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Does internalization diminish the impact of quote aggressiveness on dealer market share?

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Abstract

We analyze data provided by NASDAQ to examine how quote aggressiveness affects dealer market share and whether the practice of internalization mitigates the impact of quote aggressiveness. Our empirical results show that although internalization does not reduce the impact of *price* aggressiveness on dealer market share, it mitigates the impact of *size* aggressiveness. This result suggests that although internalization may not affect the dealer's incentive to post aggressive prices, it may reduce the incentive to post large depths. We find that aggressive quotes are more effective in raising dealer market share in stocks with a less competitive (more concentrated) market structure. Our results also show that the effective spread is wider (narrower) for stocks with a smaller price (size) elasticity of dealer market share.

JEL classification: G18; G19

Keywords: Dealer market share; Market concentration; Herfindahl-index; Internalization; Quote aggressiveness; Decimalization

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1. Introduction

Brokers and dealers on NASDAQ frequently internalize their order flow or route through payment for order flow agreements. Internalization is the direction of order flow by a broker-dealer to an affiliated market maker. Payment for order flow agreement involves either direct monetary payments or in-kind goods and services provided by dealers to brokers in return for routing customer orders. Chung et al. (2004) show that a large portion of NASDAQ order flow is internalized and stocks with greater internalized trades exhibit wider spreads.[1] Although a number of prior studies show either analytically or with experimental data that internalization exerts a negative impact on dealer competition and market quality, there is relatively little empirical evidence on the issue.

In this study, we examine whether internalization adversely affects market quality by reducing dealers' incentives to post aggressive quotes. To address this question, we first investigate the relation between dealer market shares and quote aggressiveness. Whether dealers who quote more aggressively have larger market shares is an interesting question given the fact that a significant portion of NASDAQ volume is internalized. If dealers who quote aggressively have the same market share as dealers who do not quote aggressively, dealers would have little incentives to post competitive quotes. If dealers do not post competitive quotes, investors are likely to incur larger trading costs. We then address a related, perhaps more intriguing question whether inter-stock differences in internalization can explain inter-stock differences in the elasticity of dealer market share with respect to quote aggressiveness. If the practice of internalization reduces the incentive to quote aggressively because such practice lowers the effect of quote aggressiveness on market share, then internalization may have an adverse effect on market quality.

Prior studies suggest that order preferencing (i.e., internalization and payment for order flow) reduces the incentive to post aggressive quotes. Godek (1996) holds that order preferencing weakens the linkage between quote aggressiveness and order flow and diminishes the incentive to narrow the spread. Huang and Stoll (1996) and Bessembinder (1999) suggest that internalization and payment for order flow are likely sources of wider spreads on NASDAQ. Bloomfield and O'Hara (1998) show that order preferencing may significantly degrade market performance if preferenced orders are a large share of the market or are received by virtually all market makers. Ackert and Church (1999) provide experimental evidence that payment for order flow and internalization limit dealers' incentive to improve price. Christie and Schultz (1994), Battalio and Holden (1996), Dutta and Madhavan (1997), and Kandel and Marx (1997, 1999) suggest that order preferencing facilitates collusion and thus results in wider bid–ask spreads.[2]

Although prior studies offer both analytical predictions and experimental evidence regarding the effects of order preferencing on execution costs, they offer limited evidence

[1] Hansch et al. (1999) find that preferenced (internalized) trades pay higher (lower) spreads for a sample of London Stock Exchange stocks. They find no significant relation between the extent of preferencing or internalization and spreads across stocks.

[2] Benveniste et al. (1992), Easley et al. (1996), Battalio et al. (1997), SEC (1997), Battalio and Holden (2001), Battalio et al. (2001a, 2001b), Chung et al. (2004), and Peterson and Sirri (2003) also examine the effect of order preferencing on market quality.

as to the relation between quote aggressiveness and market share and whether this relation varies with order preferencing. Only recently have studies begun to shed some light on the direct empirical link between quote aggressiveness and market share. Blume and Goldstein (1997) find that non-NYSE market makers attract more order flow for NYSE stocks when they post the best available quotes. Smith (1999) shows that the bulk of interdealer orders on NASDAQ are routed on the basis of the quotes of the potential recipients. Bessembinder (2003) finds substantial quote-based competition for order flow in NYSE-listed stocks. Bessembinder also shows that off-NYSE liquidity providers use quotations as a selective signaling device to indicate whether they are prepared to give better than normal trade executions and order routing responds to these signals.

Klock and McCormick (2002) show that dealer market share increases with quote aggressiveness on NASDAQ. The authors also find that stocks with a higher Herfindahl-index (i.e., less competitive market structure) exhibit a smaller effect of quote aggressiveness on market share. They interpret the latter result as evidence that order preferencing weakens the effectiveness of aggressive quoting on order flow (given the assumption that stocks with large Herfindahl-indexes also have high levels of order preferencing). Because the authors do not utilize data on order preferencing, however, the study fails to show any direct effect of order preferencing on the value of aggressive quotes. To date, no prior study provided direct empirical evidence on whether order preferencing lowers the elasticity of dealer market share with respect to quote aggressiveness.

In the present study, we analyze data provided by NASDAQ to examine how quote aggressiveness affects dealer market share and whether the practice of internalization mitigates the impact of dealer quotes on market share. Considering the academic and regulatory debates on whether internalization degrades market quality,[3] it may be of great interest to both regulatory authorities and the general public to know how internalization affects the dealer's incentive to quote aggressively.

Our empirical results show that aggressive quotes help increase dealer market share, despite the fact that a large proportion of NASDAQ order flow is internalized. We find that while the impact of price aggressiveness on dealer market share does not vary with the extent of internalization, the impact of size aggressiveness is significantly and negatively related to internalization. These results suggest that although internalization may not affect the dealer's incentive to post aggressive prices, it may reduce the incentive to post large depths. Contrary to the finding of Klock and McCormick (2002) from the pre-reform data, we show that aggressive quotes are more effective in raising dealer market share in stocks with *less* competitive (more concentrated) market structure from our post-reform data. Our results also show that the effective spread is wider (narrower) for stocks with a smaller price (size) elasticity of dealer market share.

The paper is organized as follows. Section 2 describes data sources and sample selection procedures and presents descriptive statistics. Section 3 analyzes the effects of price and size aggressiveness on dealer market share. Section 4 examines whether the practice of internalization mitigates the impact of quote aggressiveness on dealer market share. Sec-

[3] See Christie and Schultz (1994), Huang and Stoll (1996), and Chung et al. (2001).

tion 5 analyzes the effect of the elasticity of dealer market share on the effective spread. Section 6 provides a brief summary and concluding remarks.

2. Data sources and sample characteristics

We obtain data for this study from NASTRAQ® Trade and Quote Data. To examine whether decimal pricing has any impact on dealer quotation behavior, we use data from before and after the implementation of decimal pricing. For example, dealer quotation behavior may change if decimal pricing reduces internalization drastically. We use trade, inside quote, and dealer quote data for November 2000 as our study sample for the pre-decimalization period. We use corresponding data for June 2001 for the post-decimalization period.[4]

We use proprietary data from NASDAQ to determine whether each trade is internalized. Because the primary purpose of this study is to examine whether internalization lowers the elasticity of dealer market share with respect to quote aggressiveness, we include a stock in our study sample only if there are at least 12 dealers who make a market in the stock during both periods.[5] The final study sample consists of 1121 NASDAQ-listed stocks.

We omit the following to minimize data errors:

(1) quotes if either the ask or the bid is less than or equal to zero;
(2) quotes if either the ask size or the bid size is less than or equal to zero;
(3) quotes if the bid–ask spread is greater than \$5 or less than zero;
(4) before-the-open and after-the-close trades and quotes;
(5) trades if the price or volume is less than or equal to zero;
(6) trade price, p_t, if $|(p_t - p_{t-1})/p_{t-1}| > 0.5$;
(7) ask quote, a_t, if $|(a_t - a_{t-1})/a_{t-1}| > 0.5$; and
(8) bid quote, b_t, if $|(b_t - b_{t-1})/b_{t-1}| > 0.5$.

