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Did NASDAQ market makers successfully collude to increase spreads? A reexamination of evidence from stocks that moved from NASDAQ to the New York or American Stock Exchanges

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ABSTRACT

This paper examines all movements of stock from NASDAQ to the NYSE or Amex from 1983 through 1997 (1044 observations), as did Barclay (1997) for 472 stocks through 1992. He found a greater average decrease in spreads for NASDAQ stocks quoted on even eighths compared to stocks quoted on mixed eighths, from which he concluded that NASDAQ market makers had successfully colluded to widen spreads. A closer examination of the data and consideration of an important difference between how quotes are set on NASDAQ compared to the NYSE/Amex finds no support for the collusion hypothesis. Spreads on stocks with quoted spreads of one-eighth have no or limited scope for change, as this was the minimum quoted tick size on NYSE/Amex as well as on NASDAQ; hence inclusion of these observations reduces the average post-move spread decrease of mixed stocks, thereby biasing the finding. In fact, the higher average decrease in percentage effective spreads (%EPS) for even-eighth-quoted stocks is due entirely to the few stocks with high spreads (twelve eighths or higher). These stocks are relatively thinly traded and have small capitalizations and, when traded on NASDAQ (but not the NYSE/Amex) are subject to informed (adverse) trading. Furthermore, in the period after the alleged collusion was publicly identified and, presumably, stopped, there was no change in post-move decrease in %EPS on even-eighth stocks that supports the collusion hypotheses.

Keywords: NASDAQ, market-maker collusion, even-eights quotes, microstructure, exchange listing

JEL classification: G18

Note: The referee's report rejecting the article for publication in the *Journal of Financial Economics* and my response to that report are presented in Appendix II.

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1. Introduction

There is reason to believe that some NASDAQ market makers attempted to fix stock prices that widened spreads. Triggered by press coverage in May 1994 of a study by William Christie and Paul Schultz (published in December 1994) that alleged collusion among NASDAQ market makers to widen spreads by avoiding quoting stocks with even eighths, the Department of Justice (DOJ) and Securities and Exchange Commission (SEC) undertook investigations in 1995. These investigations (DOJ 1996 and SEC 1996) revealed telephonic transcriptions in which traders for market makers apparently asked other firms' traders to set prices or lambasted them for "breaking the spread." Such remarks are per se illegal under the anti-trust laws, whether successful or not in actually fixing prices. The DOJ and SEC reports do not describe the absolute or relative quantity or pervasiveness of the damning transcripts. Christie and Schultz (1994) did not examine the relationship between stocks' quotations at even eighths and spreads. The belief that these attempts were in fact both widespread and successful is based substantially on Michael Barclay's (1997) study of decreases in the spreads of stocks that moved from NASDAQ to the New York or American stock exchanges (NYSE/Amex). The fact that spreads on the dealer-structured NASDAQ exchange generally have been higher than those on NYSE/Amex, in large measure because NASDAQ prices include commissions that are not otherwise charged, has long been recognized. But Barclay found that the spreads on stocks that had been quoted on NASDAQ almost entirely on even-eighths (even stocks) decreased substantially more than spreads on stocks quoted on both even and odd eighths (mixed stocks) when the corporations moved to NYSE/Amex. This finding lead him to conclude (following some analyses) that NASDAQ markers had "avoided" mixed eighths as a means of increasing spreads to super-competitive levels.

Christie and Schultz (1994) studied 200 stocks, 100 traded on NASDAQ and 100 on the NYSE. They were surprised to find that about 70 percent of the NASDAQ stocks were quoted with both inside best bids and offers (BBO) on even eighths, compared to about half on the NYSE. Unable to determine the reason for this difference, they concluded that even-eighths quotation was a collusive device. When stocks are quoted only on even eighths, the one-eighth spread is obviated, resulting in higher quoted spreads and, presumably, higher actual transaction prices. Although they did not actually look at spreads, a

companion paper with Jeffrey Harris (Christie et al., 1994) reported and, in dramatic figures, showed immediate and dramatic drops in quoted and effective spreads on four of the five most heavily traded of the 70 even stocks they studied on the day after Christie-Schultz's findings were publicized by the press (May 26, 1994).[1] Their paper was awarded the Smith Breeden prize for the best Journal of Finance article, conferences followed (one of which gave rise to a 1997 special issue of the Journal of Financial Economics), and they published a paper in the Journal of Economic Perspectives in which they described how their research revealed and broke a major price-fixing scheme (Christie and Schultz, 1995).

Barclay (1997) is perhaps the most important research paper that convinced academics and possibly NASDAQ market-maker defendants to settle a class-action lawsuit (In re: NASDAQ Market Makers Antitrust Litigation; Barclay was an expert witness for the plaintiffs) for $925 million and NASDAQ to agree to an $875 thousand SEC fine and substantial operating changes. Previously, Christie and Huang (1994) found a significant decline in bid-ask spreads when stocks moved from NASDAQ to NYSE/Amex. Barclay expanded their study with data from 472 stocks that moved in 1983 through 1992. His innovation was to separate the stocks into those quoted when on NASDAQ in even- and on mixed-eighths and to examine their spreads in the sixty trading days before and the sixty trading days after their moves.

Barclay's research design is simple. As he states in his introduction (Barclay, 1997, p. 36): "If NASDAQ spreads are competitive, and the cross-sectional variation in spreads reflects differential costs of market making, then securities for which market makers avoid odd-eighth quotes on Nasdaq should continue to have larger spreads when they move to the NYSE or Amex." He does not offer any evidence that market makers "avoided" rather than simply did not post mixed-eighth quotes. But, using several spread metrics, he finds a dramatic, immediate reduction in the average percentage of quotes in even eighths and in effective half-spreads (and other spreads) on even, but not on mixed stocks, on the first and subsequent 59 days after stocks moved from NASDAQ to NYSE/Amex. He presents these results in figures similar to those presented by Christie et al. (1994). Figure 1 shows the percentage effective half spreads (price less the best bid and offer midpoint, BBOM, divided by BBOM) from 1983 through May 25, 1994, after which date the collusion among NASDAQ market makers presumably was ended (Christie and Schultz, 1995).[2] As was the situation with Christie et al.'s figures, Barclay appears to have found the

[1] Kleiden and Willig (1995), Godek (1996), Grossman et al. (1997) and Bessembinder and Kaufman (1997) find that this reaction is not present in the other even stocks studied by Christie and Schultz (1994) and in a larger sample of 300 stocks.

[2] Barclay's (1997) figures present the dollar effective half-spreads (price less BBOM). Because the average price per share of even stocks is almost twice that of mixed stocks, this metric is not appropriate for comparing spreads on even and mixed stocks. Figure 1 includes 677 observations; Barclay used 472 observations through 1992. Each data point is a simple average of stocks that were traded on each of the 60 days before and after the move from NASDAQ to NYSE/Amex.

proverbial "smoking gun" that demonstrates the postulated positive relationship between market makers' "avoidance" of mixed-eighths quotes and higher spreads.

Figure 1 about here

I replicated and extended Barclay's study in order to determine whether NASDAQ market makers actually could successfully carry out a collusive scheme (implicitly or explicitly) to increase spreads.[3] Two market makers are required to set a quoted spread, one the offer and the other the bid. As documented by Chan et al. (1995), market makers almost never offer both the inside bid and ask. The product traded is a commodity with many very close substitutes that are bought and sold repeatedly by many sophisticated, experienced, and knowledgeable customers (mutual and pension fund managers, among others). There are no barriers to entry, the usual *sine qua non* of competitive markets, because any of more than 500 market makers can offer bids and asks on any NASDAQ security with two days notice. Nevertheless, from conversations with finance professors and newly minted Ph.D. faculty prospects, I conclude that the profession generally accepts Barclay's (1997, p. 60) conclusion "that the avoidance of odd-eighths [mixed] quotes is [was] used as a coordination device among Nasdaq market makers to increase bid-ask spreads to supra-competitive levels." If this were not the case, they say, what could explain his finding that even but not mixed NASDAQ stocks experienced dramatic declines in spreads when they moved to NYSE/Amex?

The "missing link" is an understanding and appreciation of the risks faced by NASDAQ market makers as dealers and the effect of those risks on the prices and depth quoted (offered), particularly compared to the way prices and depth are determined on NYSE/Amex, as well as a closer examination of the data. Unlike NYSE/Amex specialists, until 1997 NASDAQ market makers had to post and honor bids and offers for at least 1000 shares. In addition, trades made through NASDAQ's small order execution system (SOES, which was mandatory by the SEC after June 1988 as a result of investors' inability to contact market makers by telephone during the 1987 market crash) could be made at the posted prices for up to 5000 shares before market makers could change those prices. In effect, traders with NASDAQ market makers had open options on stocks posted at quoted prices. Market makers could deal with this risk by keeping a constant vigil on stock movements, by reducing the number of stocks in which they made markets, and/or by increasing quoted offers and decreasing quoted bids.[4] The latter strategy is more likely to be used for stocks with relatively few transactions and for stocks for which trading by insiders is more

[3] In 1995 I was engaged by the NASD to review the Christie and Schultz (1994) and Christie et al. (1994) papers and to examine the issue empirically with Robert Wood. I was never involved in the legal actions against the NASD or NASDAQ market makers. The present paper was not a part of that examination nor was it supported, directly or indirectly, by any private (non-university) organization or person.

[4] See Copeland and Galai (1983) and Gosten and Milgrom (1985) for models showing that market makers adjust their prices to offset losses to better-informed traders.

likely to occur (Benston and Hagerman, 1974). Furthermore, given the general tendency for people to use even rather than odd numbers for large prices, wider quotes are more likely to be in evens than in odds or both odds and evens.[5]

As noted in the DOJ Report (1996, p. 12), "if a market maker's dealer spread in a stock is ¾ point (75 cents) or wider, the market maker is required to quote its bid and ask prices in even-eighth increments …. This ensures that the inside spread in those stocks is maintained at ¼ point (25 cents), or greater." Once trading in a stock has begun, changes in quotes by two eighths are as likely to narrow as widen quoted spreads above four eighths. Thus, if there were collusion among market makers, it would be effective primarily as a means of eliminating the possibility of the one-eighth quoted spread, which would increase the trading costs of the market makers' customers who purchased or sold stock at the quotes and would limit negotiation possibilities for other customers. But, customers who faced a quoted mixed spread of, say, five eighths would not be better off than if the spread were even at four eighths. It is important, therefore, to distinguish between even stocks quoted at spreads above and at two eighths.

