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Can quote competition reduce preferenced trading? A reexamination of the SEC's 1997 order handling rules

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Abstract

In 1997, the SEC implemented the new order handling rules (OHRs) on the NASDAQ. We observe that some uncompetitive positions gained market share without improving quote competitiveness after the implementation of the OHRs. Also observed is a significant decline in the sensitivity of trading volume to quote competitiveness, indicating lower incentive for NASDAQ dealers to engage in quote competition in the post-OHR regime. We find that positions that gained trading volume without improving quote competitiveness were less competitive and were more closely associated with stocks showing low information asymmetry, which suggests that preferenced trading might be responsible for the decline in the trading volume sensitivity. Examining entries and exits around the periods of adopting OHRs, we observe net entry of uncompetitive positions and net exit of competitive positions, which indicates that preferenced trading crowded out quote competition subsequent to the OHRs. Our findings suggest that forcing intense quote competition alone produced an unwanted effect that preferencing emerged as a more attractive alternative to quote competition.

Key words: Preferenced trading; Quote competitiveness; Order flow competition; Order handling rules; Market reforms

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1. Introduction

Order flow competition is a major policy issue, especially in segmented stock markets. Fair and intense quote competition for order flow among market venues effectively promotes efficient price discovery. Over the years, the National Association of Securities Dealers Automated Quotations (NASDAQ) implemented several major market reforms to promote quote competition. Among these reforms, the new order handling rules (OHRs), imposed by the SEC in January 1997, produced profound impact by requiring the display of customer limit orders and the public dissemination of better prices placed in proprietary trading systems. Barclay *et al*. (1999) and Weston (2000) find that spreads and dealer rent declined and conclude that quote competition significantly improved subsequent to the adoption of the new rules.

One closely related issue is the regulation of preferenced trading because it serves as an alternative means of posting competitive quotes.[1] Over the years, widely practiced preferenced trading has faced a number of regulatory changes while evolving. The U.S. regulatory authorities have been reluctant to implement comprehensive regulations directly restricting preferenced trading. Instead, the Securities and Exchange Commission (SEC) has introduced gradual reform programmes to promote quote competition, hoping that preferenced trading declines as the market quality improves. Many academics believe that preferenced trading is detrimental to quote competition and market quality. Parlour and Rajan (2003) prove the harmful effect from a theoretical point of view, while Chung *et al*. (2004) provide the most direct evidence on the harmful effect of preferenced trading using proprietary data. Practitioners are equally concerned with the practice. A May 2010 online poll by *TheTradeNews.Com* shows that almost two-thirds of participants agreed that payment for order flow by trading venues distorts the market. A SEC (2000) study shows that specialists paid order routing firms for over 75 per cent of the retail options orders sent to them for execution. In her remarks before the 2006 Options Industry Conference, Elizabeth King of the U.S. SEC pointed out that preferenced trading had become more pervasive in the options markets than they were in 2000.[2] Ironically, the NYSE, which has been a major victim of preferenced trading for years, sought permission from the SEC to allow payment for order flow in February 2009.

Parlour and Rajan (2003) predict that in the presence of preferenced trading, the best strategy for nonpreferencing dealers is to imitate preferencing dealers. Therefore, when preferenced trading is prevalent, forcing more quote competition may result in more preferenced trading as nonpreferencing dealers may opt

[1] Preferencing can be in one of the two forms: payment for order flow and internalization. In this paper, we do not differentiate these two forms of preferencing.

[2] Refer to (http://www.sec.gov/news/speech/2006/spch050506ekk.htm).

for it. Although the OHRs were adopted by the NASDAQ almost 14 years ago, it is worthwhile to revisit this adoption because something more has yet to be performed. So far, academic studies examine the overall improvement in quote competition to conclude the success of the OHRs. We believe that this is not sufficient because seemingly improved quote competition does not show the whole picture.

In this paper, we examine whether the OHRs have enhanced the association between quote competitiveness and market share of trading volume. In a market where orders are routed to dealers quoting the best prices, there should be a strong correlation between market share of trading volume and quote competitiveness. If the OHRs successfully promote quote competition, this correlation should become stronger. Our investigation is well deserved given that an alternative strategy for order flow, preferenced trading, was prevalent at the time the OHRs were implemented. While it has been shown that more quote competition after the OHRs reduced spreads and economic rent, it is unclear whether the correlation between quote competitiveness and market share of trading volume was enhanced. This is an important issue because an enhanced correlation suggests greater incentive for dealers to engage in quote competition, whereas a reduced correlation suggests lower incentive for quote competition.

We find that the market share of trading volume, became less sensitive to quote competitiveness, suggesting a weaker incentive for dealers to compete for order flow using quote competition. We provide evidence that the observed change in the sensitivity is likely due to preferenced trading. We identify positions that gained percentage trading volume without improving quote competitiveness and positions that lost percentage trading volume with significantly improved quote competitiveness. We find that the former group of positions were associated with low quote competitiveness and low information asymmetry stocks, whereas the latter group of positions were significantly more competitive and less likely to be associated with low information asymmetry stocks. As low information asymmetry and low quote competitiveness are the characteristics of preferencing dealers, our findings are consistent with the notion that the observed weaker link between percentage trading volume, and quote competitiveness is attributable to preferenced trading.

An examination of entry and exit activities reveals a net entry of uncompetitive positions and a net exit of competitive positions around the implementation of the OHRs, suggesting that some quote-competition-oriented positions were forced out while preferenced trading became a more favourable strategy in the competition for order flow. This finding is consistent with the prediction by Parlour and Rajan (2003).