We measure share price by the mean daily closing quote midpoints and return volatility by the standard deviation of daily returns calculated from daily closing quote midpoints. We measure number of trades by the average number of transactions during each month. We measure trade size by the average dollar transaction size. We measure firm size by the market value of equity at the beginning of each study period.

We report select attributes of our study sample of 1121 stocks in Table 1. The average share price is \$23.51 before decimalization and \$16.61 after decimalization. The average dollar trade size and the average number of transactions are \$15,217 and 36,980, respec-

[4] We do not consider Electronic Communications Networks (ECNs) as dealers because ECNs are purely order-driven trading systems. The MMIDs of ECNs are ISLD, INCA, BTRD, NTRD, ATTN, BRUT, REDI, STRK, MKXT, LSPD, GNET, TRAC, and ARCA. Although we do not view ECNs as market makers in the present study, our inside market quotes reflect the highest bid price and lowest ask price among quotes from all market participants, including ECNs.

[5] To assess the robustness of our results, we replicate the analysis with stocks with at least 10, 15, and 20 dealers. The results are similar to those presented here.

Table 1
Descriptive statistics

Variable	Decimalization	Mean	Standard deviation	Percentile						
				Min	5	25	50	75	95	Max
Share price ($)	Before	23.51	23.78	0.52	2.19	7.06	16.05	32.08	69.65	210.48
	After	16.61	15.83	0.13	0.92	4.16	12.14	24.64	49.92	93.30
Number of trades	Before	36,980	121,789	411	1492	3586	6938	17,483	154,854	1,428,967
	After	32,928	100,204	303	953	3241	7133	17,874	137,507	1,087,648
Trade size ($)	Before	15,217	11,840	852	2167	5953	11,987	22,010	38,579	66,976
	After	10,398	8871	436	1142	3348	8444	15,252	26,390	93,400
Return volatility	Before	0.0637	0.0303	0.0068	0.0206	0.0435	0.0609	0.0803	0.1130	0.4208
	After	0.0492	0.0274	0.0010	0.0163	0.0322	0.0440	0.0616	0.0956	0.3593
Market value of equity ($) (in thousands)	Before	3,253,407	17,774,031	2769	62,766	203,308	524,454	1,513,360	9,183,270	387,361,000
	After	1,754,427	8,760,813	2473	25,971	109,912	358,887	949,990	5,457,470	194,268,000
Number of dealers	Before	20	8	12	12	14	17	23	38	46
	After	23	11	12	13	15	20	27	47	64

Notes. This table shows the attributes of our study sample of 1121 NASDAQ stocks before and after decimalization. We measure share price by the mean daily closing quote midpoints and return volatility by the standard deviation of daily returns calculated from daily closing quote midpoints. We measure number of trades by the average number of transactions during each month. We measure trade size by the average dollar transaction size. We measure firm size by the market value of equity at the beginning of each study period.

tively, before decimalization and $10,398 and 32,928 after decimalization. The average standard deviation of daily returns is 0.0637 before decimalization and 0.0492 after decimalization. The average market capitalization is $3253 millions before decimalization $1754 millions after decimalization. The larger percentage change in market capitalization between the pre- and post-decimalization periods relative to the corresponding change in share price indicates that the firm with a greater number of shares outstanding experienced a larger reduction in share price. The mean, median, minimum, and maximum numbers of dealers are 20, 17, 12, and 46 during the pre-decimalization period and 23, 20, 12, and 64 during the post-decimalization period, respectively.

To examine the extent to which market share is concentrated on top dealers, we cluster our sample stocks into seven portfolios according to the number of dealers. For each stock within each portfolio, we rank dealers according to their market shares and then calculate the cross-sectional average market share for each rank within each portfolio. Table 2 shows the mean market share of each of the 10 largest dealers within each portfolio. For instance, in the case of stocks with 12 to 15 dealers in panel A, the average market shares of the top three dealers are 28.2, 17.3, and 12.7%, respectively, during the pre-decimalization period. The top three dealers collectively account for nearly 60% of the total volume.

As expected, the average market shares of the top three dealers are lower for stocks with larger number of dealers. For stocks with more than 40 dealers, the average market shares of the top three dealers are 12.4, 9.6, and 8.4%, respectively. The combined market share (30.4%) of these dealers is only slightly larger than one-half of the corresponding figure (58.2%) for stocks with 12–15 dealers. For our entire study sample of stocks, the average market shares of the top three dealers are 24.0, 15.2, and 11.4% during the pre-decimalization period. The three dealers account for about 50% of the total volume. Note also that the top five dealers account for more than two-thirds of the total volume. We find similar results during the post-decimalization period. On the whole, these results suggest that NASDAQ market shares are highly concentrated on a smaller number of dealers.[6]

The degree of market concentration for our whole study sample, however, is lower than that reported in Ellis et al. (2002) for a sample of IPO stocks. They show that the most active dealer accounts for about 40 to 45% of the total volume and the top three dealers handle the vast majority (greater than 70%) of trades in their IPO sample. This should not come as a surprise because the average number (20 +) of dealers for our study sample is much larger than the corresponding figures (between 7 and 10, depending on time periods) for their IPO sample. The combined market share (58.2%) of the top three dealers for those stocks with 12–15 dealers in our study sample is closer to the corresponding figure (70 + %) for the above IPO sample.

To shed further light on the nature of competition among dealers, we examine inter-dealer differences in quote aggressiveness for our sample of stocks. We cluster our sample stocks into seven portfolios according to the number of dealers. For each stock within each portfolio, we rank dealers according to the percentage of time at the inside on at least one

[6] Trades routed by a dealer to an ECN for execution are included in that dealer's market share. A dealer is defined as a firm that reported at least one trade in a particular stock.

Table 2
Market share of 10 largest dealers

No. of dealers	Top 10 dealers									
	1	2	3	4	5	6	7	8	9	10
A. Before decimalization										
12–15	28.2	17.3	12.7	9.9	7.9	6.3	5.1	4.0	3.1	2.2
	(28.2)	(45.5)	(58.2)	(68.1)	(76.0)	(82.3)	(87.4)	(91.4)	(94.5)	(96.7)
16–20	24.5	15.4	11.5	9.1	7.6	6.3	5.2	4.4	3.7	3.1
	(24.5)	(39.9)	(51.4)	(60.5)	(68.1)	(74.4)	(79.6)	(84.0)	(87.7)	(90.8)
21–25	21.4	13.9	10.9	8.6	7.1	5.9	5.2	4.5	3.9	3.3
	(21.4)	(35.3)	(46.2)	(54.8)	(61.9)	(67.8)	(73.0)	(77.5)	(81.4)	(84.7)
26–30	19.6	13.0	9.5	7.9	6.7	5.7	5.0	4.3	3.8	3.4
	(19.6)	(32.6)	(42.1)	(50.0)	(56.7)	(62.4)	(67.4)	(71.7)	(75.5)	(78.9)
31–35	17.0	11.4	9.2	7.4	6.4	5.6	4.7	4.3	3.8	3.6
	(17.0)	(28.4)	(37.6)	(45.0)	(51.4)	(57.0)	(61.7)	(66.0)	(69.8)	(73.4)
36–40	16.6	10.6	8.6	7.4	6.1	5.5	5.0	4.1	3.8	3.5
	(16.6)	(27.2)	(35.8)	(43.2)	(49.3)	(54.8)	(59.8)	(63.9)	(67.7)	(71.2)
41 +	12.4	9.6	8.4	7.4	6.5	5.8	5.1	4.4	3.8	3.4
	(12.4)	(22.0)	(30.4)	(37.8)	(44.3)	(50.1)	(55.2)	(59.6)	(63.4)	(66.8)
Whole sample	24.0	15.2	11.4	9.1	7.4	6.1	5.1	4.2	3.5	2.9
	(24.0)	(39.2)	(50.6)	(59.7)	(67.1)	(73.2)	(78.3)	(82.5)	(86.0)	(88.9)
B. After decimalization										
12–15	28.8	17.6	12.6	9.6	7.7	6.2	4.9	3.9	3.0	2.2
	(28.8)	(46.4)	(59.0)	(68.6)	(76.3)	(82.5)	(87.4)	(91.3)	(94.3)	(96.5)
16–20	26.0	15.4	11.3	9.0	7.3	6.0	5.1	4.3	3.6	3.0
	(26.0)	(41.4)	(52.7)	(61.7)	(69.0)	(75.0)	(80.1)	(84.4)	(88.0)	(91.0)
21–25	22.4	14.7	10.9	8.4	7.0	5.9	5.1	4.4	3.7	3.2
	(22.4)	(37.1)	(48.0)	(56.4)	(63.4)	(69.3)	(74.4)	(78.8)	(82.5)	(85.7)
26–30	19.5	13.3	9.7	8.0	6.8	5.7	5.1	4.4	3.9	3.4
	(19.5)	(32.8)	(42.5)	(50.5)	(57.3)	(63.0)	(68.1)	(72.5)	(76.4)	(79.8)
31–35	18.3	12.3	9.3	7.3	6.0	5.2	4.7	4.3	3.8	3.4
	(18.3)	(30.6)	(39.9)	(47.2)	(53.2)	(58.4)	(63.1)	(67.4)	(71.2)	(74.6)
36–40	14.7	10.5	8.4	7.0	6.1	5.4	4.7	4.2	3.8	3.5
	(14.7)	(25.2)	(33.6)	(40.6)	(46.7)	(52.1)	(56.8)	(61.0)	(64.8)	(68.3)
41 +	13.1	9.2	7.6	6.6	5.8	5.2	4.7	4.3	3.9	3.6
	(13.1)	(22.3)	(29.9)	(36.5)	(42.3)	(47.5)	(52.2)	(56.5)	(60.4)	(64.0)
Whole sample	23.4	14.7	10.8	8.6	7.0	5.9	5.0	4.2	3.5	3.0
	(23.4)	(38.1)	(48.9)	(57.5)	(64.5)	(70.4)	(75.4)	(79.6)	(83.1)	(86.1)