I took these considerations into account in my extension and replication of Barclay's study. First, analysis of the data shows that there really three distinct samples: (1) mixed stocks with quoted spreads (QS) of one eighth (average on NASDAQ in the sixty pre-move days of less than two eighths); these stocks cannot change when stocks move from NASDAQ to NYSE/Amex; (2) stocks with both mixed and even QS; and (3) stocks for which there are only even QS. Figure 2A shows this distribution for the 677 stocks that moved from NASDAQ to NYSE/Amex from 1983 through May 25, 1994, when, according to Christie and Schultz (1995), the collusion to increase spreads among NASDAQ market makers was disclosed and stopped. Figure 2B shows the percentages of QS eighths for the even- and mixed-eighth sub-samples separately. About two-thirds (65.1%) of the mixed sub-sample have average NADSAQ QS < 2 eighths, with balance (34.9%) having QS of 2 ≤ 5. In contrast, 79.0 percent of the even sub-sample is in this overlapping QS range, with the balance (21.0%) having QS > 5.

Figures 2A and 2B about here

As shown in Figure 3, although there are relatively few stocks with large QS, the decreases in %EHS when these stocks moved from NASDAQ to NYSE/Amex are particularly great. Figure 3 also shows that there is but a small change in %EHS for the mixed stocks with QS averaging less than two eighths. However, for stocks with QS that include both mixed and even stocks, the decrease in %EHS is greater for the mixed than for the even stocks.

Figure 3 about here

[5] Grossman et al. (1997) give many examples of quotes in even numbers that follow this pattern.

Including stocks with average QS below two eighths biases the average change %EHS of mixed stocks downward, since there is almost no room for the transaction prices to change when the stocks move from NASDAQ to NYSE/Amex. Furthermore, these stocks can provide no evidence of collusion on NASDAQ that was stopped when the stocks moved to NYSE/Amex, as presumably they had not previously been subject to collusion on NASDAQ. As is shown below, stocks with QS of twelve eighths ($1.50) and above are very different from other stocks, in that they are much more subject to informed trading. With stocks with QS of one eighth or less and those with QS of twelve eighths and above excluded, the %EHS presented in Figure 1 are very different, as shown in Figure 4. Indeed, %EHS decreased more on mixed than on even stocks, contrary to the "NASDAQ-collusion" hypothesis.

Figure 4 about here

Thus, the evidence that %EHS decreased more on even than on mixed stocks is due entirely to stocks with QS of twelve eighths or more. These 21 even stocks have much lower daily dollar transactions, lower market capitalizations, and fewer market makers and trades among dealers than other even stocks. It is possible that NASDAQ firms that made markets in these stocks did collude to widen spreads. However, as shown below, they could have gained little from such collusion. Thus, this is a weak reed, indeed, on which to base a conclusion that NASDAQ market makers in general colluded.

I also examined whether, as claimed by Christie and Schultz (1995), exposure of their results ended the presumed collusion and, hence, elimination of the difference in the decrease of %EHS between even and mixed stocks. Figures 5A and 5B present the move-related decreases in %EHS for each of the 515 even and 237 mixed stocks over the years 1983 through 1997. It is clear that there was no meaningful change in the decrease experienced by even compared to mixed stocks before and after Christie and Schultz's findings were publicized. Consequently, I find no support for Barclay's (1997, p. 32) conclusion that "the avoidance of even-eighths quotes is used as a coordination device among Nasdaq market makers to maintain supra-competitive bid-ask prices."

Figure 5 about here

2. The Sample

I identified all 1,430 stocks that had moved from NASDAQ to either the NYSE or Amex from January 2, 1983 through December 31, 1999.[6] Closing prices, quotations, and other data for the sixty trading days before (taken from CRSP) and after (prices and volume taken from CRSP and quotations

[6] Observations with the following condition codes were excluded: TAQ: D, I, N, P, S, V, W, Z, C, FG, L, X; ISSM: 0, 3, 4, 5, 6, 7, 8, 11, 13, 14, 15, 16, 17, 18, 19, 20, 27, 28, 29.

from TAQ or ISSM) a stock moved were recorded.[7] Where the CRSP price was negative (volume = 0), indicating no trading for a particular day, that day was eliminated from the analysis. To exclude data that were incorrect, I rejected quoted and effective spreads using the algorithm described in the footnote and used the next latest data on that day.[8] Stock prices and quotes were adjusted for splits and stock dividends going forward, so that NASDAQ numbers dominated. Daily stock prices and quotes were weighted by the dollar volume traded on each day of each period to obtain volume-weighted averages for each period for each stock.[9] Stocks were classified as "even" when 75 percent of pairs of best bid and offer quotes (BBO) on NASDAQ were both at even eighths, following Christie and Schultz (1994). The other stocks were classified as "mixed."[10]

Two of the 1,430 stocks were omitted because they had very large share prices; including them affects only the average price per share. No NASDAQ or NYSE/Amex data were available for 215 stocks. The 169 stocks that moved in 1998 and 1999 were omitted because all but two were quoted on NASDAQ on mixed-eighths. The two even stocks had 33 and 31 days with no trades and decreases in %EHS of 0.99 and 2.07. This left 1,044 stocks for analysis.

Prior to conducting the analysis, I compared the data presented by Barclay (1997) in his Table 1 with the calculations I made from the same sample of 472 stocks and from a larger sample of 583 observations that includes all stocks that moved during the same time period, both daily-volume weighted and unweighted (for comparison).[11] There are but small differences among the percentage and dollar quoted half-spreads and effective half-spreads among the three samples. [The table is included in an appendix for the benefit of the referee and could be included in the paper if the editor so wishes.] I find, as did Barclay, greater decreases in spreads associated with even-eighths stocks. My daily trading dollar volume is greater than Barclay's. I included only days on which there were trades; Barclay (1997) does not indicate what he did. The largest difference is the decrease in the percentage of even-eighth quotes on even stocks. Barclay (1997, Table 1) reports an average decrease of 43 percent. I find decreases of 61 – 65 percent for the weighted and unweighted samples. I believe the difference is due to Barclay's method

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[7] Barclay [1997, p. 52] reports: "The results using the full transaction record … are similar to the results using daily closing prices and quotations." Hence, I did not attempt to get these data, much of which were not available to me.

[8] Delete if relative effective spread (RES) >= 20% and (1) the price per share (PPS) or bid or ask >= 5.00, or (2) PPS < 5.00 and PPS < bid or PPS > ask.

[9] Barclay does not appear to have done this, as no mention is made of weighting (or not).

[10] Barclay calls these "odd-eighths" stocks. I prefer "mixed," as a stock quoted on odd eighths at both the bid and offer would have an even-eighths spread and would exclude one-eighth quoted spreads. Barclay classified as "even" stocks with 90 percent of all even-eighth bid or ask quotes, regardless of the other side of the quote, which violates the underlying even-eighths hypothesis. However, if no stocks were quoted with both bids and asks in odd eighths, Barclay's 90% rule is the equivalent of an 80% paired even-eighths procedure. Considering that some stocks are quoted with both bids and asks on odd-eighths, I concluded that Barclay's procedure was close to the Christie-Schultz rule that touched off the controversy.

[11] Barclay kindly provided a list of the stocks included in his study, but he was unable to identify those he classified as even and mixed. I do not know why I found more stocks than Barclay used in his study.

of counting even eighths. Although counting all even bids and asks does not impart much of a bias for even NASDAQ stocks (since, as discussed earlier, almost all of the quotes are on even eighths), the fact that there are many more mixed stocks on NYSE/Amex results in a much larger number of bid and ask evens quotations that are not paired with ask and bid even quotations.

3. Movements of stock from NASDAQ to NYSE/Amex before the Publication on May 25, 1994 of the Christie-Schultz (CS) "Finding" of Collusion on NASDAQ

Christie and Schultz (1995, p. 203) state: "[we] concluded that our [Christie and Schultz, 1994] results most likely reflected an understanding or implicit agreement among the market makers to avoid the use of odd-eighth price fractions when quoting these stocks." This conclusion was confirmed, they say, when, immediately following publication of their findings by the Los Angeles Times on May 26, 1994, "[o]vernight, the market makers in these stocks abandoned a pricing practice that had been followed for at least the previous three years [ibid, p. 206, emphasis added]." If, as Christie and Schultz (1995) claim, the price-fixing collusion had been exposed and stopped, the NASDAQ to NYSE/Amex data would be contaminated by including stocks that changed markets after May 26, 1994. Consequently, I first examine the 362 even and 315 mixed stocks, 53.5 and 46.5 percent of the 677 stocks that moved from NASDAQ to NYSE/Amex from January 1983 through May 25, 1994.

Table 1 presents the data for the 677 pre-Christie-Schultz stocks disaggregated according to the stocks' NASDAQ quoted half-spreads (QHS). As shown in Panel A, average %EHS on even stocks are substantially higher for NASDAQ stocks with greater QHS, increasing from 0.99 on stocks with QHS of .125 < .25 to 3.58 on stocks with QHS of .75+. For mixed stocks, NASDAQ %EHS is higher for greater QHS, although the increase is not as great since the largest QHS is .340, included in the .25 < .375 group. As shown in Panel B, the patterns are similar for %QHS (percentage quoted half-spreads).[12]

Table 1 about here

The decrease in %EHS after the stocks moved to NYSE/Amex is only 0.31 for mixed stocks with QHS < .125, since there is little scope for change, and zero for %QHS, since .125 is the minimum quoted spread on both NASDAQ and NYSE/Amex. Among QHS groups for which there are both even and mixed stocks, %EHS decrease more for mixed than for even stocks: 0.35 for QHS of .125 < .25 (significant at .00 level) and 0.77 for QHS of .25 < .375 (significant at .09 level, as there are only 13 mixed stocks). For both groups with even and mixed stocks combined (QHS .125 <.375), the decrease in %EHS is greater for

[12]Quoted half-spreads are not as relevant as effective half-spreads, which report actual prices paid and received by investors. The dollar amount of effective half-spreads is not appropriate for comparing even and mixed stocks, because (as shown in Barclay, 1997, Table 1), the price per share of even stocks is almost twice as great as the price per share on mixed stocks, and because investors spreads should relate to the dollars they are investing (divesting) rather than to the number of share they are purchasing (selling).

mixed than for even stocks (0.24, significant at the .02 level). A large percentage decrease (1.78) is found for the 55 even stocks with QHS of .375 < .75, and the largest decrease (3.24) occurs for the 21 even stocks with QHS of .75+. With these 21 even stocks and the 205 mixed stocks with QHS < .125 removed from the data, the mean decrease in %EHS for even stocks is 0.96 compared to 1.05 for mixed stocks. The difference between these two numbers is significantly different from zero only at the .23 level. The findings are similar for %QHS.