Our findings are not in conflict with those of Barclay *et al.* (1999) and Weston (2000). The finding of a weaker correlation between quote competitiveness and market share of trading volume can coexist with reduced spreads and dealer's rent. Preferenced trading is largely concentrated in small retail orders with low information content (Easley *et al.*, 1996; Bessembinder and Kaufman, 1997; and

Battalio and Holden, 2001). The low cost order flow gives preferencing dealers such an advantage over quote competition that preferencing dealers were able to pay significant amount to brokers to buy order flow. The payment for order flow by preferencing dealers was as high as 3.5 cents per share in the 1994–1995 period and remained at 2 cents per share subsequent to the OHRs (Kandel and Marx, 1999). This suggests that preferencing dealer's profitability was not seriously affected. As the OHRs reduced spreads and dealer's rent, quote competition for order flow became increasingly less attractive than preferenced trading. Therefore, we observe reduced spreads and at the same time the weaker sensitivity of percentage trading volume to quote competitiveness.

Our findings show that forcing more quote competition did not reduce preferenced trading. To the best of our knowledge, this is the only study that shows this paradoxical result that preferenced trading emerged as a more attractive alternative strategy over quote competition. Our study complements Odders-White (2004) who reports that the OHRs did not increase quote competition in the third market, which is a segment of the national market system where NYSE-listed stocks are traded on NASDAQ. In this paper, we highlight curious realities on the NASDAQ market. Our findings suggest that the single act of forcing more intensive quote competition alone is not the panacea for promoting quote competition in the presence of another competition strategy. These findings carry significant implications for policy makers.

The rest of the paper is organized in the following manner: Section 2 provides a review of the literature; Section 3 describes the data and the methodology; Section 4 presents the empirical findings; and Section 5 concludes the paper.

2. Literature review

Our paper contributes to the literature on the effects of the OHRs. Barclay *et al.* (1999) report that quoted and effective spreads are narrowed by approximately 30 per cent as a result of the OHRs. Weston (2000) observes that a decline in dealer's rent reduces trading costs. On the basis of these findings, Barclay *et al.* and Weston conclude that quote competition significantly improved after the adoption of the OHRs. Bessembinder (1999) also finds significantly reduced spreads on NASDAQ; however, the spreads are still wider than the spreads for a matched sample on the NYSE. Chung *et al.* (2002) report similar findings, which show that spreads are still wider for NASDAQ stocks than for NYSE-listed stocks after the OHRs. In contrast, Odders-White (2004) reports that both quoting frequency and quote quality are worse in the post-OHR period in the third market. Her findings have important implications as she demonstrates that the impact of OHRs is not uniformly benign.

Our study is also closely related to the existing literature on preferenced trading. Christie and Schultz (1994) believe that the absence of odd-eighth quotes for the majority of actively traded NASDAQ stocks is explained by an implicit agreement among NASDAQ dealers. Godek (1996), Dutta and

Madhavan (1997), and Kandel and Marx (1999) argue that the practice of preferencing allows implicit collusion by dealers. Huang and Stoll (1996) and Bessembinder (1999) attribute the higher spreads on NASDAQ to preferenced trading. Bloomfield and O'Hara (1998), Ackert and Church (1999), and Kluger and Wyatt (2002) report that preferencing leads to higher spreads, a lower incentive to narrow spreads and a greater likelihood of tacit collusion on the basis of laboratory experiments. Chung *et al.* (2002) find that the spread is positively related to the proportion of internalized volume. Parlour and Rajan (2003) model the competition among dealers for liquidity provision. Their model predicts that when a payment is received for order flow, spreads will widen and the brokerage commissions will decline; however, the total cost will be higher for limit orders.[3]

The literature debates whether a reduction in the dealers' profit margin could significantly reduce preferenced trading. Kandel and Marx (1999) and Choridia and Subramanyam (1995) predict that declining profit margins would reduce preferenced trading. In contrast, Easley *et al.* (1996) and Bessembinder and Kaufman (1997) propose a 'cream skimming' hypothesis, and Battalio and Holden (2001) offer a 'sorting' hypothesis. Each of these hypotheses argues that preferencing could survive a reduction in profit margin because preferencing-oriented dealers obtain order flow with lower information costs. Kandel and Marx (1999) report that the payment for order flow is as high as 3.5 cents per share in the period between 1994 and 1995, and it remains at 2 cents per share after the OHRs. Consistent with Battalio and Holden (2001), Parlour and Rajan (2003) predict that spreads will widen to compensate for the payment with the practice of payment for order flow. Chung *et al.* (2004) report that further decline in spreads triggered by decimalization is unable to reduce the level of preferenced trading. The magnitude of reduction is only 3 per cent. The small amount of reduction in preferenced trading provides an indirect support of the 'cream skimming' hypothesis as well as the 'sorting' hypothesis. Moreover, Chung *et al.* (2004) report that an average of 80 per cent of all volumes on the NASDAQ was preferenced prior to decimalization. Huang *et al.* (2010) find that preferenced trading in NYSE listed stocks declined as much as 22 per cent over a 1-year period around decimalization. Although the magnitude of decline they report is far greater than

[3] Researchers are not unanimous on the impact of preferenced trading. Battalio (1997), Battalio *et al.* (1997), and Peterson and Sirri (2003) find evidence suggesting that preferenced trading does not affect market quality. The debate on the impact from preferenced trading is extended to the aspects beyond execution cost. Battalio *et al.* (2001) examine net trading cost and find no difference between preferencing and non-preferencing dealers. Battalio *et al.* (2003) show that nonprice dimensions of execution quality are better for preferenced trades, therefore, they argue that price-based market quality may be misleading. However, Parlour and Rajan (2003) show that consumer and social welfare will reduce under payment for order flow.

the decline reported by Chung *et al.* (2004) for NASDAQ stocks, both studies suggest that preferenced trading survived decimalization.