Notes. This table shows the market share of each of the 10 largest dealers within each portfolio of stocks formed by the number of dealers.We report the results for pre- and post-decimalization periods. The numbers in parentheses are the cumulative dealer market shares for the portfolio.

side of the quote (*PTINS*) and then calculate the cross-sectional average of *PTINS* for each rank within each portfolio.

Table 3 shows the mean values of *PTINS* for the 10 most aggressive dealers within each portfolio. For instance, in the case of stocks with 12 to 15 dealers in panel A, the most aggressive dealer is at the inside 55.5% of time, the second most aggressive one is at the inside 44.3% of time, and so on. Notice that the percentage of time at the inside declines gradually across dealers within each portfolio. Hence, the inside market quotes for a given

Table 3
Percentage of time at the inside for 10 most aggressive dealers

No. of dealers	10 most aggressive dealers									
	1	2	3	4	5	6	7	8	9	10
A. Before decimalization										
12–15	55.5	44.3	36.8	31.5	27.0	22.9	19.6	16.0	12.8	10.0
16–20	53.9	42.9	36.2	31.7	27.8	24.7	21.7	18.7	16.3	13.9
21–25	51.0	40.9	35.2	31.1	27.1	24.5	22.0	19.6	17.7	16.0
26–30	50.0	39.9	35.4	31.7	28.6	25.8	23.2	21.1	19.4	17.8
31–35	49.3	39.8	35.4	31.9	28.5	25.7	23.8	21.8	20.4	18.8
36–40	52.3	45.0	41.2	36.8	33.8	31.2	28.2	26.3	24.3	22.1
41 +	49.1	40.9	37.0	33.0	30.2	27.7	26.5	24.6	22.7	21.4
Whole sample	53.4	42.7	36.3	31.7	27.8	24.4	21.5	18.6	16.1	13.7
B. After decimalization										
12–15	53.2	40.2	32.9	27.1	22.4	19.0	16.0	13.3	10.7	8.3
16–20	46.9	36.3	29.8	25.3	21.9	18.9	16.4	14.1	12.2	10.5
21–25	44.0	35.0	29.3	25.2	22.1	19.6	17.5	15.5	13.8	12.1
26–30	42.8	31.8	27.1	24.2	21.8	19.6	17.8	16.0	14.4	13.1
31–35	41.4	31.2	25.9	22.8	20.0	18.0	16.5	15.2	14.2	12.7
36–40	38.4	29.0	23.8	20.6	18.5	16.3	14.9	14.0	12.9	11.9
41 +	43.5	32.6	28.4	24.6	22.4	20.4	18.8	17.5	16.5	15.7
Whole sample	46.7	35.7	29.6	25.2	21.8	19.1	16.8	14.7	12.8	11.1

Notes. This table shows the percentage of time at the inside for 10 most aggressive dealers within each portfolio of stocks formed by the number of dealers. We cluster our sample stocks into seven portfolios according to the number of dealers. For each stock within each portfolio, we rank dealers according to the percentage of time at the inside on at least one side of the quote (*PTINS*) and then calculate the cross-sectional average of *PTINS* for each rank within each portfolio. We report the results for the pre- and post-decimalization periods.

stock are established and shared by many competing dealers rather than by few dominant dealers.

3. Effect of quote aggressiveness on dealer market share

In this section we analyze the effect of quote aggressiveness on dealer market share. We first examine whether dealers attract more order flow when they are at the inside market. We then estimate the elasticity of market share with respect to dealer quote aggressiveness. We note that NASDAQ dealer quotes frequently reflect limit orders from customers rather than the dealer's trading interest. Because our main focus is to examine whether aggressive quotes (regardless of their origins) lead to larger market share, it is unimportant to distinguish whose interests are reflected in dealer quotes.

3.1. Do aggressive quotes bring more order flow?

This section analyzes whether dealers receive more order flow when they are at the inside market than when they are not at the inside. Because the proportion of time during which dealers are at the inside is usually much smaller than the proportion of non-inside time, a simple comparison of dealer volume at the inside and non-inside is likely to result

Table 4
Effect of quote aggressiveness on order flow

Variable	Mean	Standard deviation	Percentile						
			Min	5	25	50	75	95	Max
A. Before decimalization									
$TAINS(j)$	26.60	19.13	0	4.70	16.01	24.27	33.47	50.16	186.49
$TANINS(j)$	5.85	10.99	0	0.14	0.98	2.78	6.70	21.35	156.74
$TAINS(j) - TANINS(j)$	20.75** (17.75)								
B. After decimalization									
$TAINS(j)$	36.94	23.56	0	7.06	22.57	33.89	46.28	79.21	171.17
$TANINS(j)$	4.79	6.04	0	0.11	0.90	2.74	6.02	16.61	45.65
$TAINS(j) - TANINS(j)$	32.15** (23.79)								

Notes. This table shows descriptive statistics for the time-adjusted inside volume ($TAINS(j)$) and the time-adjusted non-inside volume ($TANINS(j)$). Numbers in parentheses are t-statistics testing the equality of the mean between $TAINS(j)$ and $TANINS(j)$.

** Significant at the 1% level.

in an inaccurate assessment of the effect of quote aggressiveness on order flow. Hence, we normalize dealer volume at the inside and non-inside by dealer time at the inside and non-inside, respectively.

We calculate dealer j's time-adjusted inside volume in stock i ($TAINS(i, j)$) by dividing the proportion of stock i's volume executed by dealer j while dealer j is at the inside by the proportion of time during which dealer j is at the inside for stock i. We then average $TAINS(i, j)$ across stocks to obtain dealer j's time-adjusted inside volume, $TAINS(j)$. Likewise, we calculate dealer j's time-adjusted non-inside volume ($TANINS(i, j)$) by dividing the proportion of stock i's volume executed by dealer j while dealer j is not at the inside by the proportion of time during which dealer j is not at the inside. We then average $TANINS(i, j)$ across stocks to obtain dealer j's time-adjusted non-inside volume, $TANINS(j)$.

Table 4 shows the mean value of $TAINS(j)$ ($TANINS(j)$) across dealers, together with its standard deviation and percentile values. Note that the mean value of $TAINS(j)$ is greater than the mean value of $TANINS(j)$ and the difference (20.75) is statistically significant at the 1% level before decimalization. We find similar results from the post-decimalization data. These results indicate that dealers indeed receive more order flow when they are at the inside than when they are not at the inside. These results are consistent with the finding of Klock and McCormick (2002) and Bessembinder (2003) that dealer market share increases with quote aggressiveness.