The daily trading dollar volume ($thousands) reported in Panel C shows that mixed stocks with QHS of <.125 and even stocks with QHS of .125 < .25 had much higher NASDAQ volumes than stocks with wider QHS. When these stocks moved to NYSE/Amex their trading volumes decreased substantially, reflecting higher NASDAQ volumes due to market makers' trades with each other. The most revealing statistic is the NASDAQ trading volume of even stocks with QHS of .375 and greater. The trading volume of the 55 even stocks with QHS of .375 <.75 is but 16 and 34 percent of trading volume of even stocks with QHS of .125 < .25 and those with QHS of .25 < .375. The trading volume of the 21 even stocks with QHS of .75+ is just 3 and 7 percent of the volume of those lower-QHS even stocks. Furthermore, their trading volume increases when these stocks move to NYSE/Amex. These data are consistent with the hypothesis that the reason these stocks have larger QHS is because market makers increase asks and decrease bids to protect themselves from informed trades of thinly traded stocks. Volume also may be lower because market makers do not often trade these stocks among themselves. One explanation for the changes is that, when these stocks move to NYSE/Amex, the prices are set predominantly by presumably informed limit orders. Volume increases, perhaps because informed investors face lower spreads due to the reduced cost of adverse selection. Another explanation that I examine later (in section 5) is that NASDAQ market makers did indeed collude to increase spreads on these stocks.

Panel D shows the number of NASDAQ market makers for even and mixed stocks. Although there are fewer market makers for mixed stocks within the entire sample (10.7 vs. 16.1, significant at the .00 level), the smaller even-stock number is due to the stocks with QHS of .375 and greater, and particularly to those with QHS of .75+. Otherwise, more market makers deal with even than mixed stocks, a finding that is consistent with greater or at least equivalent competition for those stocks than for mixed stocks.

Panels E and F provide additional data that support the earlier finding that even stocks with large QHS, particularly the 21 with QHS of .75+, are very different from other even and mixed stocks. Panel E shows that no trades took place on 20.8 of the 60 trading days before the stocks moved from NASDAQ, compared to 2.9 days for even stocks with QHS less than .375. Panel F shows that corporations that

issued these stocks are relatively small. Their capitalization is only $89.8 million compared to $321.2 million for even stocks with QHS less than .375.

Nor are the wide spreads that are associated with low levels of trading and capitalization limited to even stocks. Figure 3 shows a very large change in %EHS for the three mixed stocks at the 5 eighths quoted spread mark. These stocks have NASDAQ daily volume of 5, 9, and 18 thousand dollars, are traded by 2.4, 2.8, and 4.0 market makers, and have capitalization of 10.6, 9.1, and 41.4 million dollars.

Following Barclay (1997, pp. 48-51) I examine the changes in %EHS further with regression analysis. He posits that %EHS are determined by the percentage of even-eighth quote pairs (PEQ, expressed in decimals), the inverse of price-per-share (1/PPS), risk as measured by standard deviation of price-per-share (SDPPS), log dollar volume ($thousands) (logDV), log number of market makers (logMM), and a constant (CON).[13] I assume that the coefficients of the variables are the same for NASDAQ and NYSE/Amex and that the dollar volume (DV) of NASDAQ stocks is equated to the DV on NYSE/Amex stocks by a fixed factor (ff > 1 for NASDAQ, ff = 1 for NYSE/Amex). Since DV is higher on NASDAQ due to inter-dealer trades and the number of NYSE/Amex market makers is one, the relationship between SP and the independent variables, where m = market (NASDAQ or NYSE/Amex), is:

(1) $\%EHS_m = CON_m + b_1\ PEQ_m + b_2\ 1/PPS_m + b_3\ SDPPS_m + b_4\ \log(DV * ff)_m + b_5\ logMM_m$.

The change in effective spreads, then, that is analyzed with regression analysis is equation (1) for NASDAQ less equation (1) for NYSE/Amex, where the differences in the variables are denoted by d:

(2) $\%EHS_d = (CON_d + \log ff_{nms}) + b_1\ PEQ_d + b_2\ 1/PPS_d + b_3\ SDPPS_d + b_4\ logDV_d + b_5\ logMM_{nms}$.

Barclay (1997) did not present these equations and included logDV for NASDAQ and for NYSE as separate independent variables. This procedure potentially imparts a problem in interpretation, because (as noted earlier) dollar volume is low for NASDAQ stocks with large QHS; hence, this variable measures the presence of high QHS stocks, which tend to be even stocks. The question, discussed later, is which way the causation runs – high QHS result in low volume or low volume results in high QHS.

Table 2 Panel A presents the coefficients estimated with the 396 stocks for which both even and mixed stocks have roughly equivalent QHS: 286 even stocks and 110 mixed stocks with QHS of .125 < .375.[14] Column [1] does not include the dollar volume (DV) variables, column [2] includes log NASDAQ DV and NYSE/Amex DV as separate independent variables, and column [3] replaces those variables with

[13] As noted earlier, Barclay used the number of even quotes rather than even-quote pairs; he describes (and does not otherwise discuss) risk as "return standard deviation."

[14] As discussed earlier, it would misleading to include the stocks with QHS < .125, as these are only mixed stocks with spreads that cannot change much (since both trading venues have minimum one-eighth quoted spreads), and no point in including the even stocks that have no mixed-stock counterparts, particularly because it is already known that these even stocks have large NASDAQ spreads that decline substantially when the stocks move to NYSE/Amex.

$logDV_d$ (log NASDAQ DV less log NYSE/Amex DV) as shown in equation 2. The mean relationship of PEQ_d on the change in effective half-spreads is calculated by multiplying the coefficients of the variable by the difference in the mean change in PEQ of even and mixed stocks.

Table 2 about here

The coefficient of PEQ_d in the change in %EHS regression [1] is negative and insignificant, a result that is inconsistent with the collusion hypothesis. With log NADSAQ DV and/or log NYSE/Amex DV included separately (the two variables' Pearson correlation coefficient is .92) in regression [2], the coefficient of PEQ_d, is significant (.01 level). However, this result is potentially misleading, as the DV variables also measure the relationship of low dollar volumes and spreads due to NASDAQ market makers' risk avoidance rather than their avoidance of even-eighth quote pairs. With the DV variables entered as specified in equation 2 (regression [3]), the coefficient is insignificant and the effect of a mean change in even compared to mixed stocks is -0.01.

Before considering the extent to which the findings presented earlier are indicative of collusion among NASDAQ market makers, as shown by their having "avoided" even-eighth quotes, or the effect of differences in adverse selection risk faced by NASDAQ market makers and NYSE/Amex specialists and limit-order traders, I examine the changes in %EHS after Christie and Schultz's findings were publicized. This examination should provide evidence that will help distinguish between the alternative hypotheses.

4. The Christie-Schultz (CS) Effect

Christie et al. (1994) present what appears to be a very strong case for the existence of collusion among NASDAQ market makers to increase spreads by avoiding even-eighth quotes by showing that, within a few days of the publication of Christie and Schultz's (1994) findings on May 26, 1994, the quoted and effective spreads on four of the five most heavily traded of the 70 even-eighths-quoted NASDAQ stocks they previously studied declined sharply, from two to one eighth. Christie and Schultz (1995) state: "[o]vernight, the market makers in these stocks abandoned a pricing practice that had been followed for at least the previous three years [p. 206, emphasis added]." Furthermore, investigations conducted by the DOJ (1996) and SEC (1996) prompted by Christie and Schultz (1994) and Christie et al. (1994), charging NASDAQ market makers with price fixing and collusion to fix prices by avoiding odd-eighth quotes, were undertaken and published and market makers accepted a $925 million private-legal-action settlement and $875 thousand SEC fine. Surely, market makers who had been colluding to increase spreads by avoiding mixed quotes would have abandoned this practice at least by 1996 in the face of the publicity, government examinations, and pending lawsuits.

Thus, if there were collusion and it were stopped, as Christie et al. (1994) and Christie and Schultz (1995) claim, after May 26, 1994 the %EHS and %QHS on the even stocks that moved from NASDAQ to NYSE/Amex should have decreased by the same amount as mixed stocks decreased. At the least, the decrease on even relative to mixed stocks should be substantially less pronounced. Barclay, whose paper was received by the Journal of Financial Economics in a revised form in November 1996 (and who properly identified himself "as a consultant to the plaintiffs in the In re: Nasdaq Market Makers Antitrust Litigation") could have tested, but did not, for the change in spreads that should have occurred had market makers been colluding before this practice was revealed and criticized. I now conduct a test by examining the stocks that moved from NASDAQ to NYSE/Amex after May 26, 1994 through December 31, 1997, termed the "post-CS (Christie-Schultz) period."

Table 3 presents the data for the post-CS period in the same way as presented in Table 1 for the pre-CS period. Between the two time periods, changes in the economy and the markets as well as changes in the sample probably affected the variables. Perhaps the most interesting change (from the perspective of this analysis) is the percentage of even stocks when the stocks were traded on NASDAQ. The percentage declined from 53.5 percent in the pre-CS period to 41.7 percent in the post-CS period (Panels G in Tables 1 and 3). If this decline were a result of collusion having stopped, there should also have been at least a reduction in the decrease in the %EHS and %QHS on even compared to mixed stocks when these stocks moved from NASDAQ to NYSE/Amex. Daily trading dollar volume (Panels C) was generally greater in the post-CS period, particularly for mixed stocks both on NASDAQ and NYSE/Amex. The number of NASDAQ market makers (Panels D) and days with no transactions (Panels E) were roughly similar in both periods, and capitalization (Panels F) was greater.

Table 3 about here

According to collusion hypothesis, both before and after CS, NASDAQ market makers did not collude to widen the spreads on mixed stocks; hence, these stocks serve as a control. If the alleged collusion were broken (as claimed by CS), the level of %EHS and %QHS on even compared to mixed stocks in the post-CS period should be smaller than in the pre-CS period and the decrease the same as the decrease of mixed stocks.