3. Methodology and data description

3.1. Relative quote competitiveness and market share

We consider *relative quote competitiveness* (RQC) to capture the quote competitive strength for a position (dealer-stock) relative to its competitors. These relative measures capture a more precise picture on the changes in competitiveness while absolute measures cannot. Three variables are employed to measure the RQC: (i) spread defined as quoted spread divided by the quoted mid-point; (ii) depth defined as the average number of shares quoted on inside bids and asks; and (iii) duration defined as the average number of minutes per day that a position's quote stays on inside bids and asks. A generic definition of the RQC is shown in Equation (1):

$$\mathrm{RQC}_{ij} = \frac{\mathrm{QC}_{ij}}{\left(\sum_{i=1}^{n} \mathrm{QC}_{ij}\right) \Big/ N_j} \tag{1}$$

where, RQC_{ij}, relative quote competitiveness for dealer i in stock j; QC_{ij}, quote competitiveness measure for dealer i in stock j; and N_j, number of dealers in stock j.

We measure a position's market share of trading volume using the percentage trading volume as defined by Equation (2):

$$\mathrm{PTV}_{ij} = \frac{\mathrm{TV}_{ij}}{\sum_{i=1}^{n} \mathrm{TV}_{ij}} \tag{2}$$

where, PTV_{ij}, percentage trading volume for dealer i in stock j; and TV_{ij}, total trading volume for dealer i in stock.[4]

3.2. Sample selection and data description

The OHRs were implemented in phases rather than in a single market-wide event. Our data include 100 stocks that were brought under the new rules in the

[4] The relative spread and relative depth are calculated across quotes in each trading day and then averaged across the days in each period. The relative duration is calculated daily and then average across days in each period, whereas market share of trading volume is calculated across the pre- and post-OHR periods.

first two batches. The first batch began trading under the new rules on 20 January 1997; the second batch began trading under the new rules on 10 February 1997. The source of tick-by-tick trade and quote data is NASTRAQ CDs. The pre-OHR periods are from 1 November 1996 through 19 January 1997 for the first batch of stocks and from 1 November 1996 through 9 February 1997 for the second batch of stocks. The post-OHR periods are from 21 January 1997 to 28 February 1997 for the first batch of stocks and from 11 February 1997 to 28 February 1997 for the second batch of stocks. We obtain the share volume data from the NASDAQ Monthly Activity Report. This monthly publication reports the total share volume for each dealer in each stock. Owing to the constraint on data availability, the total share volume in the last quarter of 1996 is considered to be the pre-OHR period volume, and the total share volume observed for the period from March 1997 to May 1997 is considered to be the post-OHR period 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 2 months in the last quarter of 1996; and (iii) share volume data for at least 2 months during the period from March 1997 to May 1997. A total of 97 stocks meet these criteria, and these stocks involve 2376 positions. Because NASDAQ dealers can enter and exit the market making business for a stock virtually freely in a matter of days, identifying entries and exits around the OHRs is not a simple task. We use the following rules to identify entries and exits.

1 Positions that existed only in the post-OHRs period are classified as entries and positions that existed only in the pre-OHRs period are classified as exits.
2 Positions that report quotes in both pre- and post-OHRs periods but report no share volume in the pre-OHRs period are considered to be entries, while positions that report quotes in both periods but report no share volume in the post-OHRs period are considered to be post-OHRs period exits.
3 Six positions that entered and then exited the market around the reform during a very short period of time are excluded.

Following these rules, 352 of the 2376 positions are identified as new entries and exits with 177 exits and 169 entries.

4. Empirical findings

4.1. Absolute quote competitiveness, market share and market concentration

Table 1 reports the absolute quote competitiveness, percentage trading volume, market concentration, and changes in these variables to facilitate the comparison with Barclay *et al.* (1999) and Weston (2000) and to contrast with the RQC statistics summarized in Table 2. In the post-OHR period, the mean

Table 1
Absolute quote competitiveness, percentage share volume and market concentration

			Changes			
	Before	After	Mean	25th percentile	Median	75th percentile
Spread	2.16	2.05	−0.12***	−0.31	−0.02***	0.19
Depth	9.99	9.81	−0.18*	−1.30	−0.17***	0.30
Duration	169.51	133.00	−36.51***	−70.39	−35.30***	−4.71
Improvement (%)	25.60	19.81	−5.79***	−9.61	−4.54***	−1.71
PTV	4.33%	4.06%	−0.27***	−0.94	−0.09***	0.72
HHI	1155.40	941.89	−81.77***	−71.54	2.41***	38.05

The asterisks indicate significance for *t*-test (signed rank test) of the mean (median) equalling zero. ***Significance at 1 per cent level, **Significance at 5 per cent level and *Significance at 10 per cent level. Spread is measured by quoted spread divided by quoted middle point. Depth is the average number of shares quoted for inside bid and ask prices. Duration is defined as the average number of minutes per day a position's quotes stay on the inside. Improvement is per cent of trades receiving price improvement. PTV is the 3-month total trading volume for a position as a per cent of total trading volume by all positions in the same stock. HHI is the Hirschman–Herfindahl Index.

quoted spread declined from 2.16 per cent to 2.05 per cent. The decline in the quoted spread amounts to only 11 basis points. The mean depth on the inside declined marginally by 18 basis points and was significant only at the 10 per-cent level. Duration declined by 36.51 per cent or 22 per cent. As the competition intensified, inside bid and ask prices became more frequently revised; hence, on average, the length of time quotes remained on the inside declined. Consistent with Barclay *et al.* (1999) and Weston (2000), the changes in all three absolute quote competitiveness measures indicate the existence of a more intense quote competition on NASDAQ after the OHRs were introduced. The average PTV declined significantly from 4.33 per cent in the pre-OHR period to 4.06 per cent in the post-OHR period, which suggests that the reform intensified the competition for order flow. This is confirmed by the lower Herfindahl–Hirschman Index (HHI), which measures market concentration and is consistent with Weston (2000).[5]

Following Bessembinder (2003), we define price improvement as the per cent of trades completed inside the best bid and ask prices. On average, 25.6 per cent of trades enjoyed price improvement in the pre-OHR period, but this percentage declined to 19.81 per cent in the post-OHR period.[6] This decline is significant when the difference is tested using both mean and median values. The decline in price improvement suggests deterioration in market quality, which contradicts the evidence documented by Barclay *et al.* (1999) and Weston (2000).