3.2. *Elasticity of dealer market share with respect to price and size aggressiveness*

In this section, we examine how dealer market share varies with quote aggressiveness. There are two dimensions of quote aggressiveness: price and size (i.e., depth). We measure price aggressiveness by the percentage of dealer time at the inside. We measure size aggressiveness by the relative magnitude of a dealer's quoted depth in relation to the average quoted depth of all dealers at the inside for a given stock.

To examine the impact of quote aggressiveness on dealer market share, we estimate the following regression models for each stock:

$$\log\big(MS(i,j)\big) = \lambda_{0i} + \lambda_{1i}\log\big(PTINS(i,j)\big) + \lambda_{2i}\log\big(RELQS(i,j)\big) + \varepsilon_1(i,j), \tag{1}$$

$$\log\big(MS(i,j)\big) = \psi_{0i} + \psi_{1i}\log\big(PTINSA(i,j)\big) + \psi_{2i}\log\big(RELQS(i,j)\big) + \varepsilon_2(i,j), \tag{2}$$

where $MS(i,j)$ is dealer j's market share in stock i (i.e., $V(i,j)/\sum_j V(i,j)$, where $V(i,j)$ is stock i's volume accounted for by dealer j), $PTINS(i,j)$ is the percentage of time during which dealer j is at the inside for stock i, $RELQS(i,j)$ is the ratio of the average depth of dealer j's inside market quotes to the average depth of all dealers' inside market quotes for stock i, $PTINSA(i,j)$ is the percentage of time during which dealer j is at the inside alone for stock i, and $\varepsilon_1(i,j)$ and $\varepsilon_2(i,j)$ are the error terms.[7]

An alternative way to investigate whether more aggressive quotes lead to greater order flow is to look at the inter-temporal correlation between quotes and trades (instead of the inter-dealer difference in market share in each stock). For example, one can look at whether a dealer could increase his market share of order flow at time $t+1$ by actively moving quotes to the inside at time t. However, we are unable to take this approach because it requires individual dealer trade data which are not publicly available.

We estimate the above models for *each stock* using individual dealer quote data and calculate the mean coefficient across stocks and the z-statistic. We obtain the z-statistic by adding individual regression t-statistics across stocks and then dividing the sum by the square root of the number of regression coefficients. Because we take the log of the dependent and independent variables, the estimated coefficients measure elasticity, i.e., the percentage change in market share given 1% change in quote aggressiveness variables.

Table 5 shows the mean coefficients and z-statistics (in parentheses) during each study period. The results show that a 1% increase in *PTINS* results in about 0.80% (0.72%) increase in dealer market share during the pre- (post-) decimalization period. Similarly, a 1% increase in *PTINSA* results in about 0.62% increase in dealer market share during

Table 5
Elasticity of dealer market share with respect to quote aggressiveness (first-pass-regression results)

	Before decimalization		After decimalization	
	$\log(MS(i,j))$	$\log(MS(i,j))$	$\log(MS(i,j))$	$\log(MS(i,j))$
$\log(PTINS(i,j))$	0.8021**		0.7164**	
	(158.64)		(168.11)	
$\log(PTINSA(i,j))$		0.6186**		0.6205**
		(159.33)		(178.92)
$\log(RELQS(i,j))$	0.3953**	0.2063**	0.3612**	0.2220**
	(40.47)	(21.87)	(38.06)	(25.03)

Note: Numbers in parentheses are z-statistics.
** Significant at the 1% level.

[7] There is significant cross-sectional variation in $RELQS(i,j)$. The mean, median, standard deviation, minimum, and maximum values of $RELQS(i,j)$ are 0.52 (0.54), 0.38 (0.37), 0.45 (0.58), 0.01 (0.02), and 10.14 (36.40) during the pre- (post-) decimalization period.

both periods.[8] The results show that a 1% increase in *RELQS* results in about 0.21 to 0.40% increase in dealer market share, depending on different model specifications or time periods. The z-statistics indicate that the results are all statistically significant at the 1% level.

Overall, our findings indicate that aggressive quotes help increase dealer market share on NASDAQ, despite the fact that a significant portion of NASDAQ volume is either internalized or routed through payment for order flow agreements. Our findings are in line with the results reported in Klock and McCormick (2002) based on the data prior to the 1997 NASDAQ order handling rule changes.

4. Does internalization reduce the effect of quote aggressiveness on market share?

Prior studies suggest that internalization reduces the incentive to post aggressive quotes because it weakens the linkage between quote aggressiveness and order flow.[9] However, none of these studies provide direct empirical evidence regarding the effects of internalization on the elasticity of dealer market share with respect to quote aggressiveness.[10] In this section, we examine whether internalization mitigates the impact of quote aggressiveness on dealer market share.

Market structure is also likely to affect the impact of quote aggressiveness on market share. We conjecture that aggressive quotes are more effective in raising market share in less competitive (i.e., more concentrated) markets. In general, for a given stock, the average market share of dealers who are at the inside decreases with the number of dealers at the inside. Hence, the gain in a dealer's market share would be larger when he starts quoting aggressively at the inside in markets (i.e., stocks) with fewer dealers. Because the number of dealers is likely to be smaller in concentrated markets, it follows that the effect of quote aggressiveness on market share would be greater in concentrated markets.[11] In addition, it may be easier for a dealer to penetrate and gain market share in stocks with uneven distribution of dealer market shares (i.e., less competitive market structure).

4.1. Measurement of internalization and market concentration

Proprietary data from NASDAQ contain information on the quotes and transactions of all market makers that allows us to determine whether a public trade is internalized. We

[8] Although the present study holds that aggressive quotes help increase dealer market share, causality can be opposite. For example, dealers with a larger market share may get more limit orders at the inside quote, and as a result, they are at the inside more often.

[9] See Godek (1996), Huang and Stoll (1996), Battalio and Holden (1996), Dutta and Madhavan (1997), and Kandel and Marx (1997, 1999).

[10] Bessembinder (2003) shows that quote characteristics, including size, time priority, and proximity to the inside, significantly affect observed execution venue for NYSE-listed stocks, indicating a substantial degree of quote-based competition for order flow.

[11] Suppose that dealers who are at the inside split market share equally, i.e., if N dealers are at the inside, each dealer's market share is $1/N$. In such a case, if a new dealer starts quoting aggressively at the inside in a stock with N dealers already at the inside, his market share would change from zero to $1/(N+1)$. Thus, the change in market share associated with moving from the non-inside to inside market quotes is negatively related to N.

consider a trade internalized if the reporting market maker (i.e., the broker-dealer who received the order from the customer) is also a contra party in the trade. We then calculate the percentage of trades that are internalized for stock i, $INT(i)$, using the following formula:

$$INT(i) = \sum_j VINT(i,j) \Big/ \sum_j V(i,j), \tag{3}$$

where $V(i,j)$ is stock i's volume executed by dealer j and $VINT(i,j)$ is stock i's internalized volume forwarded to dealer j. We measure trading volume both in dollars and number of shares. The results are, however, qualitatively identical between the two measures. Hence, we report only the results based on dollar volume throughout the paper.

We employ the Herfindahl-index as a measure of market concentration for each stock. We calculate the Herfindahl-index for stock i using the following formula:

$$H\text{-}INDEX(i) = \sum_j \left[100V(i,j) \Big/ \sum_j V(i,j) \right]^2, \tag{4}$$

where $V(i,j)$ is stock i's dollar volume executed by dealer j. The Herfindahl-index increases as the number of dealers decreases or as the proportion of volume by the leading dealer increases.[12] Thus, a high Herfindahl-index is associated with high concentration of trading.