As shown in Panels A of Tables 3 and 1, NASDAQ %EHS on all even stocks did go down by 0.20, from 1.50 to 1.30, while %EHS on all mixed stocks declined by 0.26 from 1.26 to 1.00. For the stocks with similar QHS (.125 < .375), NASDAQ %EHS on even stocks declined by 0.17 (from 1.22 to 1.05) and by 0.65 for mixed stocks (from 1.74 to 1.09). Thus, if mixed stocks were the benchmark (as hypothesized by the collusion hypothesis), %EHS on even stocks should have declined as did %EHS on mixed stocks if the

collusion had ceased. By this measure, it would appear that collusion against even stocks increased in the post-CS period. For all stocks, the difference in the decrease in %EHS when these stocks moved from NASDAQ was significantly lower by 0.09 (0.53 vs. 0.44). However, for stocks with similar QHS, the even vs. mixed difference in the post-CS period was only 0.03 (not significant), compared to -0.24 (significant at the .02 level) in the pre-CS sample. Thus, by this measure, collusion did cease post CS, but only if the collusion pre CS had been against mixed rather than even stocks. The results are similar for %QHS, as shown in Panels B of Tables 3 and 1.

These direct comparisons between periods do not account for other changes that might affect %EHS. Hence, I computed the regressions presented in Table 2 Panel A with data from the post-CS period. The coefficients are presented in Panel B of the table. The coefficients for the change in even-eighth pairs (PEQ_d) in the post-CS periods are insignificant (equations [4] and [6]), as are the similar coefficients in the pre-CS period (equations [1] and [3]) and, where significant, are higher in the post-CS period (equations [5] and [2]), indicating an increase in collusion. This result confirms the conclusion drawn from the univariate analysis that if there were collusion manifested by higher spreads on even stocks, it did not change or increased after May 26, 1995.

It is possible that the effect on presumably colluding NASDAQ market makers was not as abrupt as Christie and Schultz (1995) claim. After all, one of the four stocks that experienced a 50 percent drop in spreads was Microsoft, which just before CS had a two-for-one stock split. And, as Kleiden and Willig (1995), Godek (1996), and Grossman et al. (1997) show, the spreads on none of the other 65 even stocks Christie and Schultz (1994) studied declined when their findings were publicized. Bessembinder and Kaufman (1997, p. 306) also conclude: “In contrast to the results that Christie, Harris, and Schultz report for their sample of five companies, average quoted half-spreads for our broad set of 300 NADAQ issues did not decline [but did increase] subsequent to May 1994.” In any event, the DOJ and SEC investigations and class-action lawsuit should have stopped a collusion, if it existed. Consequently, I examined graphically the changes (almost all decreases) in %EHS of the individual even and mixed stocks over the entire period, 1983 through 1997. I excluded mixed stocks with QHS of less than 0.125, since, as noted earlier, there is little scope for changes in EHS.

Figure 5 presents the changes in %EHS for each of the even (Panel A) and each of the mixed (Panel B) stocks at the time it moved from NASDAQ to NYSE/Amex, with the years in which the move occurred given on the horizontal axis. The date when Christie and Schultz’s (1994) findings were publicized is denoted with a dashed vertical line labeled “CS.” It is clear from these figures that post-CS there was no substantial decrease in %EHS on even compared to mixed stocks or, indeed, on even stocks

alone, as would have occurred had there been a collusion that was either unmasked and stopped or, at least, disrupted.

5. Alternative Hypotheses With Respect to Percentage Effective Half Spreads (%EHS) on Even Stocks with Quoted Half Spreads (QHS) of .375 or Greater

The analysis presented above shows that the greater decreases in average %EHS (and %QHS) experienced by even stocks compared to mixed stocks that moved from NASDAQ to NYSE/Amex in the pre-CS period are due to the 21 stocks with QHS of .75+ (3.1% of that sample). The same conclusion holds for post-CS period for the 11 stocks with QHS of .75+ (3.0% of that sample). NASDAQ market makers might have colluded to avoid odd quotes on these stocks, thereby widening the half spreads by .0625, which at the pre-CS average price per share is 0.23 percent for stocks with QHS of .75+. As shown in Panel A of Table 1, %EHS decreased by 3.24 for stocks with QHS of .75+. Thus, if NASDAQ market makers increased %EHS by avoiding odd quotes, most of the decrease in %EHS when these stocks moved was due either to some other form of collusion or to other factors.

With respect to collusion, a question that should be considered is what the benefit to anti-trust-law breakers would be from colluding to widen the %EHS on these stocks. One benefit might be that fewer market makers deal in these stocks – 3.3 compared to 11.2 for even stocks with lower QHS (as shown in Panel D of Table 1) – making collusion somewhat easier to effect. However, these stocks have relatively low volumes and many days in which there are no trades. Hence, the potential gains from collusion are relatively small.

An alternative hypothesis is that the higher %EHS (and %QHS) on stocks with high QHS is due to market makers' concerns about adverse selection. As shown in Panel C of Table 1, the daily trading volume is much lower on these stocks than on stocks with lower QHS. The number of days with no trades is greater (Panel E) and capitalization is lower (Panel F). As noted earlier, spreads on these stocks on NYSE/Amex probably are set predominantly by presumably informed limit orders. In contrast, NADSAQ market makers, who typically posted quotes for at least 1000 shares, were faced with trades by informed traders, particularly insiders and others with knowledge about these smaller corporations (Benston and Hagerman, 1974). Furthermore, in much of the period studied, market makers had to deal with trades by day traders made through NASDAQ's small order execution system (SOES), which had to be filled at the prices quoted for up to 5000 shares before market makers could change their quotes. I suggest that this difference in how prices are established on NYSE/Amex compared to NASDAQ explains the greater decrease in %EHS on even stocks with high QHS.

6. Summary and Conclusions

In the introduction to his article, Barclay (1997, p. 36) states: "If Nasdaq spreads are competitive, and the cross-sectional variation in spreads reflects differential costs of market making, then securities for which market makers avoid odd-eighth quotes on Nasdaq should continue to have larger spreads when they move to the NYSE or Amex." As noted earlier, he does not offer any evidence that market makers "avoided" mixed-eighth quotes. Rather, he simply finds that, in the aggregate, percentage effective half spreads (%EHS) decrease more on stocks that are quoted on even eighths compared to those quoted on mixed eighths. This finding is based on averages of closing prices on 472 stocks over sixty trading days before and after movement from NASDAQ over the years 1983-1992, prices that do not appear to have been value weighted.

I extended the sample to all movements through 1999, but excluded 1998 and 1999 when I found that only two of the 169 stocks had been quoted on even eighths. Unlike Barclay (1997), I considered a NASDAQ-specific cost – the risk to market makers of having informed traders pick off their stale and insufficient quotes at the posted depth of at least 1000 shares (5000 if the trade was through NASDAQ's mandatory small order execution system – SOES).[15] This risk is indicated by low average daily trading volume, many days with no trades, and lower capitalization – the smaller the volume, days traded, and capitalization, the greater the risk and the wider the quoted spread. Not surprisingly (given the general propensity to use even rather than odd digits for relatively large numbers), stocks with large quoted half spreads (QHS of .375 and greater) tend to be quoted on even eighths.

Only mixed stocks (necessarily) have QHS of less than .125 and these stocks are 65.1 percent of the mixed sample. Since this is the minimum quote spread for stocks on both NASDAQ and NYSE/Amex, there is but a small decline in effective spreads when these stocks move from NASDAQ to NYSE/Amex. Hence, these stocks are irrelevant for tests of Barclay's collusion hypothesis. Furthermore, including them in the sample biases (reduces) the average decrease in mixed stocks' %EHS and %QHS.

Among stocks with QHS of .125 > .375 before May 26, 1994 (when publicity of the Christie-Schultz (1994) finding presumably broke the NADSAQ pricing collusion), I find that %EHS of mixed stocks decreased significantly more than the decrease experienced by even stocks (1.05 vs. 0.81). This result is confirmed with regression analyses that account for stock (but not trading venue) related variables.

[15]When Barclay (1997, p. 55) separates his sample into 1983-1987 and 1988-1992, he finds that bid-ask spreads increase and that the increase "is solely attributable to the securities for which Nasdaq market makers avoided odd-eighth quotes." He does not consider that the effect of day trading through SOES, which became mandatory for Nasdaq market makers in June 1988. As shown in Benston and Wood (2006), this increase appears due to the greater risk from informed day trades faced by market makers, who in response tended to increase asks and decrease bids, thereby at least eliminating one-eighth quoted spreads.

Importantly, among stocks with quotes of .125 > .25, those for which collusively determined even-eighths quoting would unambiguously benefit market makers, mixed stocks' %EHS decreased significantly more than those on even stocks. Similar results are found for %QHS.

The entire univariate evidence of higher %EHS decreases in even stocks in the period before Christie and Schultz's (1994) findings charging collusion among NASDAQ market makers were publicized, therefore, rests on the 21 stocks with QHS of .375 or greater (3.1% of that sample). When traded on NASDAQ these stocks have much smaller daily trading volumes ($thousands, 94 vs. 1,923 for other even stocks), number of days with no trades (20.8 vs. 4.1), and smaller capitalization ($million, 89.8 vs. 294.9). I conclude, therefore, that the %EHS on these 21 even stocks decreased substantially when they moved from NASDAQ, not because they were free from collusion among NASDAQ market makers, but because, unlike quotes posted by NASDAQ market makers, the quotes on NYSE/Amex are set by presumably informed limit orders or bettered by specialists. If the QHS on these stocks really were the result of a collusion among NASDAQ market makers, one should ask "why these stocks?" They offer the least possible gain, as the average volume of trades is small. By "avoiding" mixed-eighths quotes and thereby increasing (rather than decreasing, which is just as likely) spreads by an eighth, colluding market makers might increase their gross profit by an average of $111 per day per stock (assuming no change in volume or costs).[16] That hardly seems to be a sufficient incentive for market makers to violate the antitrust laws.

As an additional (and, I submit, necessary) test of the collusion hypothesis, I examined the data over the period following publicity of the Christie-Schultz findings on May 26, 1994, after which they assert that market makers "abandoned" their practice of avoiding odd quotes (Christie and Schultz, 1995). Univariate and regression analysis similar to that conducted for stocks that moved before May 26, 1994 reveal that, if the decrease in effective spreads of even compared to mixed stocks were a valid indicator of collusion among NASDAQ market makers to widen spreads, such collusion increased rather than decreased. Since the presumed collusion may not have stopped gradually, I compared decrease in %EHS on even and mixed stocks graphically. There is no apparent difference between the pre- and post-CS revelation date, despite strong incentives for market makers to cease colluding to widen spreads, if that is what they were doing.

