, the difference is not statistically significant. The differences in the improvement across the three positions groups, and average change in their relative share volumes, signifies the disproportionate impact the reform had on different positions and the pattern confirms our belief that Group 1 positions rely on preferenced trading, while Group 3 positions are dependent on quote competition.

[Insert Table 5]

5.3. A Test of the "Cream-Skimming" Hypothesis

We believe that the unequal impact of the 1997 market reforms on the quoting behavior of NASDAQ market makers is the result of persistence of preferenced trading at high level and the differences in positions' competition strategies. Indirect evidence has been documented in the previous section in support of our conjecture about the role of preferenced trading. The relation

[16] Due to space limitations, we do not report the comparable statistics to Table 5 when the remaining four quote competitiveness variables are used for sorting of three groups. All quote competitiveness variables, except relative depth, lead to results that are similar to what we report in Table 5. When relative depth is used for classifying positions groups, Group 1 positions show the largest improvement in competitiveness, while Group 3 positions demonstrate the smallest improvement. These tables are available from the authors upon request.

between a position's preferenced trading volume and its change in quote competitiveness would have constituted direct evidence and could be tested. However, such a test requires preferenced volume for each position but that information is not available due to its proprietary nature. Consequently, we construct a test within the limitations of our data. In the absence of the position-specific preferenced trading volume data, our plan is to illustrate that preferenced-volume-dependent positions, such as Group 1 positions, should be associated with the lowest degree of information asymmetry as hypothesized by the cream-skimming hypothesis of Easley et al. (1996a) and the sorting hypothesis of Battalio and Holden (2001).

The cost of information asymmetry is estimated following Huang and Stoll (1996) by subtracting realized spreads from effective spreads. Average effective spreads and realized spreads are calculated for each stock across all observations using the last two months of trades in 1996. Effective spreads are calculated for each stock, which averages about \$0.26 across all stocks. Realized spreads are calculated for each stock at each price location with a five-minute interval. Average realized spreads at bid and ask are \$0.16 and \$0.13 respectively. The average cost of asymmetric information is about \$0.10 at bid and \$0.12 at ask. An equally-weighted average of asymmetric information cost at bid and ask price locations is used as the proxy for the cost of asymmetric information. Table 6 presents the summary statistics for the cost of information asymmetry for three groups of positions. When the change in relative duration, inside quotes, inside improvements, and depth are the criteria used to generate the three groups, (i) the size of information asymmetry cost for Group 1 is the smallest and that of Group 3 tends to be the largest; and (ii) the cost differentials between Groups 2 and 3 are not statistically significant. On average, Group 1's cost is approximately 5% to 8% lower than the largest cost recorded for either Group 3 or Group 2. This finding is expected because Group 1 positions are perceived as relying on preferenced trading rather than quote competition as the dominant way of attracting share volume.

[Insert Table 6]

The next step is to use the following ordered logistic regression to examine whether group 1 positions are more likely to be associated with low asymmetric information cost, while controlling for other confounding factors.

$$P(PG_{ij}) = a + a_1 IAC_j + a_2 QC_{ij} + a_3 \Delta QC_{ij} + a_4 H_j + a_5 SV_j + \varepsilon_{ij}, \quad (4)$$

where subscripts *i* and *j* denote position and stock, respectively. P(PG) is the logit probability of PG, which equals 1 for Group 1 positions; equals 2 for Group 2 positions; and equals 3 for Group 3 positions. We model the probability of Group 1 positions in equation (4). IAC is the cost of information asymmetry; and QC, H, and SV are defined in equation (1). If Group 1 positions are associated with stocks having low costs for information asymmetry, then the estimated coefficient of IAC should be negative. We also expect a negative coefficient for QC because Group 1 positions should be less aggressive. The coefficient for ΔQC should be negative because Group 1 positions have smaller improvements in QC than Group 3 positions due to our sorting procedure. By including ΔQC as one of the explanatory variables in the regression, we control for the possibility of a spurious relation produced from the sorting procedure.

Regression results are reported in Table 7. Panel A results are obtained when relative duration is used as the proxy for QC and Panel B results are obtained when all other variables (relative spreads, relative inside quotes, relative inside improvements, and relative depth) are used as proxies for QC. As expected, the estimated coefficient for IAC is significant and negative in all cases, which suggests that the logit probability of being in Group 1 is higher when the cost of information asymmetry is lower. This negative coefficient supports our prediction that preferenced trading enables NASDAQ market makers to maintain or even increase their share volume without improving quote competitiveness. Relative duration is also significant and negative in all the regressions, suggesting that a lower quote aggressiveness level leads to a higher logit probability of being assigned to Group 1. Change in relative duration is significantly

negative as expected. In Panel B, we use other quote competitiveness measures to replace relative duration. The results are generally consistent with Panel A.

[Insert Table 7]

5.4. Entries and Exits of Preferencing and Quote Competition Positions

We have so far established that preferenced trading is associated with a low information asymmetry cost and low quote competitiveness. Although our analysis is restricted to positions that survived the reform, this finding should also apply to positions that exited or entered the market after the reform. Wahal (1997) confirms that large-scale entry and exit of market makers are associated with significant declines (increases) in quoted spreads in the pre-reform period after controlling for changes in volume and volatility on the NASDAQ market. Kandel and Marx (1999), based on a model which explicitly recognizes preferencing and internalization, demonstrate that an increase in market makers is possible because the net entry of small order execution system (SOES) market makers exceeds the net exit of preferencing-based market makers. In contrast, Weston (2000) observes that the average daily number of market makers actually declines after the OHR changes when other confounding factors are controlled for. Weston's (2000) observations appear to contradict Kandel and Marx (1999). We take up this discrepancy and offer a valid explanation within the framework of our analysis.

The 352 positions that are excluded from the analysis in previous sections are examined to determine whether they are entries or exits. The positions that exited the market are defined as exits and the positions that entered the market are defined as entries.[17] For these positions, it is

[17] If pre-reform (post-reform) quote and share volume data are available for a position, this position is said to be in existence before (after) the reform. If either pre-reform (post-reform) quote or share volume or both are unavailable for a position, this position is considered not in existence before (after) the reform. Positions that are in existence before the reform but not after the reform are considered to have exited the market. Positions that are not in existence before the reform but are in existence after the reform are considered to have entered the market. Out of the 352 positions, 177 positions meet the criteria for exits, 169 positions meet the criteria for entries, and 6 positions do not meet the criteria for either the exits or the entries, which are excluded. Clearly, our method of defining entry and exit results in a decrease in the number of positions after the reform, which confirms our suspicion that exits tend to take place before the

impossible to calculate the changes in share volume and changes in quote competitiveness. Thus, our sorting procedure, which separates preferencing dependent positions from quote competition dependent positions, cannot be used here. Instead, we use a sorting procedure that is based upon the magnitude of the cost of information asymmetry and the level of quote competitiveness. All the entries and exits are classified into four subgroups: HH, HL, LH, and LL, where the first letter indicates the level of the cost of information asymmetry and the second letter refers to level of quote competitiveness, such that HH positions are characterized by high information asymmetry cost and high level of quote competitiveness, LL positions are with low information asymmetry cost and low level of quote competitiveness.