Table 6 shows descriptive statistics for $INT(i)$ and $H\text{-}INDEX(i)$ during the pre- and post-decimalization periods. The mean and median values of $INT(i)$ are 33.98 and 35.48% before decimalization and 31.55 and 33.60% after decimalization, respectively. Hence,

Table 6
Internalization and the Herfindahl-index before and after decimalization

Variable	Decimalization	Mean	Standard deviation	Percentile						
				Min	5	25	50	75	95	Max
$INT(i)$	Before	33.98	13.81	0.81	9.58	24.68	35.48	43.67	55.08	70.07
	After	31.55	14.00	0.04	5.81	21.89	33.60	41.45	51.59	78.92
	After – Before	−2.43**								
		(−4.13)								
$H\text{-}INDEX(i)$	Before	1152	504	345	521	821	1070	1362	2026	4510
	After	1061	498	302	432	724	976	1301	1950	4614
	After – Before	−91**								
		(−4.29)								

Notes. This table shows the proportion of internalized trades and the Herfindahl-index for our study sample of 1121 NASDAQ stocks before and after decimalization. Numbers in parentheses are t-statistics testing the equality of the mean between the pre- and post-decimalization periods.

** Significant at the 1% level.

[12] Note that Herfindahl-index can be decomposed into two parts: $H\text{-}INDEX(i) = 10{,}000[SSD(i) + 1/J(i)]$, where $SSD(i)$ is the sum of squared deviations of individual dealer market shares from the mean for stock i and $J(i)$ is the number of dealers for stock i. The first part measures inequality of market share across dealers and the second part measures the fewness of market-making dealers. We note that our estimates of Herfindahl-index are overstated because we do not consider ECNs as dealers.

about one-third of trading volume for our study sample of stocks is internalized. Note also that there is wide variation in internalized volume across stocks. The percentage of internalized volume ranges from 0.81 (0.04) to 70.07 (78.92) before (after) decimalization. Although the difference in the mean between the two periods (−2.43%) is statistically significant at the 1% level, the observed decline is not as dramatic as some market observers have anticipated. Consequently, decimal pricing is unlikely to significantly change the way quote aggressiveness influences dealer market share.

The mean Herfindahl-index is 1152 before decimalization and 1061 after decimalization and the difference (−91) is statistically significant at the 1% level. Schultz (2000) shows that the average Herfindahl-index for NASDAQ stocks is 2883 just prior to the 1997 order handling rule change and 2756 after the rule change. Ellis et al. (2002) report a mean Herfindahl-index of between 3542 and 4589 during the first 140 days after the IPO for a sample of NASDAQ stocks. The smaller Herfindahl-index of our study sample is largely due to the fact that we include only those stocks with at least 12 market makers in our study sample.

There is wide variation in the Herfindahl-index across our stocks: from 345 to 4510 before decimal pricing and from 302 to 4614 after decimal pricing. The Federal Trade Commission (FTC) considers the Herfindahl-index values below 1000 as characteristics of an unconcentrated industry, the index values between 1001 and 1800 as indicative of moderate concentration, and the index values greater than 1800 as indicative of high concentration. Hence, our study sample of stocks covers a wide range of dealer market structure: from highly competitive 'unconcentrated' market structure to highly concentrated market structure. Although the Herfindahl-index is usually applied to broadly defined industries rather than narrowly defined industries like market-making in a specific stock, the FTC guidelines offer some insight on the nature of dealer competition on NASDAQ.

4.2. *Regression results*

We estimate the following second-pass regression model to determine whether the effect of quote aggressiveness on dealer market share varies with internalization and market structure:

$$\begin{aligned}\lambda_{1i} \text{ or } \lambda_{2i} = {} & \omega_0 + \omega_1 \mathit{INT}(i) + \omega_2 H\text{-}\mathit{INDEX}(i) + \omega_3 \log\bigl(\mathit{PRICE}(i)\bigr) \\ & + \omega_4 \log\bigl(\mathit{NTRADE}(i)\bigr) + \omega_5 \log\bigl(\mathit{TSIZE}(i)\bigr) + \omega_6 \mathit{VOLATILITY}(i) \\ & + \omega_7 \log\bigl(\mathit{MVE}(i)\bigr) + \varepsilon_1(i), \end{aligned} \tag{5}$$

$$\begin{aligned}\psi_{1i} \text{ or } \psi_{2i} = {} & \upsilon_0 + \upsilon_1 \mathit{INT}(i) + \upsilon_2 H\text{-}\mathit{INDEX}(i) + \upsilon_3 \log\bigl(\mathit{PRICE}(i)\bigr) \\ & + \upsilon_4 \log\bigl(\mathit{NTRADE}(i)\bigr) + \upsilon_5 \log\bigl(\mathit{TSIZE}(i)\bigr) + \upsilon_6 \mathit{VOLATILITY}(i) \\ & + \upsilon_7 \log\bigl(\mathit{MVE}(i)\bigr) + \varepsilon_2(i), \end{aligned} \tag{6}$$

where λ_{1i}, λ_{2i}, ψ_{1i}, and ψ_{2i} are the coefficient estimates from the first-pass regressions (i.e., regression models (1) and (2)), $\mathit{INT}(i)$ is the proportion of stock i's internalized volume, and $H\text{-}\mathit{INDEX}(i)$ is the Herfindahl-index of stock i. We include the following five stock attributes as control variables: the average quote midpoint ($\mathit{PRICE}(i)$), the number of transactions ($\mathit{NTRADE}(i)$), the average dollar trade size ($\mathit{TSIZE}(i)$), the standard deviation of quote midpoint returns ($\mathit{VOLATILITY}(i)$), and the market value of equity ($\mathit{MVE}(i)$).

Panel A of Table 7 shows the results of weighted regressions and panel B shows the results of non-weighted regressions. In the weighted regression, we use the absolute values of t-statistics from the first-pass regressions as weights. This approach assigns smaller weights to the first-pass regression coefficients in the second-pass regression when they are less meaningful (i.e., smaller t-statistics). In contrast, in the non-weighted regression, the estimated coefficients from the first-pass regressions have the same weight, regardless of their statistical significance. We employ both approaches to assess the robustness of our results to different estimation methods. In each panel, we report the results for both study periods.

For each period, the first two columns show the results of the second-pass regressions (i.e., regression model (5)) when we use *PTINS* and *RELQS* as price and size aggressiveness measures in the first-pass regression (i.e., regression model (1)). The next two columns show the results of the second-pass regressions (i.e., regression model (6)) when we use *PTINSA* and *RELQS* as price and size aggressiveness measures in the first-pass regression (i.e., regression model (2)).

Panel A shows that the elasticity (λ_{1i} and ψ_{1i}) of dealer market share with respect to price aggressiveness is invariant to the percentage of trades that are internalized during both periods, regardless of whether we use *PTINS* or *PTINSA* as price aggressiveness measure. Hence, our results suggest that a dealer can raise his market share in a stock by quoting aggressively, regardless of the extent to which its order flow is internalized. We find qualitatively identical results from the non-weighted regressions (see panel B). These results suggest that the dealer's incentive to post aggressive price quotes may not be adversely affected by internalization.

Prior studies suggest that internalization may adversely affect market quality because internalization reduces the dealer's incentive to quote aggressively. For instance, Godek (1996) holds that non-price driven order flow (e.g., internalized or preferenced order flow) diminishes the incentive to narrow the spread. This conjecture is largely based on the presumption that internalization and payment for order flow mitigate the effectiveness of aggressive quotes in raising dealer marker shares. Our empirical results indicate that such a presumption may not be warranted. Consequently, the effect of internalization on market quality is not so evident as prior studies have suggested.[13]

Bloomfield and O'Hara (1998) examine how order preferencing affects the competitiveness and informational efficiency of laboratory financial markets. The authors offer experimental evidence that order preferencing has deleterious effects on market quality if preferenced orders are received by all, or virtually all, dealers in a market. However, the study shows that order preferencing does not have adverse effects on market quality and the informational efficiency of prices when two or more dealers are not receiving preferenced orders.

In November 2000, the Securities and Exchange Commission adopted Rule 11Ac1-6, which requires all broker-dealers that route orders in equity and option securities to make available quarterly reports that present a general overview of their order routing practices.

[13] Our results are similar, in spirit, to the finding of Battalio et al. (1997) that internalization has little short-run effect on execution cost.