Barclay (1997, p. 59) concludes by offering "three potential explanations for the observation that bid-ask spreads are higher on Nasdaq on the NYSE: (1) Spreads are competitive and reflect the higher costs of market making for Nasdaq securities; (2) Spreads on Nasdaq are supra-competitive because of an inefficient market structure or institutional practices that suppress the incentives for price competition; and

[16] Trading volume of $94 per day x .125 (increase in spread) x (1 – 20.8/60 trading days) ÷ 21 stocks ÷ 3.3 market makers.

(3) Spreads on Nasdaq are supra-competitive because of implicit or explicit collusion by Nasdaq market makers." He offers no evidence on the second of these "potential explanations," but ends (ibid, p. 60) with: "These results support the conclusion that the avoidance of odd-eighth quotes is used as a coordination device among Nasdaq market makers to increase bid-ask spreads to supra-competitive levels." Barclay draws an incorrect conclusion because he does not adequately analyze an important, indeed vital, aspect of NASDAQ market makers' costs (the first explanation) – the risk of having to offer an option to informed traders to buy or sell shares at the posted price and depth (greater for SOES trades). NASDAQ market makers could (and I believe did) deal with this risk by increasing the sale and decreasing the purchase prices. This is not, I submit, evidence of collusion, explicit or implicit, but of the pricing one would expect in a competitive market.

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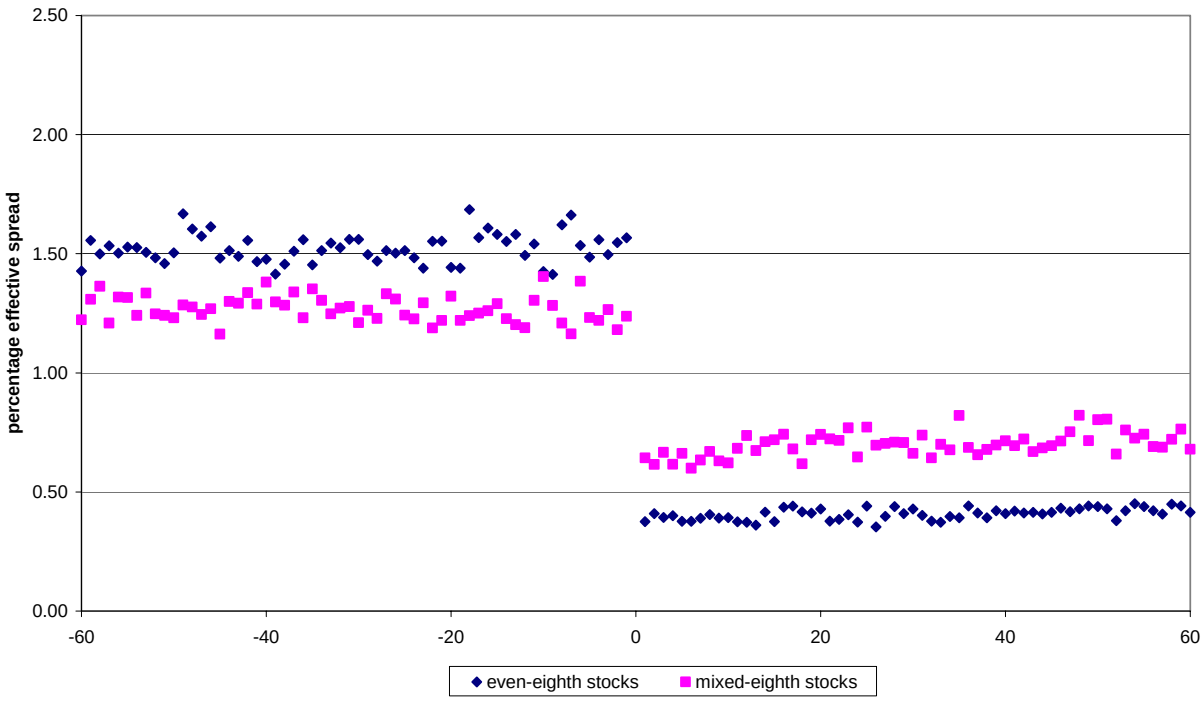


Figure 1. Effective percentage half-spreads (%EHS) on 362 even- and 315 mixed-eighths stocks 60 days before and 60 days after they moved from NASDAQ to the NYSE/Amex between 1983 and May 26, 1994, daily averages of all stocks with trades on that day. Even stocks have 75% of both their daily-volume-weighted closing best bid and offer quotes stated in even eighths during the 60 days the stocks were traded on NASDAQ.

Figure 2A. Percentages of total sample of 677 even- and mixed-eighth stocks

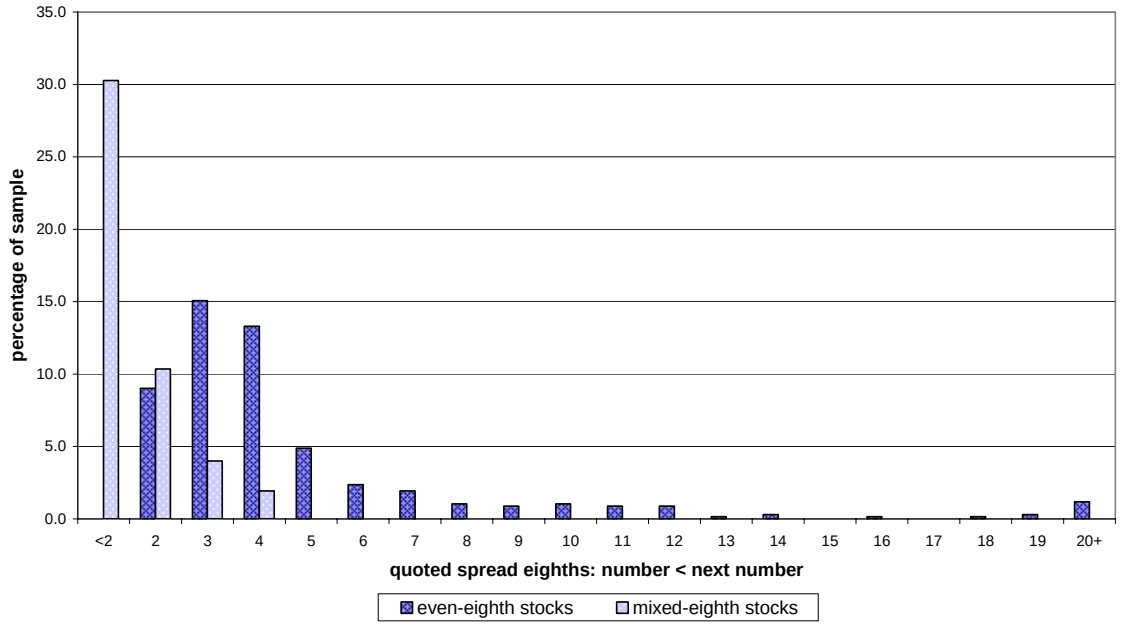


Figure 2B. Percentages of 362 even- and 315 mixed-eighth sub-samples

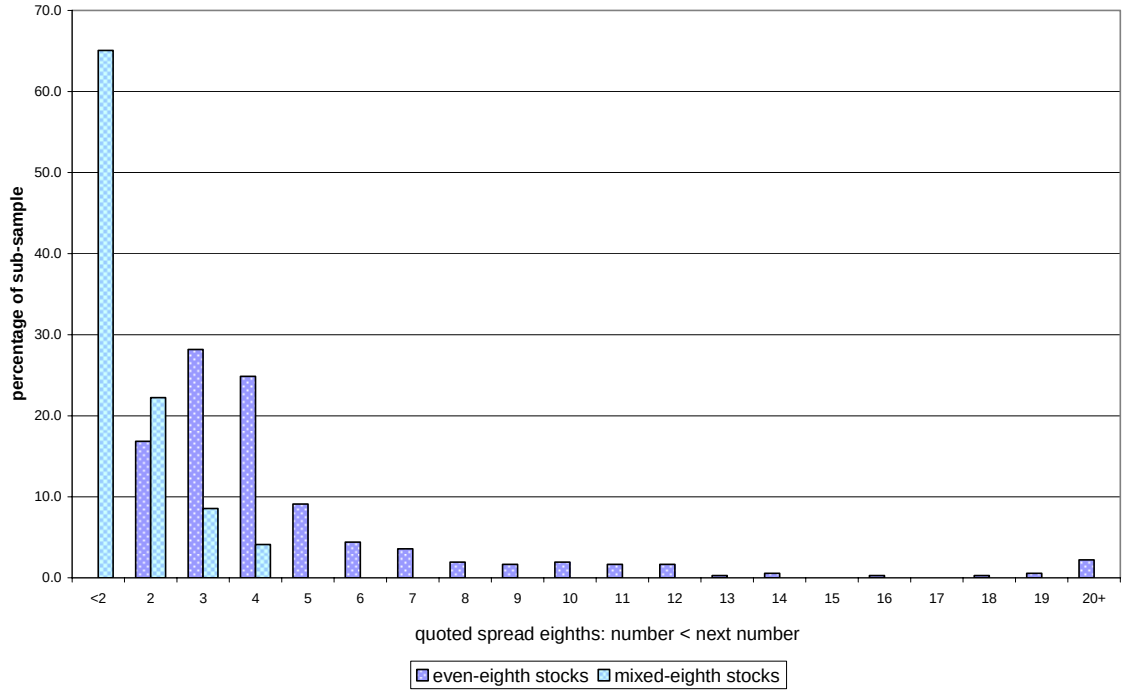


Figure 2. Percentage of total and sub-samples of stocks that moved from NASDAQ to NYSE/Amex in 1983 through May 25, 1994. Even stocks have 75% of both their daily-volume-weighted closing bid and offer quotes stated in even-eighths during the 60 days the stocks were traded on NASDAQ.