Since HH and LH positions compete for order flow using competitive quotes, they are considered as quote-competitive positions regardless of the magnitude of the information asymmetry cost. LL positions are not competitive on quotes but they may obtain order flow through preferenced trading arrangements. HL positions also do not quote competitively, but are associated with high information asymmetry cost. This suggests that HL positions may secure order flow from either preferenced trading arrangements or quote competition, or both. We argue that these positions are located somewhere between the two polar cases; hence, they may not be clearly characterized. In Panel A of Table 8, we summarize the differences among the four subgroups.

[Insert Table 8]

Panel B of Table 8 shows how net entry and net exit would differ under the two scenarios discussed in Section 2. With the level of preferenced trading substantially reduced as in Scenario II, the change in competition structure favors quote competition. Therefore, quote-oriented HH and LH positions would experience net entry, while the preferenced-oriented LL positions would have a net exit. HL positions are also expected to have a net exit in view of their non-competitive

reform while entries tend to take place after the reform, which biases the pre-reform daily average number of market makers downwards and the post-reform average upwards.

quoting behavior. Kandel and Marx (2000) demonstrate that (A+C)+(B+D) > 0 under this scenario, where A and C are net entry by HH and LH positions respectively and B and D are net exit by HL and LL positions, respectively. Because net entry by quote-competition positions is greater than net exit by preferencing positions, one expects an increase in the total number of positions. However, if preferencing remains largely unchanged as in Scenario I, preferencing-oriented positions are under less pressure than quote-oriented positions for quote competition. Consequently, HH and LH positions are expected to experience net exit, while HL and LL positions are expected to experience a net entry. Under this scenario, the prediction by Kandel and Marx (1999) may no longer hold because (A+C) + (B+D) may be less than zero.

This presents a possible solution to the contradictory findings of Weston (2000) and Kandel and Marx (1999). Using the entry and exit data, we confirm the empirical validity of our prediction by investigating the pattern of entry and exit by four subgroups of positions. Since the average asymmetric information cost is $0.11 over the 97 stock, we use it as the cutoff point in defining high and low cost of information asymmetry.[18] Relative duration is used as the quote competitiveness measure. A relative duration greater than 1.00, the market average, is considered high level of quote competitiveness. Likewise, a relative duration of less than 1.00 is considered a low level of quote competitiveness. Table 9 presents the results of entry and exit analysis.

[Insert Table 9]

Panel A reports the information asymmetry cost and quote competitiveness for each position category, while Panel B reports the number of positions for each positions category. From Panel A, it is clear that the HH and LH positions are very competitive, while the HL and LL positions are much less competitive, which is expected given our sorting procedure. As predicted for Scenario I, the number of net exits, 20 positions was observed for HH and LH positions together, whereas the LL positions experienced a net entry of 10 and the HL positions had the

[18] We also use the average information cost ($0.09) for preferencing dependent positions group, reported in Table 6 as the cutoff point. The results are similar to the findings summarized in Table 9.

smallest change, a net entry of 2. The pattern in entry and exit by different types of positions supports our prediction regarding the entry and exit of market makers.

5.5 Is the Reduction in Execution Cost Inconsistent with Sustained Preferencing Level?

Both Barclay et al. (1999) and Weston (2000) report large decline in the order execution cost. Weston (2000) further points out that the decline in execution cost is not caused by change in information asymmetry cost or inventory cost; rather, it is the reduction in the dealers' rents that leads to the decline in execution costs. The reduction in dealers' rents is seemingly inconsistent with our conjecture that preferenced trading is sustained after the reform. The common wisdom is that preferencing will prevent a decrease in execution costs and a decrease in execution costs should reduce preferencing. We believe that it is possible for reduction in execution cost to coexist with sustained high level of preferenced trading.

On the one hand, according to Kandel and Marx (1999), an exogenous shock to competition will reduce dealers' rents, which in turn will make preferenced trading unsustainable at the current level. How do we reconcile the 30% reduction in dealers' rents with persistently high levels of preferenced trading? We believe that there are two possible explanations. First, although the reduction in dealers' rents reported by Weston (2000) is large, it may not be a large enough reduction to eliminate (or even substantially reduce) preferenced trading. Kandel and Marx (1999) discuss how the payment for orders has declined over the years. Reduction in the payment for order flow could make preferencing easier in a time of decreased profit margins. Second, the 'cream skimming' and 'sorting' hypothesis suggest that preferencing-dependent positions are paying the same price for orders with lower costs.[19] This makes the reduction in dealers' rents less influential on positions dependent upon preferenced trades. This could result in

[19] A recent study by Peterson and Sirri (2003) documents that the Cincinnati Stock Exchange which has formal preferencing program exhibits the tightest spreads among all regional exchanges even though the market quality statistics based on quoted spread and quoted depth indicate better performance for the NYSE than the regional exchanges.

a sustained preferencing level even after a decrease in execution costs. For these two reasons, a reduction in execution costs could be ineffective in reducing the level of preferenced trading.

On the other hand, if the preferenced trading level is high and does not decrease, how and by what mechanism is the reduction in execution costs achieved? We believe that it is the 'best execution' rule that is responsible. As we have discussed earlier, preferenced trading, effectively, segments the NASDAQ market into, a quote competition segment and preferenced trading segment. When an exogenous shock intensifies quote competition, execution costs in the quote competition segment fall and the impact from the lower bid ask spread passes through the rest of the market because of the 'best execution' rule. No matter what competition strategy a market maker adopts, a transaction has to be executed at the best market price, even for preferenced orders. This means that preferencing cannot prevent the decrease in spreads that results from quote competition. As long as there is any new quote competition, spreads will be narrowed. However, using such regulatory methods to improve market quality comes with a price: (i) decreased sensitivity between share volume and quote competitiveness, and (ii) negative correlation between change in share volume and quote competitiveness.

6. Conclusion

In this paper, we have developed a theory that predicts very different impacts to the structure of quote competition from an exogenous shock depending upon whether preferenced trading is substantially reduced by the shock. If an exogenous shock that increases quote competition is accompanied by a large reduction in preferenced order flow, the sensitivity of share volume to quote competitiveness will increase and positions that were less competitive on quotes are under greater pressure to improve their quote competitiveness; otherwise, share volume losses will be substantial. The higher pressure on less competitive positions and greater sensitivity between quote competitiveness and share volume means that positions dependent upon preferenced trading will either have to improve their quote competitiveness significantly or suffer losses in their share volume. A decreased level of preferenced trading and a greater sensitivity

between quote competitiveness and share volume makes quote competitiveness a much more important determinant in the distribution of share volume.

When there is no substantial reduction in preferenced order flow, the impact from the intensified competition is very different. Positions that were more aggressive on quotes are under greater pressure to increase their quote competitiveness. This is because the maximum loss in share volume, the loss if positions were to completely forego quote competition, are greater for more competitive positions and are limited for preferencing dependent positions that are not competitive. As a result, incentives for improving quote competitiveness under intensified competition are also different. This leads to a flatter volume curve, i.e., lower sensitivity between quote competitiveness and share volume. The decrease in the slope of the volume curve, in turn, results in negative correlation between quote competitiveness and change in share volume. Despite the contrasts, quote competition intensifies and dealers' rents decline in both scenarios, as long as some portion of the market competes for order flow using quotes. The impacts from an exogenous shock on quote competition initially affect positions in the quote competition segment, however, because the 'best execution' rule, the decreased spreads and lower dealers' rents affect all positions across the market. Thus, improved market efficiency and a persistent preferencing level can coexist.