[5] The HHI is defined as the sum of squared market share over all positions.

[6] The post-OHRs price improvement of 19.81 per cent is comparable to the 20.12 per-cent price improvement for the NASDAQ before decimalization (Bessembinder, 2003).

Table 2
Changes in relative quote competitiveness and percentage trading volume

	Quintile 1 (least competitive)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (most competitive)
Relative spread					
Before	1.1237	0.9920	0.9723	0.9525	0.9178
After	1.1176	0.9803	0.9423	0.8810	0.8721
Δ	−0.0233	−0.0170	−0.0297***	−0.0730***	−0.0332***
Δ PTV	0.0098**	−0.1982*	−0.1020**	−0.2341***	−0.1511**
Relative depth					
Before	0.9702	0.9942	0.9997	1.0017	1.0184
After	0.9108	0.9748	1.0223	1.0158	1.0531
Δ	−0.0618***	−0.0211***	0.0228	0.0141*	0.0129*
Δ PTV	−0.0579	−0.0067	−0.0805	−0.2341***	−0.1604*
Relative duration					
Before	0.4721	0.9096	1.0705	1.1953	1.3995
After	0.4385	0.9028	1.0131	1.1704	1.5055
Δ	−0.0068	0.0026	−0.0481**	−0.0257	0.0526***
Δ PTV	−0.0022	−0.1454	−0.1271**	−0.2000***	−0.2432**

The asterisks indicate significance for signed rank test of the null hypothesis that the medium equals zero. ***Significance at 1 per cent level, **Significance at 5 per cent level and *Significance at 10 per cent level. This table reports medians in the level and change in relative quote competitiveness and change in PTV around the implementation of the order handling rules (OHRs). Spread is quoted spread divided by quoted middle point. Depth is the average number of shares quoted for inside bid and ask prices. Duration is defined as the average number of minutes per day a position's quotes stay on the inside. Relative Spread, Relative Depth and Relative Duration are computed based on Equation (1):

$$\mathrm{RQC}_{ij} = \frac{\mathrm{QC}_{ij}}{\left(\sum_{i=1}^{n} \mathrm{QC}_{ij}\right) \Big/ N_j} \tag{1}$$

Subscripts i and j denote market maker i and stock j, respectively. RQC is the relative quote competitiveness; QC is the absolute quote competitiveness measure; and N is the number of dealers in the same stock. PTV is percentage trading volume, defined as 3-month total trading volume for a position as a per cent of total trading volume by all positions in the same stock. Positions quintiles are based on the ranking of pre-OHR RQC measures.

4.2. Changes in relative quote competitiveness and percentage trading volume

Table 2 presents median values of RQC, ΔRQC and ΔPTV for position quintiles sorted by each of the RQC measures. All positions are sorted based on pre-OHR RQC. Quintile 1 contains the least competitive positions, while quintile 5 includes the most competitive positions.

When relative spread is used to sort the positions, quintile 5 positions have a median value of 0.9178 before the reform and 0.8721 after the reform. This means that the postreform quoted spreads for these positions were 8.22 per cent and 12.79 per cent below the average spread, respectively, indicating above

average competitiveness and further improvement in quote competitiveness after the OHRs were implemented. Nevertheless, PTV for quintile 5 positions declined 15.11 per cent. In contrast, uncompetitive positions in quintile 1 show insignificant improvement in relative competitive strength but a significant increase in PTV. Obviously, the increased PTV is not driven by the change in quote competitiveness. Positions in quintiles 2, 3 and 4 show improvements in quote competitiveness, but their PTVs also declined like quintile 5 positions.

When sorting is performed using relative depth, the most competitive quintile 5 positions exhibit improvement in competitiveness. However, they experienced a loss of PTV of 16.04 per cent. The least competitive quintile 1 positions show deterioration in competitiveness and a loss of PTV, but the PTV loss was much smaller than that of quintile 5 positions.

When relative duration is used to sort positions, the most competitive quintile 5 positions show the largest improvement in competitiveness, but their PTV declined by 24.32 per cent. In contrast, the least competitive quintile 1 positions maintained PTV without significant improvement in competitiveness.

4.3. Percentage trading volume sensitivity to quote competitiveness

Table 2 clearly illustrates that the changes in quote competitiveness and the changes in market share of trading volume are delinked. We conduct a formal test as to whether there is a decline in PTV sensitivity to quote competitiveness using Equation (3):

$$\begin{aligned} \mathrm{PTV}_{ij} = {} & a_0 + a_1 \mathrm{RQC}_{ij} + a_2 D_{ij} + a_3 (\mathrm{RQC}_{ij} * D_{ij}) + a_4 \mathrm{LNT}_j \\ & + a_5 H_j + a_6 (H_j * \mathrm{RQC}_{ij}) \\ & + a_7 (H_j * \mathrm{RQC}_{ij} * D_{ij}) + \varepsilon_{ij}, \end{aligned} \tag{3}$$

where, PTV is percentage share trading volume; RQC is one of the three RQC measures; D is a dummy variable, which is assigned 1 if the observation belongs to the postreform period and 0 otherwise; LNT is the log value of average daily number of trades of individual stock; and H is a dummy variable, which is assigned 1 if HHI is ≥1800. The U.S. Department of Justice uses a cut-off value of 1800 when evaluating market concentration. Markets with HHI > 1800 are considered to be concentrated.[7] LNT is used to control for the liquidity effect and the HHI dummy variable is included to control for the impact from market concentration. The coefficient of RQC measures the sensitivity of share volume

[7] Smith (1998) observes the effects of the OHR changes and 16ths on the trading characteristics of stocks with different levels of liquidity. Klock and McCormick (2002) find that share volume sensitivity is greater for stocks with low market concentration while Chung *et al*. (2002) report the opposite.

to quote competitiveness in the prereform period, whereas the coefficient of the interaction terms (RQC*D) measures the change in the sensitivity in the postreform period. The coefficient of (H*D*RQC) captures the difference in the change in share volume sensitivity between high HHI stocks and low HHI stocks.