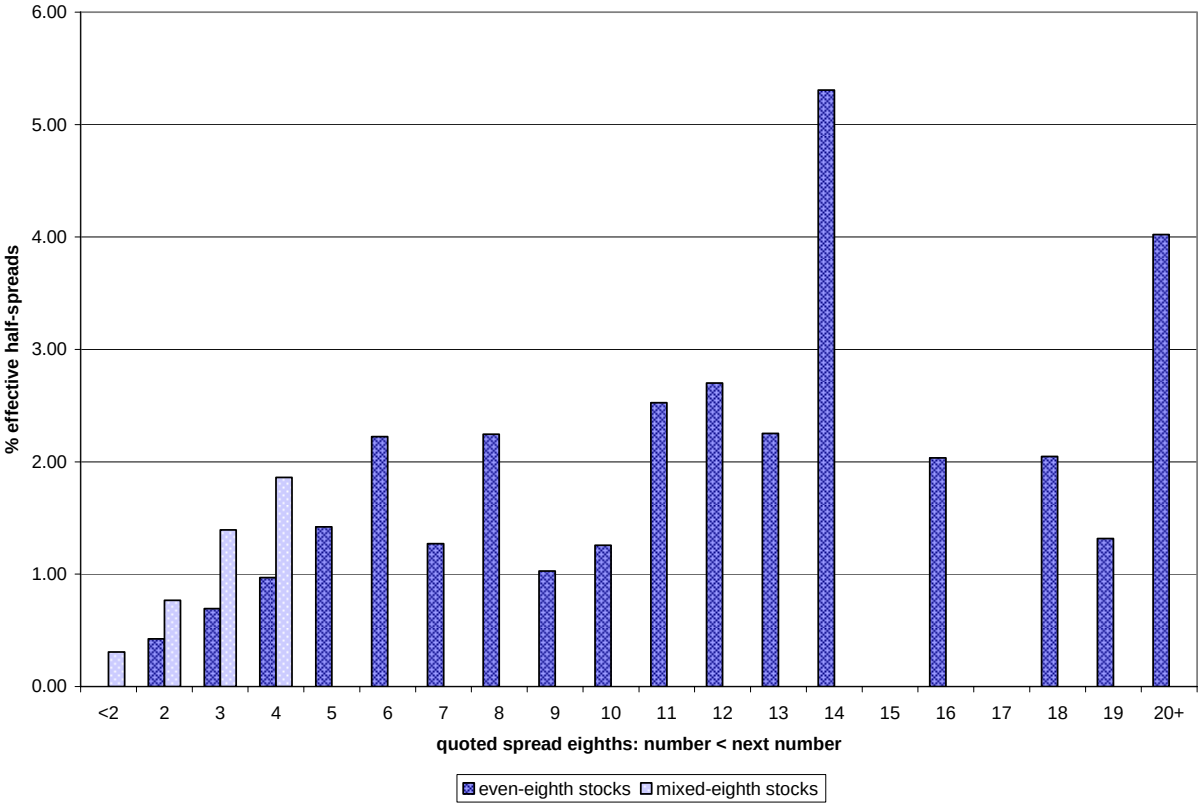


Figure 3. Decreases in percentage half-spreads (%EHS) of 362 even- and 315 mixed-eighth stocks that moved from NASDAQ to the NYSE/Amex between 1983 and May 26, 1994, computed from daily-volume-weighted averages over the 60 trading days before and 60 trading days after the move, grouped according to the daily-volume-weighted quoted spreads in eighths when the stocks were traded on NASDAQ. Even stocks have 75% of both their daily-volume-weighted closing bid and offer quotes states in even eighths during the 60 days the stocks were traded on NASDAQ.

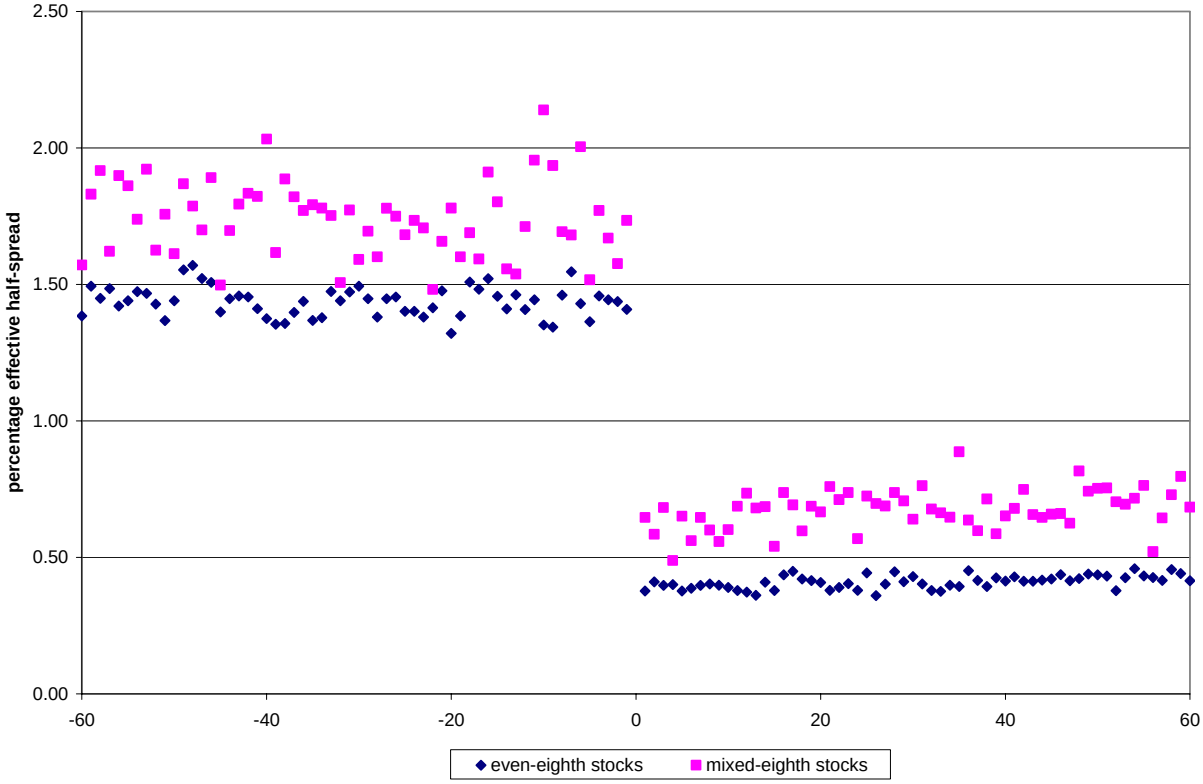
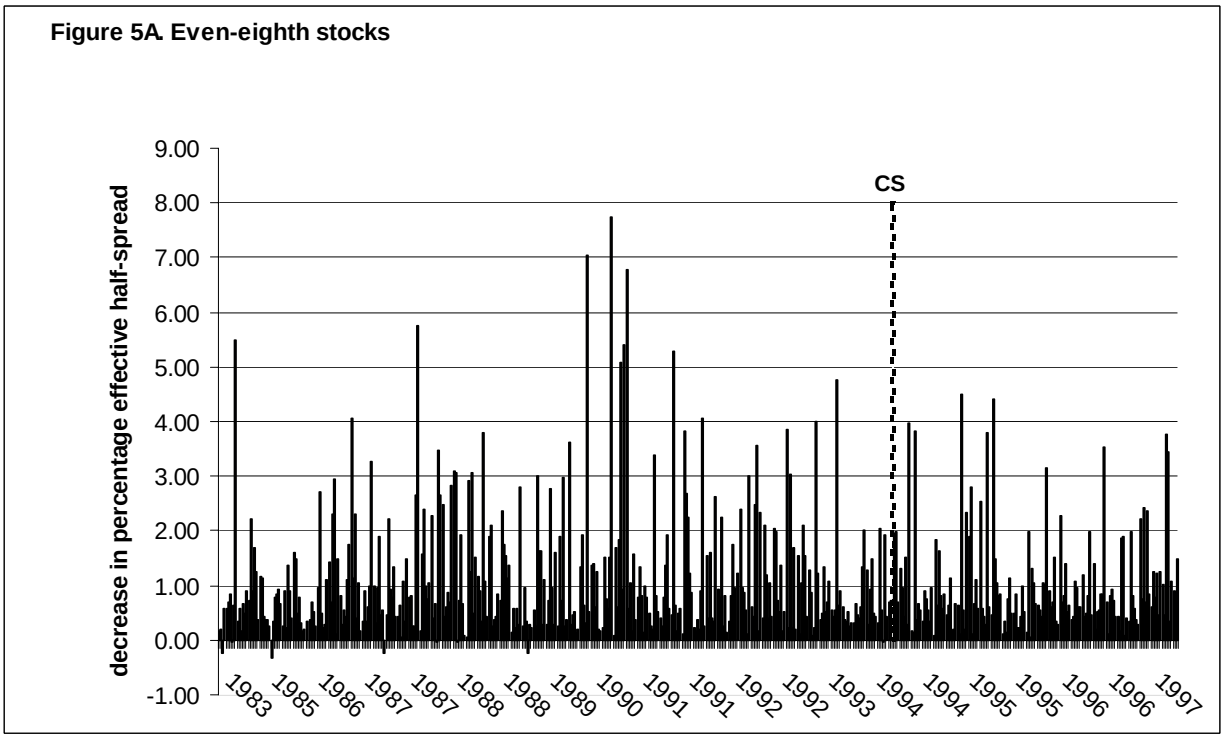


Figure 4. Effective percentage half-spreads (%EHS) on 341 even- and 110 mixed-eighths stocks 60 days before and 60 days after they moved from NASDAQ to the NYSE/Amex between 1983 and May 26, 1994, daily averages of all stocks with trades on that day, excluding 205 mixed stocks with average quoted spreads less than two eighths and 21 even stocks with quotes spreads of twelve eighths and greater. Even stocks have 75% of both their daily-volume-weighted closing best bid and offer quotes stated in even eighths during the 60 days the stocks were traded on NASDAQ.