Our findings suggest that preferencing is harmful in terms of damaging quote competition. However, as long as there is quote competition, preferencing can not prevent improvements in market efficiency due to the existence of the 'best execution' rule. Although, the improvement could be much greater if preferencing was not present or substantially declined. Our conclusion on the effect of preferenced trading is similar to the conclusion of Bloomfield and O'Hara (1997), which examined the impact of preferenced trading in a controlled experimental setting.

Our research provides some important implication for policy makers. First, the greater spreads on the NASDAQ are not simply a matter of not enough quote competition. As many authors have argued, preferenced trading damages the incentives for quote competition. This paper presents additional evidence in support of this view. We believe that preferenced trading is the root of the problem, and should be addressed explicitly. Second, the 'best execution' rule has effectively forced the outcome of quote competition in a segment of the market upon the entire market, and has largely reduced the negative consequences of preferenced trading. The reinforcement of the 'best execution' rule probably has also had the same effect on other non-competitive behavior, which is worthy of further investigation. Given this impact, the 'best execution' rule should be forcefully implemented in order to minimize the inefficiency that have arisen from non-competitive behavior. Third, policies that are intended to enhance quote competition but do not address preferenced trading could have serious negative impacts on the market. We demonstrate that enhanced quote competition after the 1997 rule change on the NASDAQ causes a decreased sensitivity of share volume to quote competitiveness and larger losses in volume for more competitive positions. Our finding of net entry by preferencing positions and net exit by quote competition positions provides further evidence of the negative impact from such a policy.

References

Battalio, R., 1997. Third market broker-dealers: Cost competitors or cream-skimmers? An empirical analysis. Journal of Finance 52, 341-352.

Battalio, R., and C. Holden, 2001. A simple model of payment for order flow, internalization, and total trading cost. Journal of Financial Markets 4, 33-71.

Battalio, R., R. Jennings, and J. Selway, 2001. The relationship among market-making revenue, payment for order flow, and trading costs for market orders. Journal of Financial Services Research 19, 39-56.

Battalio, R., J. Greene, B. Hatch, and R. Jennings, 2002. Does the limit order routing decision matter? Review of Financial Studies 15, 159-194.

Battalio, R., J.Greene, and R. Jennings, 1997, Do competing specialists and preferencing dealers affect market quality? Review of Financial Studies 10, 969-993.

Barclay, M., W. Christie, J. Harris, E. Kandel, and P. Schultz, 1999. Effects of market reform on the trading costs and depth of Nasdaq stocks. Journal of Finance 54, 1-34.

Bloomfield, R., and M. O'Hara, 1997. Does order preferencing matter? Journal of Financial Economics 50, 3-37.

Bessembinder, H., 2003. Quote-based competition and trade execution costs in NYSE-listed stocks. Forthcoming in Journal of Financial Economics.

Bessembinder, H. and H. Kaufman, 1997. A cross-exchange comparison of execution costs and information flow for NYSE-listed stocks. Journal of Financial Economics 46, 293-319.

Chang, R., C. Liu, and S. Rhee, 2002. Is the London market competitive? A study of trading behavior of London market makers. Working paper, University of Hawaii.

Choridia, T. and A. Subramanyam, 1995. Market making, the tick size and the payment-for-order-flow: Theory and evidence. Journal of Business 68, 543-576.

Christie, W., and P. Schultz, 1994, Why do NASDAQ market makers avoid odd-eighth quotes? Journal of Finance 49, 1813-1840.

Chung, K., C. Chuwonganant, T. McCormick, 2003. Order preferencing and market quality on NASDAQ before and after decimalization. Forthcoming in Journal of Financial Economics.

Chung, K., C. Chuwonganant, T. McCormick, 2002. Does internalization diminish the impact of quote aggressiveness on dealer market share? Working Paper, SUNY at Buffalo.

Chung, K., B. Van Ness, and R. Van Ness, 2001. Can the treatment of limit orders reconcile the differences in trading costs between NYSE and NASDAQ issues? Journal of Financial and Quantitative Analysis 36, 267-286.

Dutta, P., and A. Madhavan, 1997. Competition and collusion in dealership markets, Journal of Finance 52, 245-276.

Easley, D, N. Kiefer, and M. O'Hara, 1996. Cream-skimming or profit-sharing? The curious role of purchased order flow. Journal of Finance 51, 811-833.

Easley, D., N. Kiefer, M. O'Hara, and J. Paperman, 1996. Liquidity, information, and infrequently traded stocks. Journal of Finance 51, 1405-1436.

Ellis, K, R. Michaely, and M. O'Hara, 2002. The making of a dealer market: From entry to equilibrium in the trading of NASDAQ stock. Journal of Finance 57, 2289-2316.

Hansch, O., N. Naik, and S. Viswanatha, 1999. Preferencing, internalization, best execution, and dealer profits. Journal of Finance 54, 1799-1828.

Harris, L., 1999. Trading in pennies: A survey of the issues. Working Paper, University of Southern California.

Heflin, F., and K. Shaw, 2001. Adverse selection, inventory-holding costs, and depth. Journal of Financial Research 24, 65-82.

Huang, R. and H. Stoll, 1996. Dealer versus auction markets: A paired comparison of execution costs on NASDAQ and the NYSE. Journal of Financial Economics 41, 313-357.

Huang, R. and H. Stoll, 1997. The components of the bid-ask spread: A general approach. Review of Financial Studies 10, 995-1034.

Kandel, E., and L. Marx, 1997. NASDAQ market structure and spread patterns. Journal of Financial Economics 45, 61-89.

Kandel, E., and L. Marx, 1999. Payments for order flow on NASDAQ. Journal of Finance 54, 35-66.

Klock, M. and D. McCormick, 1999. The impact of market maker competition on NASDAQ spreads. Financial Review 34, 55-74.

Klock, M. and D. McCormick, 2002. The effect of market structure on the incentives to quote aggressively – an empirical study of NASDAQ market makers. Financial Review 37, 403-420.

Lin, J., G. Sanger, and G. Booth, 1995. Trade size and components of the bid-ask spread. Review of Financial Studies 8, 1153-1183.

Macey, J., and M. O'Hara, 1997. The law and economics of best execution. Journal of Financial Intermediation 6, 188-223.

Peterson, M. and E. Sirri, 2003. Order preferencing and market quality on U.S. equity exchanges. Review of Financial Studies 16, 385-415.

Smith, J., 1998. The effects of order handling rules and 16ths on NASDAQ: A cross-sectional analysis. NASD Working Paper 98-02.

Stoll, H., 1989. Inferring the components of the bid-ask spread: Theory and empirical test. Journal of Finance 39, 1127-1139.

Wahal, S., 1997. Entry, Exit, market makers, and the bid-ask spread. Review of Financial Studies 10, 871-901.

Weston, J., 2000. Competition on the NASDAQ and the impact of recent market reforms. Journal of Finance 55, 2565-2598.