Regression results using the duration as the RQC measure are reported in Table 3. The coefficients for RQC and H*RQC are positive and significant in all regressions indicating that competitive quotes do increase share volume under both market concentration levels. The coefficient for RQC*D is significantly negative, indicating a reduced PTV sensitivity to quote competitiveness post-OHRs. The coefficient for H*D*RQC is negative but insignificant, suggesting that the reduction in PTV sensitivity for high HHI stocks is not different from low HHI stocks. Thus, the regression results confirm the results from Table 2 that PTV sensitivity to quote competitiveness declined after the implementation of the OHRs.[8]

4.4. Is the reduction in share volume sensitivity because of preferenced trading?

As the univariate statistics in Table 2 imply, preferenced trading emerges as the only plausible explanation for those positions that gained or maintained PTV without improving quote competitiveness because preferencing dealers do not need to post competitive quote to attract order flow. To provide stronger evidence, we identify those positions whose increase in PTV cannot be explained by their changes in quote competitiveness. An association of these positions with preferencing characteristics would provide evidence that is consistent with the notion that the decline in PTV sensitivity is attributed to preferenced trading.

We select the positions that gained PTV and were ranked among bottom 40 per cent by the changes in RQC. These positions (Group 1) are suspected to engage in preferenced trading. We also select positions that lost PTV but were ranked among top 40 per cent by the changes in RQC. It is unlikely that these positions (Group 2) engage in preferencing trading. Group 2 is used as a control group to be compared with Group 1.

We consider two preferencing characteristics: (i) low quote competitiveness and (ii) low information asymmetry. Because preferencing positions do not rely on competitive quotes to attract order flow, it is only natural to expect low quote competitiveness for these positions. This is consistent with the empirical evidence from market microstructure literature. The cream skimming hypothesis (Easley *et al.,* 1996; Bessembinder and Kaufman, 1997) and the 'sorting' hypothesis (Battalio and Holden, 2001) imply that preferencing dealers prefer positions in the stocks with low information asymmetry cost (IAC). Therefore, if Group 1 positions are indeed preferencing positions, they should be more closely

[8] Regression results based on relative quoted spreads and relative quote depth are not reported but are qualitatively the same as the results shown in Table 3.

Table 3
Order flow sensitivity to quote competitiveness

	1	2	3	4	5
Intercept	6.6143 (<0.0001)	−2.3817 (<0.0001)	−1.7105 (<0.0001)	−1.7078 (<0.0001)	5.7968 (<0.0001)
RQC	6.2478 (<0.0001)	6.1745 (<0.0001)	5.5193 (<0.0001)	5.5104 (<0.0001)	5.5358 (<0.0001)
D	1.9330 (<0.0001)	2.0292 (<0.0001)	1.6889 (<0.0001)	1.6878 (<0.0001)	1.7207 (<0.0001)
RQC**D*	−2.0214 (<0.0001)	−2.0231 (<0.0001)	−1.6970 (<0.0001)	−1.6834 (<0.0001)	−1.6527 (<0.0001)
LNT	−1.3319 (<0.0001)				−1.1384 (<0.0001)
H		7.0069 (<0.0001)	−8.1741 (<0.0001)	−8.2572 (<0.0001)	−10.8886 (<0.0001)
*H**RQC			14.6195 (<0.0001)	14.8012 (<0.0001)	15.0290 (<0.0001)
*H***D**RQC				−0.3512 (0.6273)	−0.6884 (0.3134)
Adjusted R^2	0.2779	0.2229	0.2620	0.2619	0.3424

The following regression model is used to test the first hypothesis:

$$\begin{aligned} \mathrm{PTV}_{ij} = & a_0 + a_1 \mathrm{RQC}_{ij} + a_2 D_{ij} + a_3 (\mathrm{RQC}_{ij} * D_{ij}) + a_4 \mathrm{LNT}_j + a_5 H_j + a_6 (H_j * \mathrm{RQC}_{ij}) \\ & + a_7 (H_j * \mathrm{RQC}_{ij} * D_{ij}) + \varepsilon_{ij}, \end{aligned} \tag{3}$$

where, subscripts *i* and *j* denote position and stock, respectively; PTV is percentage trading volume by position *i* in stock *j*; RQC is relative quote competitiveness; *D* is a dummy variable, which is assigned 1 if the observation belongs to the postreform period and 0 otherwise; LNT is logged average daily number of trades; and *H* is Herfindahl–Hirschman Index (HHI) dummy variable, which is assigned 1 if HHI is ≥1800. Relative duration is used as the RQC. Figures in parenthesis are the *p*-values.

Table 4
Pre-order handling rule relative quote competitiveness (RQC) and information asymmetry cost (IAC)

	N	Relative spread	Relative depth	Relative duration	IAC
RQC used in sorting = relative spread					
Group 1	325	0.9780	0.9991	1.0130	0.0803
Group 2	391	0.9594***	0.9997	1.1177***	0.0907**
RQC used in sorting = relative depth					
Group 1	345	0.9817	0.9968	0.9570	0.0754
Group 2	414	0.9643***	0.9999***	1.1472***	0.1029***
RQC used in sorting = relative duration					
Group 1	310	0.9794	0.9985	1.0590	0.0782
Group 2	356	0.9672***	0.9998**	1.0986*	0.0930***

The asterisks indicate significance level for the Wilcoxon two-sample test of equal medians between Group 1 positions and Group 2 positions. This table reports median RQC and IAC for two categories of positions identified as follows. Group 1 positions gained PTV and were ranked among bottom 40 per cent by the changes in RQC. Group 2 positions lost PTV and were ranked among top 40 per cent by the changes in RQC Spread is quoted spread divided by quoted middle point. Depth is the average number of shares quoted for inside bid and ask prices. Duration is defined as the average number of minutes per day a position's quotes stay on the inside. Relative Spread, Relative Depth and Relative Duration are computed based on Equation (1).

associated with low IAC stocks. To measure IAC, we use the Huang and Stoll (1996) approach by subtracting the realized spread from the effective spread. The average effective spread and the realized spread are calculated for each stock across all observations using the last 2 months of trades in 1996.[9] We compute an equally weighted average of IACs at the bid and ask price locations.