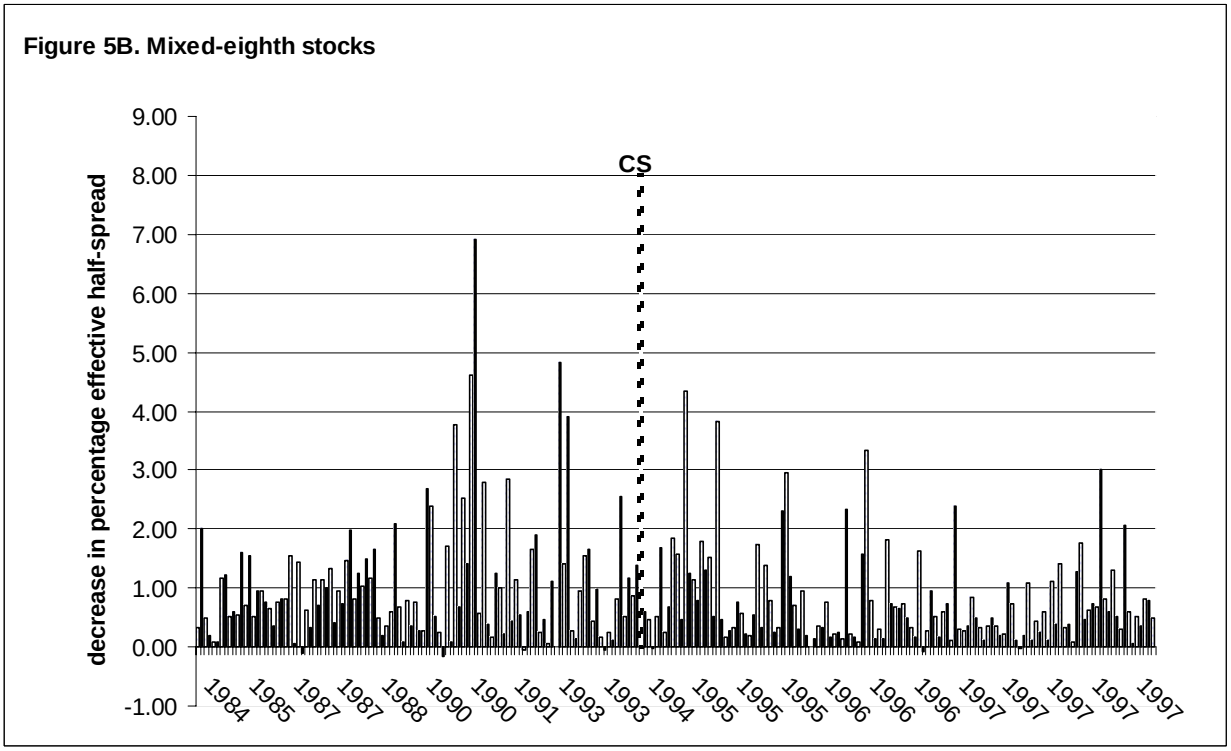


Figure 5. Changes in percentage effective half-spread (%EHS) for each of the 515 even-eighth stocks and each of the 237 mixed-eighth stocks that moved from NASDAQ to the NYSE/Amex in 1983-1997. . Even stocks have 75% of both their daily-volume-weighted closing best bid and offer quotes stated in even eighths during the 60 days the stocks were traded on NASDAQ. "CS" identifies 5/26/94, the date after Christie and Schultz's (1994) findings charging NASDAQ market makers with collusion were publicized.

Table 1. This table compares the key variables' means for 677 stocks that moved from NASDAQ to the NYSE or Amex between 1983 and May 23, 1994 (before the Christie-Schultz findings claiming collusion among NASDAQ market makers were publicized on May 26, 1994). The variables are measured as described in the text. The data are organized by quoted half-spreads when the stocks were traded on NASDAQ.

	Even Quotes		Mixed Quotes		Decrease		Difference	probability
Quoted	Before	After	Before	After	Even	Mixed	Even	(one-tail)
Half-spreads (QHS)	NYSE/Amex Listing		NYSE/Amex Listing		Quotes	Quotes	less Mixed	Diff. = 0
A. Effective Half-spreads (%)								
all quote sizes	1.50	0.41	1.26	0.69	1.10	0.57	0.53	0.00
all excluding QHS:								
mixed <.125, even .75+	1.37	0.41	1.74	0.69	0.96	1.05	-0.09	0.23
mixed <.125, even .375+	1.22	0.41	1.74	0.69	0.81	1.05	-0.24	0.02
.75+	3.58	0.34			3.24			
.375 < .75	2.19	0.41			1.78			
.25 < .375	1.52	0.43	2.61	0.75	1.09	1.86	-0.77	0.09
.125 < .25	0.99	0.4	1.63	0.68	0.59	0.94	-0.35	0.00
< .125			1.00	0.69		0.31		
B. Quoted Half-spreads (%)								
all quote sizes	2.14	0.82	1.57	1.22	1.32	0.35	0.97	0.00
all excluding QHS:								
mixed <.125, even .75+	1.91	0.82	1.74	1.34	0.82	1.09	-0.27	0.00
mixed <.125, even .375+	1.64	0.81	2.32	1.34	0.82	0.98	-0.16	0.00
.75+	5.84	0.88			4.96			
.375 < .75	3.34	0.85			2.49			
.25 < .375	2.07	0.88	3.68	1.36	1.19	2.32	-1.13	0.09
.125 < .25	1.31	0.76	2.13	1.33	0.55	0.80	-0.25	0.02
< .125			1.16	1.16		0.00		
C. Daily Trading Volume ($thousands)								
all quote sizes	1,817	997	1,636	953	820	683	137	0.26
all excluding QHS:								
mixed <.125, even .75+	1,923	1,049	616	315	874	301	573	0.00
mixed <.125, even .375+	2,204	1,184	616	315	1,020	301	719	0.00
.75+	94	158			-64			
.375 < .75	460	346			114			
.25 < .375	1,337	797	503	222	540	281	259	0.12
.125 < .25	2,859	1,476	631	327	1,383	304	1,079	0.07
< .125			2,183	1,295		888		

Table 1 Continued

NASDAQ Data

D. Number of Market Makers			E. Days with No Transactions		F. Capitalization ($millions)	
	Even	Mixed	Even	Mixed	Even	Mixed
all quote sizes	10.7	16.1	5.0	3.1	283	238.3
all excluding QHS:						
mixed <.125, even .75+	11.2	10.3	4.1	5.6	294.9	135.5
mixed <.125, even .375+	12.1	2.9	2.9	5.6	321.2	135.5
.75+	3.3		20.8		89.8	
.375 < .75	6.4		9.9		157.9	
.25 < .375	9.3	7.8	4.8	12.9	236.4	134
.125 < .25	14.2	10.7	1.6	4.6	385.2	135.7
< .125		19.2		1.8		293.5

G. Sample Number of Observations

	Number of stocks			Percent of Total	
	Even	Mixed	total	Even	Mixed
all quote sizes	362	315	677	53.5	46.5
all excluding QHS:					
mixed <.125, even .75+	341	110	451	75.6	24.4
mixed <.125, even .375+	286	110	396	72.2	27.8
.75+	21		677	3.1	
.375 < .75	55		677	8.1	
.25 < .375	123	13	677	18.2	1.9
.125 < .25	163	97	677	24.1	14.3
< .125		205	677		30.3

Table 2. Coefficients (t values) computed with regressions of the change in percentage effective half spreads (%EHS) when stocks moved from NASDAQ to the NYSE/Amex between [A] January 2, 1983 and May 23, 1994 and [B] May 27, 1994 and December 31, 1997 (before and after the Christie-Schultz findings claiming collusion among NASDAQ market makers were publicized on May 26, 1994) on changes in variables that presumably affect the spreads. Panel A includes 286 even-eighths and 110 mixed-eighths stocks (396 in total) with quoted half-spreads (QHS) of .125 < .375 (excluding QHS < .125, for which there are no even stocks, and QHS > .375, for which there are no mixed stocks). Panel B includes 115 even-eighths and 98 mixed-eighths stocks (213 in total), with QHS of .125 < .375 (excluding QHS < .125, for which there are no even stocks, and QHS > .375, for which there are only 12 mixed stocks).

	A. Moved Jan. 2. 1983 – May 23, 1994			B. Moved May 27 and Dec. 31, 1997		
	[1]	[2]	[3]	[4]	[5]	[6]
Intercept (CON_d + $logff_{nms}$)	2.88	2.89	2.88	2.05	2.86	2.08
	(20.30)	(23.03)	(20.29)	(9.15)	(15.97)	(9.35)
Change in even-eighth quote	-0.016	0.250	-0.016	0.020	0.370	0.05
pairs (decimals) (PEQ_d)	(0.15)	(2.46)	(0.15)	(0.13)	(3.08)	(0.76)
Change in price-per-	12.22	11.35	11.93	5.41	3.82	3.17
share (PPS_d)	(10.19)	(1.18)	(8.99)	(1.65)	(1.47)	(0.92)
Change in std. dev.	-0.12	0.58	-0.08	-0.62	0.56	-0.32
of PPS / 1000 ($SDPPS_d$)	(0.33)	(1.74)	(0.22)	(1.36)	(1.53)	(0.68)
Log number of market	-2.01	-0.63	-2.00	-1.39	-0.10	-1.37
makers ($logMM_{nms}$)	(14.91)	(3.54)	(14.57)	(6.40)	(0.53)	(6.35)
Log NASDAQ dollar volume		-0.48			-0.76	
($thousands) ($logDV_{nms}$)		(4.24)			(5.69)	
Log NYSE/Amex dollar volume		0.12			(0.00)	
($thousands) ($logDV_{nyam}$)		(1.15)			(0.02)	
Log NASDAQ DV less			(0.06)			-0.34
Log NYSE/Amex DV ($logDV_d$)			(0.51)			(2.02)
Adjusted R square	0.48	0.59	0.48	0.19	0.54	0.20
Mean change in even-eight-quote pairs:						
even stocks	0.62			0.64		
mixed stocks	0.09			0.18		
difference	0.53			0.46		
Mean change in effective spreads:						
even less mixed	-0.01	0.13	-0.01	0.01	0.17	0.09

Table 3. This table compares the variables' means for 367 stocks that moved from NASDAQ to the NYSE or Amex between May 27, 1994 and December 31, 1997 (after the Christie-Schultz finding claiming collusion among NASDAQ market makers was publicized on May 26, 1994). The variables are measured as described in the text. The data are organized by quoted half-spreads when the stocks were traded on NASDAQ.