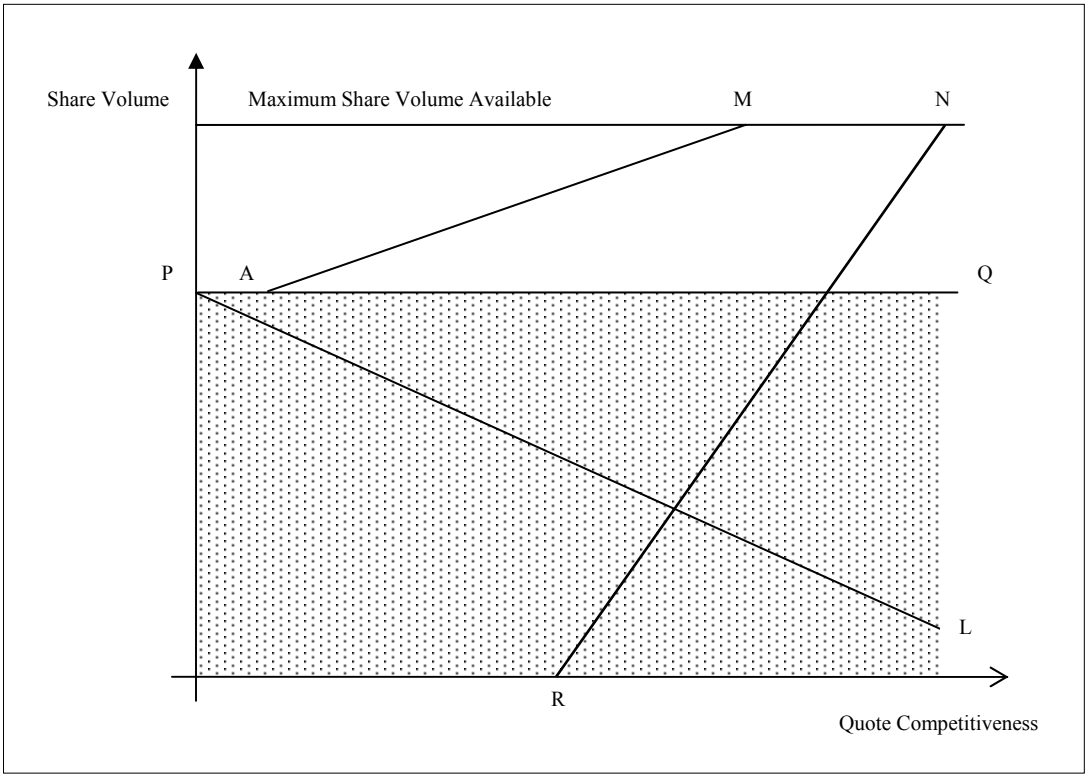


Figure 1
The Relation between Share Volume and Quote Competitiveness

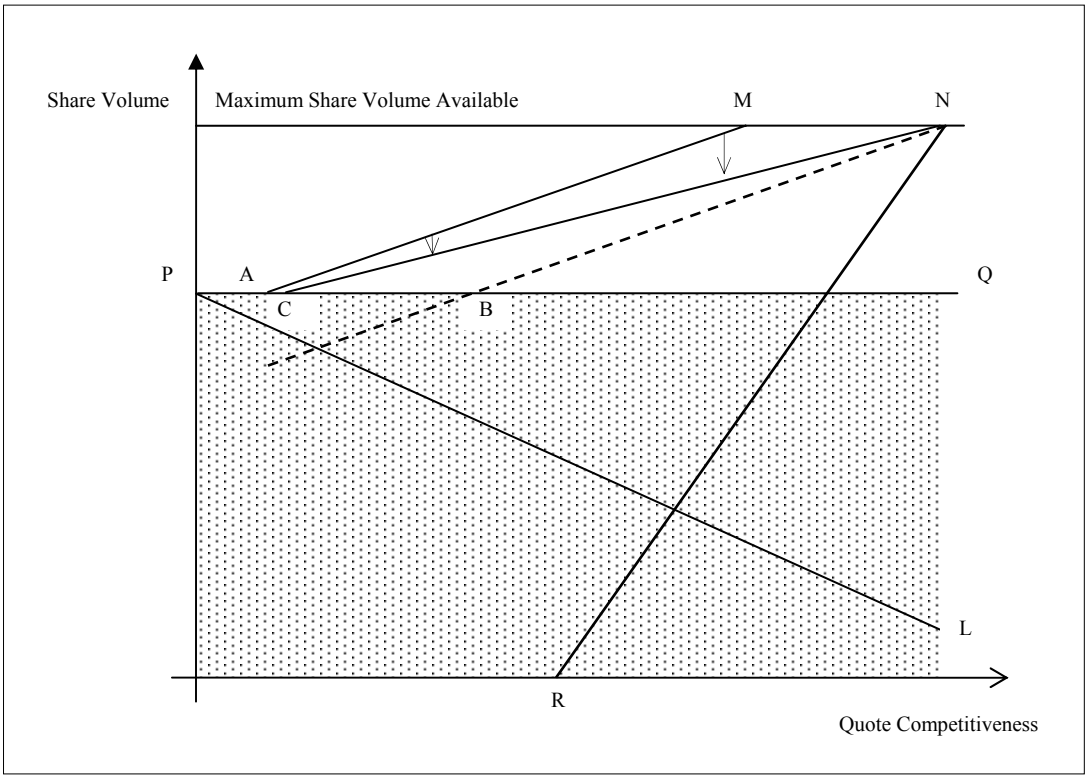


Figure 2
The Relation between Share Volume and Quote Competitiveness:
No Change in Preferenced Trading