Table 4 reports the median values of RQC and IAC. The number of positions varies depending on which proxy variable for RQC is used to create the two groups. Group 1 positions show significantly higher spread, lower depth and shorter durations than Group 2 positions, suggesting that Group 1 positions are significantly inferior in quote competitiveness. At the same time, Group 1 positions also display a significantly lower IAC than Group 2 positions. Lower RQC and lower IAC of Group 1 positions suggest that these positions are preferencing positions, supporting the notion that the decline in PTV sensitivity after the OHRs is attributed to preferenced trading.

We further confirm that Group 1 positions are characterized by low RQC and low IAC using a binary logistic regression Equation (4):

$$P(\mathrm{PG}_{ij}) = a + a_1\mathrm{IAC}_j + a_2\mathrm{RQC}_{ij} + a_3\mathrm{HHI}_j + a_4\mathrm{LNT}_j + \varepsilon_{ij}, \quad (4)$$

[9] Effective spread average about \$0.26 across all stocks. Realized spread is calculated for each stock at each price location using a 5-min interval. Average realized spread at bid and ask is \$0.16 and \$0.13, respectively. The average cost of asymmetric information is about \$0.10 at the bid price and \$0.12 at the ask price.

where P(PG) is the logit probability of PG, which equals 1 for Group 1 positions and 0 for Group 2 positions, and subscripts i and j denote dealer and stock, respectively. IAC is the information asymmetry cost of a stock, and RQC is the relative quote competitiveness before the OHRs are introduced. HHI and LNT are the Herfindahl–Hirschman Index and the natural log of trading volume per day before the reform. Table 5 shows that estimated correlations are significant among RQC and ΔRQC variables. In the presence of significant correlations between each of RQC variable and its own changes, we take special care in running regression Equation (4). For example, when changes in relative spread is used to identify Group 1 and Group 2 positions, relative spread is not admitted as an independent variable.

Table 6 reports logistic regression results. The first two columns report the results when the changes in the relative spread are used to construct Groups 1 and 2. The middle two columns report results when the changes in the relative depth are used for group sorting, and the last two columns present the results when the changes in relative duration is used for group sorting. Across the regressions, the estimated coefficients for relative depth and relative duration are all negative and mostly significant, whereas the coefficient for relative spread is significantly positive. This suggests that Group 1 positions tend to be less competitive than Group 2 positions. The estimated coefficients for IAC are significantly negative in all regressions; this suggests that a low IAC is more likely to be associated with Group 1 positions.

To summarize, Group 1 positions exhibit significantly lower RQC and closer association with low IAC stocks. This evidence suggests that Group 1 positions are likely preferencing positions.

4.5. Entries and exits of market makers

As the PTV sensitivity to quote competitiveness declined, dealers had less incentive to engage in quote competition. One consequence would be exits of quote competition dealers and entries of preferenced dealers. We examine entries and exits around the implementation of the OHRs to assess the impact of OHRs on dealer's preference over alternative competition strategies.

We sort entries and exits into four groups based on the level of their relative duration and the IAC of the stock involved: (i) high IAC and high relative duration, (ii) high IAC and low relative duration, (iii) low IAC and high relative duration and (iv) low IAC and low relative duration.[10] The cut-off point for high and low relative duration is 100 per cent and the cut-off point for IAC is 0.11.

Panel A of Table 7 reports mean IAC and mean relative duration for the four groups of entries and four groups of exits. Panel B reports the frequency of

[10] We use the other two RQC measures to replace relative duration in the analysis. The results are similar and are not reported.

Table 5
Correlations among relative quote competitiveness (RQC) and change in RQC variables

	ΔRelative spread	ΔRelative depth	ΔRelative duration	Relative spread	Relative depth	Relative duration
ΔRelative spread	1	−0.1629 (< 0.0001)	−0.5558 (< 0.0001)	−0.1543 (< 0.0001)	0.0458 (0.0392)	−0.1131 (< 0.0001)
ΔRelative depth	−0.1629 (< 0.0001)	1	0.2042 (< 0.0001)	−0.0926 (< 0.0001)	0.0098 (0.6585)	0.2634 (< 0.0001)
ΔRelative duration	−0.5558 (< 0.0001)	0.2042 (< 0.0001)	1	−0.0630 (0.0046)	0.0098 (0.6596)	−0.0392 (0.0781)
Relative spread	−0.1543 (< 0.0001)	−0.0926 (< 0.0001)	−0.0630 (0.0046)	1	−0.2860 (< 0.0001)	−0.4914 (< 0.0001)
Relative depth	0.0458 (0.0392)	0.0098 (0.6585)	0.0098 (0.6596)	−0.2860 (< 0.0001)	1	0.2051 (< 0.0001)
Relative duration	−0.1131 (< 0.0001)	0.2634 (< 0.0001)	−0.0392 (0.0781)	−0.4914 (< 0.0001)	0.2051 (< 0.0001)	1

This table reports correlations for the RQC and ΔRQC variables. Spread is quoted spread divided by quoted middle point. Depth is the average number of shares quoted for inside bid and ask prices. Duration is defined as the average number of minutes per day a position's quotes stay on the inside. Relative spread, Relative depth and Relative duration are computed using Equation (1).