Table 7
Effect of internalization and market concentration on the elasticity of dealer market share with respect to quote aggressiveness

	Before decimalization				After decimalization			
	λ_{1i}	λ_{2i}	ψ_{1i}	ψ_{2i}	λ_{1i}	λ_{2i}	ψ_{1i}	ψ_{2i}
A. Weighted regression results								
Intercept	0.2666	0.7224	0.1140	−0.8630	0.1409	0.2107	0.4033**	−0.9790*
	(0.91)	(1.46)	(0.59)	(−1.52)	(0.69)	(0.58)	(2.85)	(−2.39)
$INT(i)$	0.1229	−0.6717**	0.0016	−1.0780**	0.0286	−0.6024**	0.1589	−0.7195**
	(1.08)	(−3.80)	(0.02)	(−4.93)	(0.33)	(−3.82)	(1.67)	(−5.02)
$H\text{-}INDEX(i)/10{,}000$	1.0155**	1.5463**	0.9788**	−0.1020	0.9780**	1.9309**	0.6563**	0.4760
	(4.30)	(3.98)	(6.43)	(−0.22)	(4.79)	(5.25)	(4.63)	(1.14)
$\log(PRICE(i))$	−0.1022**	0.1307**	−0.0441**	0.0188	−0.0583**	0.1133**	0.0018	0.0461
	(−3.75)	(2.83)	(−2.46)	(0.36)	(−2.88)	(3.22)	(0.13)	(1.13)
$\log(NTRADE(i))$	0.0230	0.0169	0.0447**	0.0459	0.0325**	0.0418*	0.0564**	0.0128
	(1.73)	(0.78)	(5.21)	(1.85)	(3.08)	(2.16)	(7.87)	(0.59)
$\log(TSIZE(i))$	0.0647	−0.1049	0.0429	0.1222	0.0465	−0.0754	−0.0224	0.1056
	(1.61)	(−1.50)	(1.61)	(1.53)	(1.50)	(−1.36)	(−1.03)	(1.65)
$VOLATILITY(i)$	0.1460	−0.4735	0.0987	−0.6397	0.3322	0.4265	−0.0153	0.2594
	(0.45)	(−0.85)	(0.47)	(−0.97)	(0.98)	(0.70)	(−0.07)	(0.36)
$\log(MVE(i))$	−0.0089	0.0316	−0.0198*	0.0012	−0.0064	0.0263	−0.0137	0.0278
	(−0.66)	(1.41)	(−2.28)	(0.05)	(−0.58)	(1.27)	(−1.81)	(1.20)
F-value	13.61**	8.01**	12.28**	13.24**	9.94**	9.67**	21.00**	18.03**
Adjusted R^2	0.073	0.042	0.066	0.071	0.053	0.051	0.111	0.096

(*continued on next page*)

Table 7 (*continued*)

	Before decimalization				After decimalization			
	λ_{1i}	λ_{2i}	ψ_{1i}	ψ_{2i}	λ_{1i}	λ_{2i}	ψ_{1i}	ψ_{2i}
B. Non-weighted regression results								
Intercept	0.1644	0.2832	0.0734	−0.6794	0.2780	−0.2782	0.4576**	−0.9394**
	(0.55)	(0.61)	(0.36)	(−1.49)	(1.30)	(−0.79)	(2.98)	(−2.72)
$INT(i)$	0.0934	−0.6420**	−0.0467	−0.7927**	0.0616	−0.4833**	0.1199	−0.4754**
	(0.81)	(−3.63)	(−0.60)	(−4.52)	(0.68)	(−3.25)	(1.85)	(−4.26)
$H\text{-}INDEX(i)/10{,}000$	0.7819**	1.6463**	1.0035**	−0.1681	0.8937**	1.4548**	0.8671**	0.6314
	(3.40)	(3.83)	(6.42)	(−0.48)	(4.25)	(4.20)	(5.73)	(1.85)
$\log(PRICE(i))$	−0.1026**	0.0554	−0.0329	0.0135	−0.0233	0.0505	0.0368*	0.0150
	(−3.62)	(1.27)	(−1.71)	(0.31)	(−1.09)	(1.43)	(2.39)	(0.43)
$\log(NTRADE(i))$	0.0179	0.0182	0.0529**	0.0179	0.0469**	0.0438*	0.0754**	0.0340
	(1.30)	(0.86)	(5.65)	(0.85)	(4.12)	(2.33)	(9.20)	(1.84)
$\log(TSIZE(i))$	0.0621	−0.0644	0.0299	0.0617	0.0038	−0.0493	−0.0685**	0.0452
	(1.52)	(−1.02)	(1.07)	(0.99)	(0.12)	(−0.94)	(−3.01)	(0.88)
$VOLATILITY(i)$	0.3273	−0.5112	−0.0746	−0.5909	0.1227	0.1694	0.0207	−0.1075
	(0.93)	(−0.95)	(0.31)	(−1.11)	(0.34)	(0.28)	(0.08)	(−0.18)
$\log(MVE(i))$	0.0022	0.0431*	−0.0174	0.0331	−0.0068	0.0435*	−0.0099	0.0398*
	(0.15)	(1.98)	(−1.80)	(1.53)	(−0.56)	(2.15)	(−1.12)	(2.01)
F-value	10.02**	7.04**	11.78**	11.41**	6.92**	7.72**	27.30**	13.06**
Adjusted R^2	0.053	0.036	0.063	0.061	0.036	0.040	0.141	0.070

Note: Numbers in parentheses are t-statistics.

* Significant at the 5% level.

** Significant at the 1% level.

The reports should include information regarding the significant venues to which customer orders are routed for execution and disclose the material aspects of the broker-dealer's relationship with such venues. Inspection of these reports suggests that, for a given stock, there are typically more than two dealers who are not receiving preferenced orders. We consider this as a possible reason why internalization does not diminish the elasticity of market share with respect to price quote aggressiveness.

Although Chung et al. (2004) find a negative correlation between dealer quote aggressiveness and internalization, they acknowledge that it is difficult to determine the causality of the observed correlation. For example, with a large relative spread, the dealer may seldom be at the inside and thus may receive only internalized orders. In this case, it is the large dealer spread that causes greater internalization.

Chung et al. (2004) also note that the positive relation between the effective spread and internalization shown in their study may be driven by investor behavior rather than a difference in market quality. The authors hold that investors may value immediate liquidity more than price improvement in stocks with higher internalization. That is, internalization may be high in these stocks because demand for immediate liquidity is high. Investors may also be choosing to trade "net" to a greater degree in stocks with high internalization, which implies that the effective spread includes an implicit commission.

Alternatively, the negative relation between quote aggressiveness and internalization could have resulted from dealers' false beliefs that internalization would weaken the effect of quote aggressiveness on market share. In addition, one cannot rule out the possibility that market makers post less aggressive quotes in stocks with larger internalized trades for reasons that are unrelated to market share.

Table 7 shows that the elasticity (λ_{2i} and ψ_{2i}) of dealer market share with respect to *size* aggressiveness is significantly and negatively related to the extent of internalization during both periods. This result indicates that the effect of size aggressiveness on dealer market share is smaller for stocks with larger internalized volumes. We find qualitatively identical results from the weighted and non-weighted regressions. To the extent that internalization reduces the value of aggressive size quotes in raising dealer market share, the dealer's incentive to post large depths may be adversely affected by internalization. Consequently, dealers may quote smaller depths for stocks with larger internalized trades, reducing the overall liquidity for these stocks.

It is unclear why internalization reduces the effect of aggressive size quotes on dealer market share. Prior studies, including Bloomfield and O'Hara (1998), focus mostly on the possible effects of order preferencing on price competitiveness. Consequently, existing theory provides little guidance on how internalization influences the effect of size quote aggressiveness on dealer market share. A possible explanation for our result is that for stocks with larger internalized volumes, quoting large depth may be less important in attracting additional order flow because internalization is accompanied by execution size guarantees that are larger than the typical size at the inside quotes.

Another possible explanation may be in the role of public limit orders. For instance, dealers with lots of public limit orders may quote on the inside more often and also have large market share. Although larger depth leads to greater market share, dealers with more public limit orders tend to have smaller quotes. Consequently, assuming that dealers with more public limit orders also internalize more often, quoting a large size in stocks with large internalization volume would be a less effective means for attracting market share. Indeed, we find from our data that dealers who internalize more have larger market share, are on the inside more often, and quote smaller sizes.