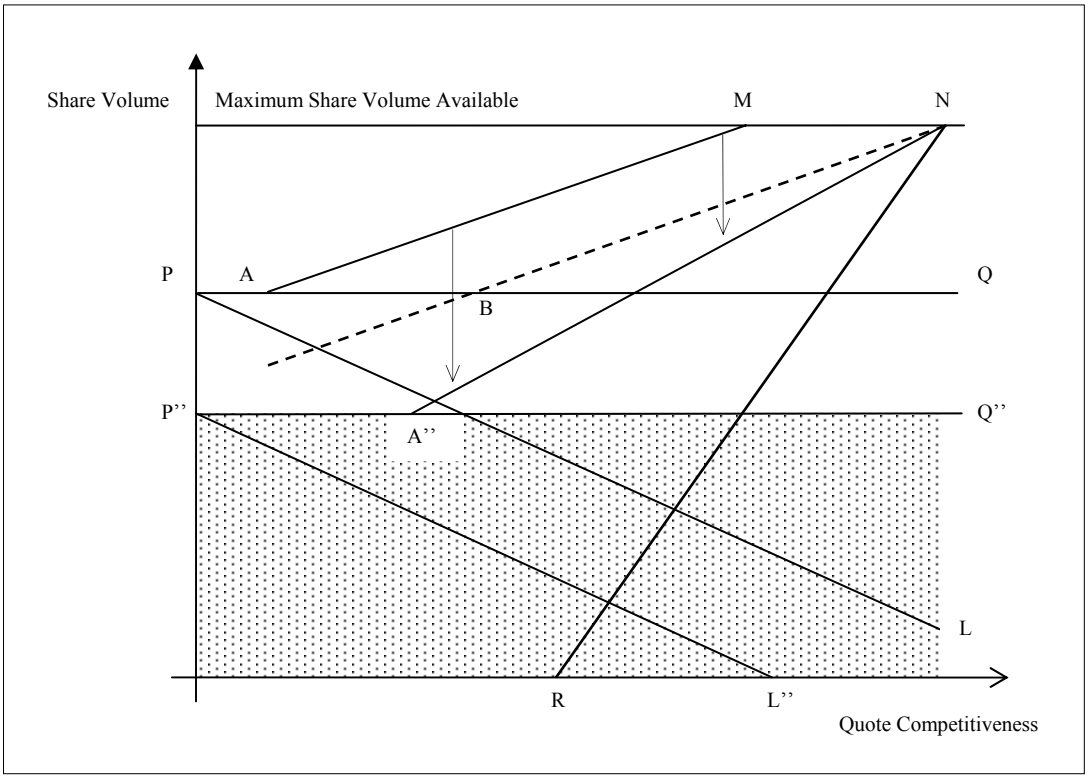
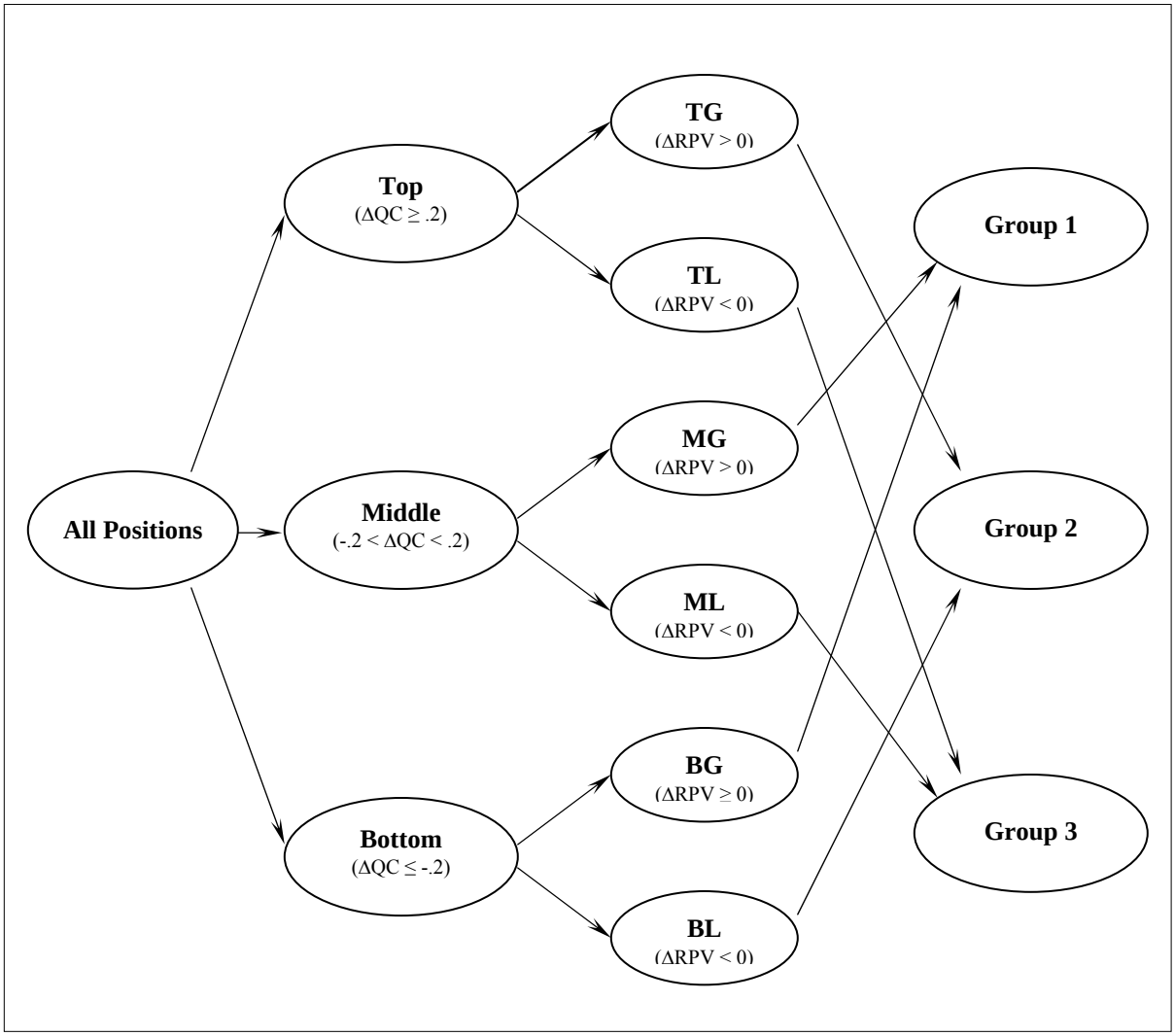


Figure 3
The Relation between Share Volume and Quote Competitiveness:
Large Decline in Preferenced Trading



All sample positions are sorted into three categories based on the magnitude of the changes in quote competitiveness. For example, when we use relative duration as the quote competitiveness variable, we identify the positions with at least 0.20 increase in relative duration (20% increase relative to the mean) and place these positions in the TOP category. The positions with at least a 0.2 decline (20% decline relative to the mean) are placed in the BOTTOM category; the rest of the positions are assigned to the MIDDLE category. The same sorting rules are imposed as we use different measures of quote competitiveness, except for relative spread. Each of the three categories is then subcategorized as having either an increased or decreased share volume. As a result, a total of six subcategories exist. In the final step, we consolidate the six subcategories into three groups depending on the relation between the changes in quote competitiveness and the changes in share volume.

Figure 4
Creation of Three Subgroups

Table 1. Difference between the Two Scenarios

Scenario I Preferenced trading declines little after an exogenous shock	**Scenario II** Preferenced trading declines substantially after an exogenous shock
The volume curve in the quote competition segment of the market is pushed to the right with a flatter slope	The volume curve in the quote competition segment of the market is pushed to the right with a steeper slope
The more competitive positions lose more volume in the quote competition segment of the market than less competitive positions.	The more competitive positions lose less volume in the quote competition segment of the market than less competitive positions.

Table 2. Descriptive Statistics

Table 2 presents the equally-weighted averages of all the variables used in this study: (i) duration; (ii) percentage spreads; (iii) the number of quotes that are on the inside per day, which is referred to as "inside quotes"; (iv) the number of quotes that improve the inside spread per day, which is referred to as "inside improvements"; (v) depth on the inside; (vi) position volume; (vii)stock volume; and (viii) the Herfindahl-Hirshman index (HHI) for the pre- and post-reform periods. We sort the 2,024 positions into four quartiles on the basis of the changes in absolute measure of duration. For the four quartiles, numbers outside the parentheses are absolute measures that reflect quote aggressiveness and numbers inside the parentheses are relative measures that reflect quote competitiveness. The second row in the "change" field is the *p*-values for significant test of equal means before and after the reforms.