Table 6
Logistic regressions

RQC used in sorting	Relative spread		Relative depth		Relative duration	
Intercept	5.7147 (0.0015)	6.6630 (< 0.0001)	−2.1913 (0.1968)	4.6571 (0.0028)	−1.1311 (0.5076)	2.8439 (0.1134)
IAC	−3.8743 (0.0052)	−4.0381 (0.0042)	−7.8173 (< 0.0001)	−8.2950 (< 0.0001)	−3.7089 (0.0078)	−3.5097 (0.0109)
Relative spread			4.5951 (< 0.0001)		3.1312 (0.0002)	
Relative depth	−0.0064 (0.9945)					−0.7629 (0.4871)
Relative duration		−0.9892 (< 0.0001)		−2.1962 (< 0.0001)		
HHI	0.2112 (0.2294)	0.2272 (0.2025)	0.0128 (0.9352)	0.0099 (0.9516)	−0.0186 (0.9089)	−0.0380 (0.8141)
LTV	−0.3167 (< 0.0001)	−0.3143 (< 0.0001)	−0.1022 (0.1756)	−0.1018 (0.1967)	−0.0983 (0.1955)	−0.1043 (0.1666)
Max-rescaled R^2	0.0777	0.1174	0.1278	0.2177	0.0484	0.0164

This table reports results from binary logistic regression model as follows.

$$P(\mathrm{PG}_{ij}) = a + a_1\mathrm{IAC}_j + a_2\mathrm{RQC}_{ij} + a_3\mathrm{HHI}_j + a_4\mathrm{LNT}_j + \varepsilon_{ij}, \tag{4}$$

Subscripts i and j denote market maker i and stock j, respectively. P(PG) is the logit probability of PG, which equals 1 for Group 1 positions and equals 0 for Group 2 positions; Group 1 positions gained PTV and were ranked among bottom 40 per cent by the changes in RQC. Group 2 positions lost PTV and were ranked among top 40 per cent by the changes in RQC. Information asymmetry cost (IAC) is the cost of information asymmetry; RQC is relative quote competitiveness; LTV is the natural log of trading volume before the reform; and HHI is the Herfindahl–Hirschman Index before the reform. Figures in parenthesis are the p-values.

Table 7
Entries and exits

Panel A

		Entries		Exits	
Relative duration	Information asymmetry	Relative duration	IAC	Relative duration	IAC
High	High	1.28	0.1675	1.28	0.1556
High	Low	1.38	0.0723	1.21	0.0681
Low	High	0.51	0.1569	0.63	0.1623
Low	Low	0.53	0.0657	0.54	0.0542

Panel B

Relative duration	Information asymmetry	Entry	Exit	Net entries/ exits
High	High	23	27	−4
High	Low	24	40	−16
Low	High	53	51	2
Low	Low	69	59	10

Duration is defined as the average number of minutes per day a position's quotes stay on the inside. Relative Duration is positions' duration standardized by the average duration across positions in the same stock. Information asymmetry cost (IAC) greater than or equal to the sample average of $0.11 is considered to be high and is considered to be low if otherwise. Relative Duration is considered to be higher if it is ≥1 and is considered to be low if otherwise.

entries and exits. A net exit is observed for positions with high relative duration, whereas a net entry is observed for positions with low relative duration. Moreover, the net exit for the two competitive groups (groups with high relative duration) and the net entry for the two uncompetitive groups (groups with low relative duration) are mostly in the low IAC stocks. This is consistent with preferencing becoming more prevalent in the post-OHR period, which provides further support to our earlier claim that preferenced trading is responsible for the reduced PTV sensitivity to quote competitiveness.

4.6. Robustness in the presence of quotes from limit orders

Prior to the reform, inside quotes reflected a dealer's best prices and our quote competitiveness measures were built on dealers' quotes. In the post-OHR period, however, inside quotes may be taken from limit orders; thus, the post-OHR quote competitiveness measures may no longer accurately reflect the dealer's quote competitiveness. Consequently, the comparison of pre- and post-OHR quote competitiveness is not a simple matter in the presence of limit order book

orders. In this section, we test the robustness of our results by taking into account of the impact from limit order quotes.

Traditionally, NASDAQ dealers rarely compete on depth. Prior to the reform, NASDAQ dealers were required to quote a minimum size of 500 or 1000 shares. The inside quote data during the last 2 months in 1996 indicates that nearly 100 per cent of the inside quotes were at the required minimum quote size. When the first batch of 50 stocks began trading under the new rules, the minimum quote size was lowered to 100 shares. However, the minimum quote size for the second batch of 50 stocks, which was brought under the new rules on 2 October 1997, was maintained at the original quote size of either 500 or 1000 shares. A sample of 45 stocks from the second batch (in which dealers had to quote at least 1000 shares) was selected, and the frequency distributions of inside quotes at different depths are shown in Table 8. Prior to the reform, 99.94 per cent of inside bids and 100 per cent of inside asks have a quoted depth at the required minimum size of 1000 shares. Subsequent to the reform, however, approximately 10 per cent of these quotes were for <1000 shares, 82 per cent were exactly 1000 shares, 7 per cent were between 1000 and 5000 shares, and 1 per cent of quotes were for 5000 shares or more.

As dealers in these 45 stocks are required to quote at least 1000 shares, inside quotes offering <1000 shares are safely assumed to be limit orders.

Table 8
Frequency distribution of quotes on the inside at different depth

Depth	Before		After	
Panel A: Bid side				
100	0	0.00%	641	2.62%
(100, 500)	0	0.00%	722	2.95%
500	0	0.00%	565	2.31%
(500, 1000)	0	0.00%	428	1.75%
1000	15 094	99.94%	20 252	82.78%
(1000, 5000)	8	0.05%	1654	6.76%
(5000, ∞)	1	0.00%	202	0.83%
Panel B: Ask side				
100	0	0.00%	486	2.04%
(100, 500)	0	0.00%	669	2.80%
500	0	0.00%	541	2.27%
(500, 1000)	0	0.00%	507	2.12%
1000	14 298	100.00%	19 541	81.92%
(1000, 5000)	0	0.00%	1854	7.77%
(5000, ∞)	0	0.00%	256	1.07%

Panel A compares frequency distribution of inside quotes per day at different depths before and after the reform. Panel B compares daily duration for inside quotes at different depths. The sample is 45 stocks that were brought under the order handling rule in February 1997 and in which dealers were required to quote at least 1000 shares.