Overall, our results suggest that the extent to which dealers can raise market share by quoting larger depths is smaller for stocks with large internalized volumes. In contrast, we find that internalization does not affect the extent to which dealers can raise market share by staying at the inside market. The former result suggests that internalization may reduce the dealer's incentive to quote large depths. The latter result suggests that internalization is unlikely to reduce the dealer's incentive to quote aggressive prices.[14] Chung et al. (2004) show that internalized trades receive significantly larger size improvements than unpreferenced trades. Hence, although internalization may reduce the dealer's incentive to quote large depths, its ultimate effect on execution quality is unclear.

We find that the elasticity of market share with respect to quote aggressiveness increases with the Herfindahl-index. Panels A and B of Table 7 show that the price elasticity of dealer market share is positively and significantly related to the Herfindahl-index during both the pre- and post-decimalization periods. Similarly, the size elasticity of dealer market share is also positively and significantly related to the Herfindahl-index in most regression models. Overall, these results are consistent with our expectation that dealer quote aggressiveness is more effective in raising market share in stocks with a less competitive market structure. These results differ from the finding of Klock and McCormick (2002). They find that quote aggressiveness has greater impacts on dealer market share in stocks with *smaller* Herfindahl-indexes using the 1996 data before the introduction of the new order handling rules on NASDAQ.[15]

Finally, the regression results show that aggressive quotes are more effective in raising market share for stocks with more frequent trading. However, we find that other stock attributes (i.e., share price, trade size, return volatility, and market capitalization) have no apparent or consistent effects on the elasticity of market share with respect to quote aggressiveness during both periods.

4.3. Further analysis of the effect of internalization on dealer market share

In this section, we provide an alternative test of the effect of internalization on dealer marker share. We examine whether the effect of dealer j's quote aggressiveness on his market share of stock i's unpreferenced volume is different from the corresponding effect on his market share of stock i's internalized volume. We consider trades unpreferenced if executing dealers are at the inside market at the time of trade.[16] We then estimate the

[14] Our findings are at variance with the observation of Bessembinder (1999, p. 406) that "If, in contrast, a large portion of order flow is subject to preferencing agreements, then posting a better quote may not attract order flow, leaving little incentive to improve quotes." The results are also at variance with Kluger and Wyatt's (2002) experimental finding that internalization reduces the incentive to narrow the spread.

[15] The observed discrepancies between the two studies' findings may be attributed to differences in empirical methods, market structures, and/or study periods.

[16] This method of classifying trades into preferenced and unpreferenced is imperfect for the following two reasons. First, not all trades at the inside are unpreferenced trades because a broker may send customer orders to a

following regression models:

$$\log\big(MSINS(i,j)\big) = \alpha_0 + \alpha_1 \log\big(PTINS(i,j)\big) + \alpha_2 \log\big(PTINSA(i,j)\big) + \alpha_3 \log\big(RELQS(i,j)\big) + \varepsilon_1(i,j), \tag{7}$$

$$\log\big(MSINT(i,j)\big) = \beta_0 + \beta_1 \log\big(PTINS(i,j)\big) + \beta_2 \log\big(PTINSA(i,j)\big) + \beta_3 \log\big(RELQS(i,j)\big) + \varepsilon_2(i,j), \tag{8}$$

$$\begin{aligned}\log\big(&MSINS(i,j) \text{ or } MSINT(i,j)\big)\\ &= \gamma_0 + \gamma_1 \log\big(PTINS(i,j)\big) + \gamma_2 \log\big(PTINSA(i,j)\big)\\ &\quad + \gamma_3 \log\big(RELQS(i,j)\big) + \gamma_4 \log\big(PTINS(i,j)\big)\cdot Z + \gamma_5 \log\big(PTINSA(i,j)\big)\cdot Z\\ &\quad + \gamma_6 \log\big(RELQS(i,j)\big)\cdot Z + \varepsilon_3(i,j),\end{aligned} \tag{9}$$

where $MSINS(i,j)$ is the product of dealer j's market share of stock i's inside volume $\{VINS(i,j)/\sum_j VINS(i,j)$, where $VINS(i,j)$ is stock i's volume at the inside market accounted for by dealer $j\}$ and the number of dealers for stock i, $MSINT(i,j)$ is the product of dealer j's market share of stock i's internalized volume $\{VINT(i,j)/\sum_j VINT(i,j)\}$ and the number of dealers for stock i,[17] $PTINS(i,j)$ is the percentage of time during which dealer j is at the inside for stock i, $PTINSA(i,j)$ is the percentage of time during which dealer j is at the inside alone for stock i, $RELQS(i,j)$ is the ratio of the average quoted depth of dealer j's inside market quotes for stock i to the average quoted depth of all dealers' inside market quotes for stock i, and Z is an indicator variable which equals one for internalized volume and zero otherwise. We report the results for pre- and post-decimalization periods.

If dealer market share increases with price aggressiveness, we expect that estimates of α_1, α_2, β_1, and β_2 are all significantly positive. If the elasticity of dealer market share with respect to price aggressiveness for internalized order flow is smaller than the corresponding elasticity for unpreferenced (inside) order flow, we expect that $\gamma_4 < 0$ and $\gamma_5 < 0$. Likewise, if dealer market share increases with size aggressiveness, we expect that estimates of α_3 and β_3 are significantly positive. If the elasticity of dealer market share with respect to size aggressiveness for internalized order flow is smaller than the corresponding elasticity for unpreferenced order flow, we expect that $\gamma_6 < 0$.

We show the regression results in Table 8.[18] The first three columns show the results for the pre-decimalization period and the next three columns show the results for the post-decimalization period. For each period, the first two columns show the results of regression

market maker with preferencing arrangement when the market maker is posting the inside market quotes. Second, non-internalized trades that are executed by dealers whose quotes are away from the inside for a given stock are not necessarily all preferenced trades, especially when orders are sent by a broker who has internalized order flow in the same stock. Dealers generally choose either to internalize or to establish preferencing arrangements for the majority of their order flow in a given stock, but rarely will do both in a given stock. Therefore, some of the preferenced trades we identify may reflect order flow to dealers who do not have any explicit preferencing arrangement with the brokers. We thank Robert Battalio for the latter point.

[17] We multiply dealer market share by the number of dealers to normalize inter-stock differences in the number of dealers. See Klock and McCormick (1999) for a detailed description of this method.

[18] We also estimate the model with a dummy variable for each stock (fixed effects) and find similar results.

Table 8
Effect of quote aggressiveness on dealer market share

	Before decimalization			After decimalization		
	$\log(MSINS(i,j))$	$\log(MSINT(i,j))$	$\log(MSINS(i,j)$ or $MSINT(i,j))$	$\log(MSINS(i,j))$	$\log(MSINT(i,j))$	$\log(MSINS(i,j)$ or $MSINT(i,j))$
Intercept	2.0716**	1.9007**	1.9857**	2.1637**	2.0807**	2.1217**
	(93.50)	(77.82)	(120.35)	(93.95)	(80.18)	(122.16)
$\log(PTINS(i,j))$	0.5006**	0.5251**	0.5062**	0.4328**	0.4561**	0.4364**
	(69.68)	(68.08)	(67.42)	(64.63)	(66.18)	(62.14)
$\log(PTINSA(i,j))$	0.2686**	0.2417**	0.2539**	0.2753**	0.2520**	0.2678**
	(51.21)	(38.61)	(53.31)	(50.13)	(37.93)	(53.59)
$\log(RELQS(i,j))$	0.3378**	0.2688**	0.3230**	0.2798**	0.2161**	0.2675**
	(33.42)	(25.93)	(31.32)	(29.97)	(26.27)	(27.84)
$\log(PTINS(i,j)) \cdot Z$			0.0133			0.0262
			(1.29)			(1.45)
$\log(PTINSA(i,j)) \cdot Z$			−0.0178			−0.0186
			(−1.10)			(−1.22)
$\log(RELQS(i,j)) \cdot Z$			−0.0634**			−0.0589**
			(−6.24)			(−5.59)
F-value	10,521.40**	8020.32**	9137.88**	11,482.20**	9326.28**	10,253.00**
Adjusted R^2	0.588	0.520	0.553	0.574	0.520	0.545

Note: Numbers in parentheses are t-statistics.
** Significant at the 1% level.

models (7) and (8), and the third column shows the results of regression model (9). The regression results show that estimates of α_1, α_2, β_1, and β_2 are all positive and significant during both periods, indicating that aggressive price quotes raise both internalized and unpreferenced volumes. Similarly, we find that estimates of α_3 and β_3 are positive and significant during both periods, indicating that dealers who quote larger depths are likely to have larger market shares for both internalized and unpreferenced volumes.