	All	First Quartile	Second Quartile	Third Quartile	Fourth Quartile
Duration					
Before	169.51	216.44 (1.14)	172.02 (1.05)	147.73 (0.95)	141.85 (0.93)
After	133.40	112.56 (0.83)	120.64 (0.96)	126.76 (1.01)	172.04 (1.28)
Change	-36.51	-103.88 (-0.31)	-51.38 (-0.09)	-20.97 (0.06)	30.19 (0.04)
	<.0001	<.0001 (<.0001)	<.0001 (<.0001)	<.0001 (<.0001)	<.0001 (<.0001)
Quoted Spread					
Before	2.16	2.12 (0.98)	2.06 (0.99)	2.03 (1.01)	2.44 (1.01)
After	2.05	2.28 (1.08)	2.02 (1.00)	1.91 (0.97)	1.97 (0.89)
Change	-0.12	0.16 (0.10)	-0.04 (0.01)	-0.12 (-0.04)	-0.47 (-0.12)
	<.0001	<.0001(<.0001)	0.1231 (0.3758)	<.0001 (<.0001)	<.0001 (<.0001)
Inside Quotes					
Before	24.12	22.37 (1.07)	24.68 (1.02)	27.97 (0.97)	21.44 (0.98)
After	33.57	21.42 (0.87)	30.40 (0.96)	39.46 (1.00)	42.99 (1.31)
Change	9.45	-0.94 (-0.20)	5.71 (-0.07)	11.49 (0.03)	21.55 (0.33)
	<.0001	0.2036 (<.0001)	<.0001 (<.0001)	<.0001 (0.0223)	<.0001 (<.0001)
Inside Improvements					
Before	4.07	4.28 (1.24)	4.06 (1.15)	4.56 (1.06)	3.36 (1.10)
After	4.49	2.96 (0.87)	3.92 (1.00)	5.36 (1.11)	5.72 (1.59)
Change	0.42	-1.32 (-0.37)	-0.14 (-0.15)	0.80 (0.05)	2.35 (0.49)
	0.0001	<.0001 (<.0001)	0.2869 (<.0001)	<.0001 (0.0898)	<.0001 (<.0001)
Depth					
Before	9.99	9.91 (1.00)	10.06 (1.01)	9.97 (1.00)	10.01 (1.00)
After	9.83	9.24 (0.98)	9.62 (1.00)	9.77 (1.01)	10.58 (1.05)
Change	-0.18	-0.67 (-0.01)	-0.44 (-0.00)	-0.19 (0.01)	0.57 (0.06)
	0.0203	<.0001 (0.3137)	0.0046 (0.8612)	0.2584 (0.5986)	0.0015 (0.0004)
Position Volume (in thousands)					
Before	3,337	2,094 (5.42)	3,243 (4.56)	3,787 (3.56)	4,222 (3.78)
After	4,306	2,323 (4.66)	3,853 (3.92)	5,292 (3.56)	5,758 (4.09)
Change	970	229 (-0.76)	610 (-0.63)	1,505 (-0.00)	1,536 (0.31)
	<.0001	0.0419 (<.0001)	0.0003 (0.0001)	<.0001 (0.9958)	<.0001 (0.0261)
Stock Volume (in thousands)					
Before	75,447	-	-	-	-
After	103,275	-	-	-	-
Change	27,828	-	-	-	-
	0.0004				
HHI					
Before	1,155.40	-	-	-	-
After	941.89	-	-	-	-
Change	-213.51	-	-	-	-

	0.0001				

Table 3. Position Volume Sensitivity to Quote Competitiveness

The following regression model is used to test the first hypothesis on the post-reform changes in the sensitivity of share volume to quote competitiveness:

$$RPV_{ij} = a_0 + a_1 QC_{ij} + a_2 D_{ij} + a_3 (QC_{ij} * D_{ij}) + a_4 SV_j + a_5 H_j + \varepsilon_{ij}, \quad (1)$$

where, subscripts *i* and *j* denote position and stock, respectively; RPV = relative position share volume; QC = quote competitiveness as measured by relative quote aggressiveness; SV = natural log of trading volume of individual stock; H = HHI in thousands; and D = a dummy variable, which is assigned 1 if the observation belongs to the post-reform period and 0 otherwise. Five different measures of QC are introduced, including: (i) duration; (ii) percentage spreads; (iii) inside quotes; (iv) inside improvements; and (v) depth on the inside. Because relative duration is used as the primary variable measuring quote competitiveness, Panel A summarizes the results with relative duration as QC and Panel B reports the results with all other QC variables. Figures in parenthesis are the *p*-values.

Panel A

	(1)	(2)	(3)	(4)	(5)
Intercept	-0.8005 (<.0001)	-0.6532 (.0027)	-2.0025 (<.0001)	23.0055 (<.0001)	4.4509 (.0004)
Relative Duration	4.8983 (<.0001)	4.9005 (<.0001)	6.2271 (<.0001)	6.2713 (<.0001)	6.2162 (<.0001)
D		-0.2989 (.0585)	1.7933 (<.0001)	8.5209 (<.0001)	2.2143 (<.0001)
Relative Duration*D			-2.0533 (<.0001)	-2.0890 (<.0001)	-2.0399 (<.0001)
Log of Stock Volume				-1.3967 (<.0001)	-0.5363 (<.0001)
HH Index					3.9986 (<.0001)
Adjusted R-square	0.1497	0.1502	0.1561	0.2738	0.3562

Panel B

	(1)	(2)	(3)	(4)
Intercept	17.9617 (<.0001)	6.2758 (<.0001)	8.4054 (<.0001)	-1.0948 (.6005)
Relative Spreads	-7.1737 (<.0001)			
Relative Spreads*D	1.6485 (.0696)			
Relative InsideQuotes		4.0398 (<.0001)		
Relative InsideQuotes*D		-1.1927 (.0025)		
Relative InsideImprovements			2.5016 (<.0001)	
Relative InsideImprovements*D			-0.9504 (<.0001)	
Relative Depth				11.3954 (<.0001)
Relative Depth*D				-7.3454 (<.0001)
D	-1.5530 (.0849)	1.3021 (.0023)	1.2305 (<.0001)	7.4739 (<.0001)
Log of Stock Volume	-0.5406 (<.0001)	-0.5149 (<.0001)	-0.5576 (<.0001)	-0.5121 (<.0001)

HH Index	4.0463 (<.0001)	4.0385 (<.0001)	3.8814 (<.0001)	4.0263 (<.0001)
Adjusted R-square	0.2414	0.2610	0.3013	0.2419

Table 4. The Relation between Quote Competitiveness and Post-Reform Decline in Share Volume

The following regression model is used to test the second hypothesis on the relation between quote competitiveness and post-reform decline in share volume:

$$\Delta RPV_{ij} = a_0 + a_1 QC_{ij} + a_2 \Delta QC_{ij} + a_3 SV_j + a_4 \Delta SV_j + a_5 H_j + a_6 \Delta H_j + a_7 G1_{ij} + a_8 G2_{ij} + a_9 (G1_{ij} * QC_{ij}) + a_{10} (G2_{ij} * QC_{ij}) + e_{ij} \quad (2)$$

where, subscripts *i* and *j* denote position and stock, respectively; RPV = relative position share volume; QC = quote competitiveness as measured by relative quote aggressiveness; SV = natural log of trading volume of individual stock; and H = HHI in thousands; and the prefix Δ denotes the changes in the particular variable which follows. Five different measures of QC are introduced, including: (i) relative duration; (ii) relative spreads; (iii) relative inside quotes; (iv) relative inside improvements; and (v) relative depth on the inside. Because relative duration is used as the primary variable measuring quote competitiveness, Panel A summarizes the results with relative duration as QC and Panel B reports the results with all other QC variables. All positions are categorized into three subgroups. Group 1 is characterized by no significant improvement in quote competitiveness but with a share volume increase; Group 2 is characterized by the co-movement of changes in quote competitiveness and changes in share volume; and Group 3 is characterized by no significant deterioration in quote competitiveness but with a share volume decline. G1 and G2 are dummy variables that signify Group 1 and Group 2, respectively. In addition to the two dummy variables, G1 and G2, we also introduce two interaction terms to examine how the group classification affects the relation between pre-reform quote competitiveness and post-reform declines in position share volume. Figures in parenthesis are the *p*-values.