Table 9
Trading volume sensitivity to adjusted RQC

	RQC = adjusted relative duration
Intercept	6.3138 (<0.0001)
RQC	5.4574 (<0.0001)
D	2.8662 (<0.0001)
RQC**D*	−2.3285 (<0.0001)
LNT	−1.2656 (<0.0001)
H	−8.3664 (<0.0001)
*H**RQC	11.2195 (<0.0001)
*H***D**RQC	4.2591 (0.011)
Adjusted R^2	0.2938

This table reports regression results using model (3) with positions in 45 stocks that were brought under the order handling rules in February 1997 and in which market makers were required to quote at least 1000 shares. RQC is relative quote competitiveness; *D* is a dummy variable, which is assigned 1 if the observation belongs to the postreform period and 0 otherwise; Adjusted RQC is based on quotes with depth of 1000 shares; LNT is logged average daily number of trades; and *H* is Herfindahl–Hirschman Index (HHI) dummy variable, which is assigned 1 if HHI is ≥1800. Figures in parenthesis are the *p*-values.

Moreover, there has been no evidence to suggest that dealers began competing vigorously on depth after the new rules were implemented. Thus, post-OHR inside quotes >1000 shares were also likely to be limit orders. On the basis of this observation, we have limited our calculation of quote competitiveness to quotes with 1000 shares; this limitation has been set only to test the robustness of our results. This does not completely eliminate all limit orders from our analysis; however, by limiting ourselves to quotes with the 1000 share depth in these 45 stocks, we should be able to substantially mitigate the bias caused by limit orders.

Tables 9 and 10 present regression results based on adjusted relative duration.[11] In Table 9, the coefficient for RQC**D* is significantly negative, suggesting decrease in percentage trading volume sensitivity to quote competitiveness for low HHI stock. The coefficient for *H***D**RQC is significantly negative, suggesting the decline in sensitivity for high HHI stocks is significantly less than the decline in low HHI stocks; Table 10 shows that Group 1 positions are less competitive than Group 2 positions, and the IAC is lower for Group 1 positions than Group 2 positions. Overall, results based on adjusted RQC are qualitatively the same as results based on unadjusted RQC. Therefore, we

[11] Relative depth is not used in the robustness tests because we are using inside quotes with 1000 share depth only. Results based on relative spread are not reported to save space but are qualitatively the same as results based on relative duration.

Table 10
Logistic regressions with adjusted post-order handling rule (OHR) relative quote competitiveness (RQC)

	RQC = adjusted relative duration
Intercept	−4.5577 (0.0658)
IAC	−3.1507 (0.0927)
Relative spread	0.0434 (0.0005)
HHI	0.0650 (0.7714)
LTV	0.0235 (0.8268)
Max-rescaled R^2	0.0736

This table reports results for binary logistic regression model (4). Positions in the 45 stocks that were brought under the OHRs in February 1997 and in which market makers were required to quote at least 1000 shares are ranked based on change in PTV and change in adjusted RQC. Group 1 positions gained PTV and were ranked among bottom 40 per cent by the changes in adjusted RQC. Group 2 positions lost PTV and were ranked among top 40 per cent by the changes in adjusted RQC. Adjusted RQC is based on quotes with depth of 1000 shares. Information asymmetry cost (IAC) is the cost of information asymmetry; LTV is the logged trading volume before the reform; and HHI is the Herfindahl–Hirschman Index before the reform. Figures in parenthesis are the *p*-values.

conclude that our results remain robust after controlling for impact from limit orders.[12]

5. Conclusions

In this paper, we extend the studies by Barclay *et al.* (1999) and Weston (2000) on the effect of the OHRs implemented by the SEC in 1997. Our evidence suggests that while spreads and dealers' rent declined after the OHRs, dealer's market share of trading volume became less sensitive to quote competitiveness. This indicates that quote competitiveness and market share of trading volume became delinked. We attribute this unusual phenomenon to the dominance of preferenced trading on the NASDAQ market. Focusing on two characteristics that are closely associated with preferenced trading, low quote competitiveness and low IAC, we find evidence in support of this view. With preferenced trading largely unaffected by the OHRs, dealers used it as a more attractive alternative strategy over quote competition for order flow competition after the OHRs were implemented on the NASDAQ. Consistent with this view, we find net entry (exit) of

[12] The entry and exit results are not reported to save space. For this subset of 45 stocks, there is no net entry for any of the four categories after adjusting for quotes from limit orders. Net exits of competitive positions are higher than net exits of uncompetitive positions. There are more entries and exits in low information asymmetry stocks than in high information asymmetry stocks. Also, almost all of the entries are classified as uncompetitive after the adjustment.

uncompetitive (competitive) position and that most of the action took place in low IAC stocks.

Our findings have significant implications for policy makers. Between 1997 and today, the U.S. stock markets and options markets have undergone numerous changes in the market structure and trading rules. However, none of the reforms directly addresses the problem of preferenced trading. Owing to the scarcity of data on preferenced trades, empirical evidence is limited, with the exception of Chung *et al*. (2004) and Huang *et al*. (2010). Both studies suggest that preferenced trading is still prevalent even after decimalization. Even though academics have provided overwhelming evidence that preferenced trading is detrimental to market quality and many practitioners have openly expressed concern over this practice, the SEC has been reluctant to adopt direct measures against preferenced trading. Our findings suggest that the SEC's indirect approach may be ineffective.

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