More importantly, we find that the estimates of γ_4 and γ_5 are insignificantly different from zero. Hence, aggressive price quote helps increase the market share of both internalized and unpreferenced volumes and its effectiveness is identical between the two types of trades. In contrast, we find that the estimate of γ_6 is significant and negative during both periods. This result indicates that depth quote aggressiveness is less effective in increasing the market share of internalized volume than the market share of unpreferenced volume. Overall, these results are qualitatively similar to those reported in Table 7. Hence, we conclude that our main results are not sensitive to different empirical methodologies.

5. The effect of the elasticity of dealer market share on the effective spread

In this section we examine the relation between the elasticity of dealer market share and the effective spread. If a dealer's market share does not increase with the aggressiveness of his price quotes, the dealer would have little incentive to quote aggressive prices. In contrast, if a dealer's market share were highly responsive to his quotes, the dealer would have strong incentive to quote aggressive prices. Based on these considerations, we conjecture that stocks with a larger *price* elasticity of dealer market share exhibit narrower effective spreads. For the same reason, stocks with a larger *size* elasticity of dealer market share are likely to exhibit larger *depths*.[19] Because the slope of the liquidity supply curve is positive (i.e., larger depths are associated with wider spreads), we conjecture that stocks with a larger size elasticity of dealer market share have wider effective spreads.

We estimate the following regression models to test the above conjectures:

$$ESPRD(i) = \alpha_0 + \alpha_1\lambda_{1i} + \alpha_2\lambda_{2i} + \text{Control variables} + \varepsilon_1(i), \tag{10}$$

$$ESPRD(i) = \beta_0 + \beta_1\psi_{1i} + \beta_2\psi_{2i} + \text{Control variables} + \varepsilon_2(i), \tag{11}$$

where λ_{1i}, λ_{2i}, ψ_{1i}, and ψ_{2i} are the coefficient estimates from the first-pass regressions for stock i and $ESPRD(i)$ is the effective spread of stock i. We expect coefficients for λ_{1i} and ψ_{1i} (i.e., price elasticity) to be negative and coefficients for λ_{2i} and ψ_{2i} (i.e., size elasticity) to be positive.

Table 9 shows the regression results. To determine whether the results differ between large and small trades, we estimate the above models for the whole sample as well as for each of the three trade-size categories (100–499, 500–5000, and 5000+ shares) during the pre- and post-decimalization periods. Panel A shows the regression results without control variables. Panel B shows the regression results with control variables. We include

[19] We find that quoted depths increase with the size elasticity of dealer market share using our study sample.

Table 9
Effect of the elasticity of dealer market share on the effective spread

Trade-size category	Before decimalization				After decimalization			
	All	100–499	500–5000	5000 +	All	100–499	500–5000	5000 +
A. Regression results without control variables								
λ_{1i}	−0.2092**	−0.2037**	−0.2093**	−0.2850**	−0.1954**	−0.1775**	−0.1873**	−0.2473**
	(−4.91)	(−4.82)	(−4.93)	(−5.34)	(−3.87)	(−3.53)	(−3.67)	(−4.11)
λ_{2i}	0.0985**	0.0944**	0.1045**	0.1462**	0.0973**	0.0906**	0.0938**	0.1480**
	(3.97)	(3.84)	(4.24)	(3.72)	(3.18)	(2.98)	(3.03)	(4.08)
ψ_{1i}	−0.1990**	−0.1891**	−0.1936**	−0.2650**	−0.1958**	−0.1714**	−0.1870**	−0.2342**
	(−3.49)	(−3.35)	(−3.40)	(−3.70)	(−3.25)	(−2.85)	(−3.08)	(−3.39)
ψ_{2i}	0.1616**	0.1539**	0.1734**	0.2182**	0.1318**	0.1298**	0.1379**	0.1953**
	(5.77)	(5.54)	(6.12)	(6.19)	(4.13)	(4.08)	(4.29)	(5.35)
B. Regression results with control variables								
λ_{1i}	−0.0535**	−0.0539**	−0.0574**	−0.0899**	−0.0476**	−0.0478**	−0.0537**	−0.0876**
	(−3.04)	(−2.97)	(−3.19)	(−3.26)	(−2.72)	(−2.63)	(−3.12)	(−3.15)
λ_{2i}	0.0265**	0.0231*	0.0319**	0.0504**	0.0289**	0.0263**	0.0291**	0.0513**
	(2.82)	(2.39)	(3.32)	(3.43)	(2.92)	(2.55)	(2.90)	(3.27)
ψ_{1i}	−0.0557**	−0.0512*	−0.0571**	−0.0960**	−0.0629**	−0.0616**	−0.0630**	−0.1061**
	(−2.58)	(−2.28)	(−2.63)	(−2.79)	(−2.65)	(−2.51)	(−2.61)	(−3.04)
ψ_{2i}	0.0310**	0.0279**	0.0379**	0.0625**	0.0387**	0.0316**	0.0391**	0.0646**
	(3.05)	(2.64)	(3.71)	(3.87)	(3.25)	(2.56)	(3.23)	(3.69)

Notes. We use log of variables in the regressions. Numbers in parentheses are t-statistics.
* Significant at the 5% level.
** Significant at the 1% level.

PRICE(i), *NTRADE*(i), *TSIZE*(i), *VOLATILITY*(i), and *MVE*(i) (all in log) as control variables.

Consistent with our economic intuition, we find that estimated coefficients for λ_{1i} and ψ_{1i} are significantly negative and estimated coefficients for λ_{2i} and ψ_{2i} are significantly positive. Although coefficients for λ_{1i}, λ_{2i}, ψ_{1i}, and ψ_{2i} and their t-statistics become smaller when we include control variables in the regression, they all remain statistically significant at the 5 or 1% level. These results indicate that traders incur greater execution costs when the price elasticity of dealer market share is smaller and/or the size elasticity of dealer market share is larger. Finally, the results show that estimated coefficients for size elasticity are greater for larger trade-size categories, indicating that size aggressiveness is an especially important determinant of the effective spread of large trades.[20]

6. Summary and concluding remarks

Prior studies suggest that internalization may adversely affect market quality because it decreases the dealer's incentive to quote aggressively. Internalization decreases the dealer's incentive to quote aggressively presumably because it weakens the effectiveness of quote

[20] The authors thank an anonymous referee for suggesting this point.

aggressiveness in raising market share. However, no empirical evidence exists to date on whether internalization actually mitigates the impact of quote aggressiveness on dealer market share on NASDAQ. In the present study, we offer such evidence using proprietary data provided by NASDAQ.

Our empirical results confirm the finding of prior studies that aggressive quotes help increase dealer market share on NASDAQ. We also find that the elasticity of dealer market share with respect to price aggressiveness is similar across stocks with varying degrees of internalized volumes. This suggests that the practice of internalization may not necessarily adversely affect the dealer's incentive to post competitive price quotes. The results show however that the elasticity of dealer market share with respect to size aggressiveness varies inversely with the degree of internalization. This suggests that the practice of internalization may reduce the dealer's incentive to quote larger depths at the inside. Contrary to the finding of prior research, we find that the effect of aggressive quotes on dealer market share is greater for stocks with more concentrated (less competitive) dealer market structure.

Overall, our results suggest that the effect of internalization on market quality may not be as strong as some previous studies suggested. Despite the widespread practice of internalization, there is significant quote-based competition for order flow on NASDAQ. In particular, contrary to popular belief, internalization does not appear to hamper competition for order flow through quoting competitive prices (at the inside alone or with other dealers). Although the practice of internalization has some adverse effects on the dealer's incentive to quote large depths, its ultimate impact on execution quality is unclear because internalized trades usually receive significantly larger size improvements than unpreferenced trades.

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