Panel A

	(1)	(2)	(3)	(4)
Intercept	0.5990 (.1009)	0.6569 (.0852)	-2.9825 (.0067)	-0.9094 (.5422)
Relative Duration	-2.9457 (<.0001)	-2.7664 (<.0001)	-2.9084 (<.0001)	-2.7652 (<.0001)
Δ Relative Duration	2.367 (<.0001)	2.3966 (<.0001)	2.3644 (<.0001)	2.3902 (<.0001)
HH Index		-0.1675 (.3963)		-0.0162 (.9483)
Δ HH Index		1.4638 (<.0001)		1.5884 (<.0001)
Log of Stock Volume			0.1985 (.0005)	0.0828 (.2653)
Δ Log of Stock Volume			-0.0768 (.5906)	-0.1356 (.3413)
G1	-0.4138 (.4284)	-0.0799 (.8925)	-0.3606 (.4891)	-0.0721 (.8893)
G2	0.0294 (.9566)	0.2403 (.6530)	0.1140 (.8326)	0.2539 (.6347)
Relative Duration * G1	4.8464 (<.0001)	4.5721 (<.0001)	4.8212 (<.0001)	4.5747 (<.0001)
Relative Duration * G2	2.2807 (<.0001)	2.0469 (<.0001)	2.1673 (<.0001)	2.0258 (<.0001)

Adjusted R-square	0.2554	0.2747	0.25921	0.2748

Panel B

	(1)	(2)	(3)	(4)
Intercept	-7.1264 (.0002)	-0.2567 (.8671)	-2.0706 (.1735)	8.8648 (.0015)
Relative Spreads	3.9598 (.0009)			
ΔRelative Spreads	-3.4330 (<.0001)			
Relative InsideQuotes		-1.7257 (<.0001)		
ΔRelative InsideQuotes		1.6338 (<.0001)		
Relative InsideImprovements			-0.9550 (<.0001)	
ΔRelative InsideImprovements			1.2326 (<.0001)	
Relative Depth				-11.1429 (<.0001)
ΔRelative Depth				1.3136 (<.0001)
HH Index	-0.0682 (.7867)	-0.1793 (.4767)	-0.0631 (.8066)	-0.1843 (.4657)
ΔHH Index	1.6125 (<.0001)	1.5418 (<.0001)	1.6477 (<.0001)	1.5885 (<.0001)
Log of Stock Volume	0.0575 (.4456)	-0.0100 (.8936)	0.0550 (.4720)	0.0165 (.8261)
Δ Log of Stock Volume	-0.1427 (.3222)	-0.2104 (.1433)	-0.1708 (.2454)	-0.1491 (.3004)
G1	11.6800 (<.0001)	1.2933 (.0299)	2.4641 (<.0001)	-9.8980 (.0009)
G2	7.1547 (<.0001)	1.6586 (.0081)	1.5134 (<.0001)	-6.5903 (.0308)
QC * G1	-7.2269 (<.0001)	3.2194 (<.0001)	1.8722 (<.0001)	14.0609 (<.0001)
QC * G2	-4.4986 (.0010)	0.7932 (.1797)	0.4040 (.1328)	9.0730 (.0028)
Adjusted R-square	0.2580	0.2604	0.2270	0.2623

Table 5. Variation in the Improvements of Quote Competitiveness

All positions are categorized into three subgroups. Group 1 is characterized by no significant improvement in quote competitiveness but with a share volume increase; Group 2 is characterized by the co-movement of changes in quote competitiveness and changes in share volume; and Group 3 is characterized by no significant deterioration in quote competitiveness but with a share volume decline. Five different measures of QC are introduced, including: (i) relative duration; (ii) relative spreads; (iii) relative inside quotes; (iv) relative inside improvements; and (v) relative depth on the inside. Relative position volume is the 3-month total volume in shares for a position as a percentage of total volume in the corresponding stock. The prefix Δ denotes the changes in the particular variable which follows. In column 1 through 3, the first number in each cell is mean, the second number is median, and the third number is t-value for the test that mean equals 0. In the last column, the first figure is the p-value of the significant test of equal means between Group 1 and Group 2, the second figure is for the test between Group 1 and Group 3, and the last figure is for the test between Group 2 and Group 3.

	Group 1	**Group 2**	**Group 3**	**p-value**
N	616	662	746	
ΔRelative Duration	-0.1203 <-0.0840> (<.0001)	0.0009 <-0.2160> (0.9588)	0.1130 <0.0651> (<.0001)	<.0001 <.0001 <.0001
ΔRelative Spreads	0.0172 <-0.0127> (0.0346)	0.0052 <-0.0211> (0.5600)	-0.0566 <-0.0614> (<.0001)	0.3219 <.0001 <.0001
ΔRelative InsideQuotes	-0.0846 <-0.0827> (<.0001)	0.0317 <-0.0602> (0.1274)	0.1026 <0.0497> (<.0001)	<.0001 <.0001 0.0031
ΔRelative InsideImprovements	-0.0767 <-0.0759> (0.0019)	0.0247 <-0.0814> (0.5071)	0.0526 <-0.0177> (0.0361)	0.0254 0.0002 0.5268
ΔRelative Depth	-0.0002 <-0.0169> (0.9895)	0.0235 <0.0070> (0.0719)	0.0138 <0.0007> (0.2453)	0.2065 0.4365 0.5803
ΔRelative Volume	1.7877 <0.8107> (<.0001)	-0.0498 <-0.0683> (0.7122)	-2.1720 <-0.8654> (<.0001)	<.0001 <.0001 <.0001

Table 6. Information Asymmetry Cost for the Three Subgroups

All positions are categorized into three subgroups. Group 1 is characterized by no significant improvement in quote competitiveness but with a share volume increase; Group 2 is characterized by the co-movement of changes in quote competitiveness and changes in share volume; and Group 3 is characterized by no significant deterioration in quote competitiveness but with a share volume decline. Five different measures of QC are introduced, including: (i) relative duration; (ii) relative spreads; (iii) relative inside quotes; (iv) relative inside improvements; and (v) relative depth on the inside. The prefix Δ denotes the changes in the particular variable which follows. In column 1 through 3, the first figure in each cell is the mean information asymmetry cost, the second figure is the median, and the third figure is the standard deviation. In the last column, the first figure is the p-value of the significant test of equal means between Group 1 and Group 2, the second figure is for the test between Group 1 and Group 3, and the last figure is for the test between Group 2 and Group 3.

QC	Group 1	Group 2	Group 3	p-value
ΔRelative Duration	0.0922 (0.0826) <0.0596>	0.0987 (0.0983) <0.0568>	0.0986 (0.0930) <0.0583>	0.0458 0.0454 0.9774
ΔRelative Spread	0.0924 (0.0826) <0.0608>	0.0985 (0.0983) <0.0556>	0.0984 (0.0956) <0.0582>	0.0746 0.0563 0.9892
ΔRelative InsideQuotes	0.0924 (0.0826) <0.0593>	0.0976 (0.0982) <0.0566>	0.0996 (0.0982) <0.0586>	0.1140 0.0202 0.5078
ΔRelative InsideImprovements	0.0919 (0.0818) <0.0597>	0.0983 (0.0982) <0.0576>	0.0985 (0.0930) <0.0578>	0.0450 0.0609 0.9634
ΔRelative Depth	0.0934 (0.0826) <0.0590>	0.0979 (0.0983) <0.0559>	0.0990 (0.0923) <0.0584>	0.2319 0.0539 0.7803

Table 7. Ordered Logistic Regressions

The following logit regression model is used to test the "cream skimming" hypothesis. All positions are categorized into three subgroups. Group 1 is characterized by no significant improvement in quote competitiveness but with a share volume increase; Group 2 is characterized by the co-movement of changes in quote aggressiveness and changes in share volume; and Group 3 is characterized by no significant deterioration in quote competitiveness but with a share volume decline:

$$P(PG_{ij}) = a + a_1 IAC_j + a_2 QC_{ij} + a_3 \Delta QC_{ij} + a_4 H_j + a_5 SV_j + \varepsilon_{ij}, \qquad (4)$$

P(PG) is the logit probability of PG, which equals 1 for Group 1 positions; equals 2 for Group 2 positions; and equals 3 for Group 3 positions; IAC is the cost of information asymmetry; QC measures relative quote competitiveness; SV is the natural log of trading volume of individual stock; and H denotes the HHI in thousands. Subscripts *i* and *j* denote position and stock, respectively. Five different measures of QC are introduced, including: (i) relative duration; (ii) relative spreads; (iii) relative inside quotes defined as the standardized number of quotes that are on the inside per day; (iv) relative inside improvements defined as the standardized number of quotes that improved the inside spread per day; and (v) relative depth on the inside. Because relative duration is used as the primary variable measuring quote competitiveness, Panel A summarizes the results with relative duration as QC and Panel B reports the results with all other QC variables. Figures in parenthesis are the *p*-values. The bottom figure in each cell is the marginal effect for one unit change of standard deviation from the mean with all other variables evaluated at their means.

Panel A.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
IAC	-1.4013 (.0466) < -.0173>	-1.4060 (.0481) < -.0170>	-1.5402 (.0311) < -.0187>	-1.6613 (.0215) < -.0201>	-1.6530 (.0222) < -.0200>
Relative Duration	-0.2237 (.0478) < -.0172>	-0.2933 (.0107) < -.0221>	-0.2923 (.0110) < -.0220>	-0.2882 (.0121) < -.0217>	-0.2894 (.0118) < -.0218>
Δ Relative Duration		-1.3072 (<.0001) < -.0933>	-1.3138 (<.0001) < -.0938>	-1.3071 (<.0001) < -.0934>	-1.3111 (<.0001) < -.0936>
H			0.1543 (.0345) < .0183>		0.0936 (.2993) < .0111>
SV				-0.0703 (.0317) < -.0188>	-0.0456 (.2596) < -.0122>
Max-rescaled R-Square	0.0042	0.0766	0.0789	0.0790	0.0796

Panel B.

	(1)	(2)	(3)	(4)
IAC	-1.5137 (.0373) < -.0178>	-1.7725 (.0141) < -.0222>	-1.5847 (.0304) < -.0172>	-1.7220 (.0195) < -.0236>
Relative Spreads	1.0087 (.0015) < .0279>			
ΔRelative Spreads	2.3772 (<.0001) < .0935>			
Relative InsideQuotes		-0.1106 (.4085) < -.0074>		
ΔRelative InsideQuotes		-1.0282 (<.0001) < -.0898>		
Relative InsideImprovements			-0.0024 (.9665) < -.0004>	
ΔRelative InsideImprovements			-0.7298 (<.0001) < -.1042>	
Relative Depth				0.5211 (.4521) < .0080>
ΔRelative Depth				-0.8874 (<.0001) < -.0689>
H	0.0729 (.4187) < .0084>	0.0950 (.2920) < .0117>	0.1613 (.0787) < .0171>	0.1378 (.1338) < .0184>
SV	-0.0532 (.1913) < -.0139>	0.0003 (.9933) < .0001>	-0.0188 (.6457) < -.0045>	-0.0096 (.8153) < -.0029>
Max-rescaled R-Square	0.0810	0.0642	0.1033	0.0359

Table 8. Classification of Entries and Exits

Panel A.

Positions	Characteristics	Competition Strategy
HH	Information asymmetry cost: High Quote competitiveness: High	quote-competition oriented
HL	Information asymmetry cost: High Quote competitiveness: Low	either uncompetitive quote competition oriented or preferencing oriented
LH	Information asymmetry cost: Low Quote competitiveness: High	quote-competition oriented
LL	Information asymmetry cost: Low Quote competitiveness: Low	preferencing oriented

Panel B.

Positions	# of Entries	# of Exits	Preferencing Reduced	Preferencing Sustained
HH	N_{HH}	C_{HH}	$A = N_{HH} - C_{HH} > 0$	$A = N_{HH} - C_{HH} < 0$
HL	N_{HL}	C_{HL}	$B = N_{HL} - C_{HL} < 0$	$B = N_{HL} - C_{HL} > 0$
LH	N_{LH}	C_{LH}	$C = N_{LH} - C_{LH} > 0$	$C = N_{LH} - C_{LH} < 0$
LL	N_{LL}	C_{LL}	$D = N_{LL} - C_{LL} < 0$	$D = N_{LL} - C_{LL} > 0$
Total entry or exit			$(A+C) + (B+D)>0$	$(A+C) + (B+D)<=0$ or $(A+C) + (B+D)>0$

Table 9. Information Asymmetry, Quote Competitiveness, and Frequency for Entries and Exits

IAC denotes the information asymmetry cost. Relative duration is the duration for a position standardized by mean duration of all positions in the same stock. HH includes positions in stocks with high IAC and quote aggressively; HL includes positions in stocks with low IAC and do not quote aggressively; LH includes positions in stocks with high IAC and quote aggressively; and LL includes positions in stocks with low IAC and do not quote aggressively.

Panel A

	Entries		Exits	
	IAC	Relative Duration	IAC	Relative Duration
HH	0.1675	1.28	0.1556	1.28
HL	0.1569	0.51	0.1623	0.63
LH	0.0723	1.38	0.0681	1.21
LL	0.0657	0.53	0.0542	0.54

Panel B

	Frequency for Entries	Frequency for Exits	Net Entries
HH	23	27	-4
HL	53	51	2
LH	24	40	-16
LL	69	59	10