	Even Quotes		Mixed Quotes		Decrease		Difference	probability
Quoted	Before	After	Before	After	Even	Mixed	Even	(one-tail)
Half-spreads (QHS)	NYSE/Amex Listing		NYSE/Amex Listing		Quotes	Quotes	less Mixed	Diff. = 0
A. Effective Half-spreads (%)								
all quote sizes	1.30	0.31	1.00	0.45	0.99	0.55	0.44	0.00
all excluding QHS:								
mixed <.125; mixed, even .75+	1.22	0.32	1.12	0.37	0.90	0.75	0.15	0.06
mixed <.125; mixed, even .375+	1.05	0.30	1.09	0.37	0.75	0.72	0.03	0.41
.75+	2.38	0.23	1.60	0.16	2.15	1.44	0.71	0.11
.375 < .75	1.61	0.34	1.45	0.38	1.27	1.07	0.20	0.32
.25 < .375	1.23	0.32	1.44	0.33	0.91	1.11	-0.20	0.16
.125 < .25	0.65	0.27	0.97	0.39	0.38	0.58	-0.20	0.00
< .125			0.81	0.57		0.24		
B. Quoted Half-spreads (%)								
all quote sizes	1.90	0.61	1.35	0.76	1.30	0.59	0.71	0.00
all excluding QHS:								
mixed <.125; mixed, even .75+	1.78	0.61	1.55	0.71	1.18	0.84	0.34	0.00
mixed <.125; mixed, even .375+	1.48	0.58	1.51	0.72	0.90	0.19	0.71	0.00
.75+	3.44	0.60	2.81	0.46	2.84	2.35	0.49	0.20
.375 < .75	2.45	0.66	1.98	0.59	1.79	1.39	0.40	0.20
.25 < .375	1.75	0.64	2.03	0.71	1.12	1.32	-0.20	0.18
.125 < .25	0.91	0.47	1.33	0.73	0.44	0.61	-0.17	0.02
< .125			1.03	0.84		0.19		
C. Daily Trading Volume ($thousands)								
all quote sizes	2,108	1,395	7,130	4,498	713	2,632	-1,919	0.00
all excluding QHS:								
mixed <.125; mixed, even .75+	2,249	1,456	2,313	1,454	793	859	-66	0.40
mixed <.125; mixed, even .375+	2,645	1,663	2,320	1,379	982	941	41	0.45
.75+	281	608	72	71	-327	1	-328	0.18
.375 < .75	1,366	994	2,228	2,320	372	-91	463	0.26
.25 < .375	1,734	1,276	1,157	700	458	457	1	0.50
.125 < .25	4,615	2,499	2,731	1,619	2,116	1,112	1,004	0.04
< .125			14,213	8,973		5,240		

Table 3 Continued

NASDAQ Data

D. Number of Market Makers			E. Days with No Transactions		F. Capitalization ($millions)	
	Even	Mixed	Even	Mixed	Even	Mixed
all quote sizes	8.2	14.0	5.7	2.2	389.1	608.5
all excluding QHS:						
mixed <.125; mixed, even .75+	8.5	10.1	4.9	3.1	404.7	383.0
mixed <.125; mixed, even .375+	10.1	10.5	3.2	3.1	463.9	376.8
.75+	3.7	2.5	15.4	9.8	188.9	144.3
.375 < .75	4.9	8.9	8.9	2.7	272.7	454.2
.25 < .375	8.8	6.9	3.7	5.2	326.9	312.5
.125 < .25	12.4	11.8	2.0	2.3	759.9	399.5
< .125		20.8		0.6		978.0

G. Sample Number of Observations

	Number of stocks			Percent of Total	
	Even	Mixed	total	Even	Mixed
all quote sizes	153	214	367	41.7	58.3
all excluding QHS:					
mixed <.125; mixed, even .75+	142	125	267	53.2	46.8
mixed <.125; mixed, even .375+	98	115	213	46.0	54.0
.75+	11	2	13	3.0	0.5
.375 < .75	44	10	54	12.0	2.7
.25 < .375	67	30	97	18.3	8.2
.125 < .25	31	85	116	8.4	23.2
< .125		87	87		23.7

Appendix I [Need not be printed with paper; for the benefit of the referee and editor]

Means of variables comparing data used in Barclay (1997, Table 1) and in the present study on stocks that moved from NASDAQ to the NYSE or Amex from 1983 through 1992. The sub-sample identified as "even quotes" had more than 75% of both bids and ask of closing inside quotations on even eighths in the 60 trading days prior to listing on the NYSE or Amex (Note 1). The balance is identified as "mixed quotes." Barclay's study includes 472 stocks, apparently not value weighted. Calculations made on the same stocks as the Barclay stocks labeled "this study" are value weighted, where the daily data were weighted by dollar volumes. (The difference in means between these figures and not-value-weighted figures is slight.) The last numbers are for the 583 stocks that were found to have moved during this period and are included in the present study. The means for this study were calculated using only days where there were data; it is not clear if Barclay followed this procedure.

	Even Quotes		Mixed Quotes		Decrease		Difference
	Before NYSE/Amex Listing	After NYSE/Amex Listing	Before NYSE/Amex Listing	After NYSE/Amex Listing	Even Quotes	Mixed Quotes	Even less Mixed
Effective half-spead (%)							
Barclay Table 1	1.74	0.44	1.25	0.68	1.30	0.57	0.73
this study Barclay stocks	1.52	0.39	1.20	0.63	1.13	0.57	0.56
this study all stocks	1.54	0.42	1.22	0.68	1.12	0.54	0.58
Effective half-spread ($)							
Barclay Table 1	0.25	0.07	0.11	0.07	0.18	0.04	0.14
this study Barclay stocks	0.25	0.08	0.11	0.06	0.18	0.04	0.13
this study all stocks	0.24	0.07	0.10	0.06	0.17	0.04	0.13
Quoted half-spead (%)							
Barclay Table 1	2.23	0.88	1.48	1.22	1.35	0.26	1.09
this study Barclay stocks	2.15	0.80	1.49	1.14	1.35	0.36	0.99
this study all stocks	2.17	0.85	1.49	1.19	1.32	0.30	1.02
Quoted half spread ($)							
Barclay Table 1	0.33	0.13	0.13	0.11	0.20	0.02	0.18
this study Barclay stocks	0.35	0.15	0.13	0.11	0.20	0.02	0.18
this study all stocks, value weighted	0.33	0.15	0.12	0.11	0.18	0.01	0.17
Even-eighths quotes (%) (Note 1)							
Barclay Table 1	99	56	56	54	43	2	41
this study Barclay stocks	99	36	34	32	63	2	61
this study all stocks	97	36	28	30	61	-2	63
Price per share ($)							
Barclay Table 1	21.45	20.48	13.99	14.47	0.97	-0.48	1.45
this study Barclay stocks	23.18	23.84	14.03	14.55	-0.66	-0.53	-0.14
this study all stocks	22.11	22.83	12.94	13.79	-0.72	-0.85	0.13
Daily trading volume ($thousands)							
Barclay Table 1	1,847	989	1,911	966	858	945	-87
this study Barclay stocks	1,930	1,090	1,835	1,036	839	799	40
this study all stocks	1,824	994	1,688	1,015	830	673	157
Number of market makers							
Barclay Table 1	10.39		17.46				
this study Barclay stocks	10.71		15.89				
this study all stocks	10.50		16.02				
Number of securities	number	percent.	number	percent.			
Barclay Table 1	239	51%	233	49%			
this study Barclay stocks	227	48%	245	52%			
this study all stocks	311	46%	372	54%			

Note 1: Barclay (1997) designated as "even quotes" those with 90% of either a bid or ask quotes stated in even eighths, rather than both bids and asks stated as even eighths (which conforms to the CS hypothesis). Barclay's procedure approximates the CS rule, whereby 75% of the pairs of bids and asks are stated as even eighths. Consequently, I used the CS 75% rule. The lower percentage of even quote stocks in my study compared to Barclay's apparently is due to this difference in identifying even-quote stocks.

Appendix II. History of the Rejection of the Article

The article was rejected by the *Journal of Financial Economics* solely on the basis of the following referee report, per the editor, William Schwert. I present the referee's complete report, followed for each of the four issues with my responses (also rejected by William Schwert).

Referee

"This paper attempts to do two things: first, it reexamines the results of Barclay 1997 paper, and based on its findings claims that the collusion on Nasdaq has no empirical support. I will proceed to discuss the first, while practically disregarding the second. The reason being is that the proof of collusion is legal and not economic, and there has been ample evidence that market makers had engaged in practices to discourage quotation of all prices by their peers. Moreover, the literature shows that in the world of discrete prices the regular (Bertrand-like) arguments do not apply, thus collusion can occur even with many market makers.

"The authors claim that when Barclay studied the transfer of stocks from NASDAQ to NYSE and AMEX, he biased his results by including stocks whose quoted spread was lower than 2 ticks, since spreads in these stocks allegedly could not go down following the exchange shift.

"This is a strange argument. If these stocks were to be avoiding the even eighths, they would have shown a higher spread. So if these were trading competitively, before and after the move to the NYSE and AMEX, they SHOULD be the benchmark for other similar stocks that by exogenous reasons were avoiding odd eighths. The fact that they could not go down is not entirely correct, given the definition of these stocks. But even if they could, the comparison is between zero change for the competitive part of the market and a large change for the non-competitive part. Removing them introduces a sample bias of high cost non-avoiding stocks, which seems to me a much larger bias than what is found in Barclay."

Response

Stocks quoted at one eighth were analyzed separately, because one-eighth is the minimum tick size on both NASDAQ and NYSE/Amex. First, the referee correctly observes: "The fact that they could not go down much is not entirely correct, given the definition of these stocks." But, the referee ignores the use of effective spreads in the paper which does measure trades within the spread and the decline in relative effective spreads of these stocks of 0.31% on average is reported in the paper.

Second, the referee maintains that these stocks should not have been analyzed separately. Because "they SHOULD be the benchmark for other similar stocks that by exogenous reasons were avoiding odd eighths." As just noted, the paper does show the decline in percentage effective on one-eighth-quoted stocks. The decline of 0.31% can be used as a benchmark. This does not obviate the finding reported in Table 1 that stocks with half quotes on NASDAQ of .125 < .25, the ones that should have been affected most if NASDAQ market makers colluded to "avoid" odd eighths (as described more fully in the paper) that percentage effective spreads on mixed-eighths stocks declined by 0.94% compared to a decline of 0.59% on even-eighths stocks, a finding that is contrary to Barclay's collusion hypothesis. Furthermore, the decline was greater for mixed-eighths stocks with half quotes of .25 < .75 (the only other group with both mixed- and even-eighths stocks) than for even-eighths stocks (1.86% vs. 1.09%). If the minimum quote tick size were used as the relevant benchmark, 0.31% would be deducted from each of the numbers, but the conclusion would be the same – the decline in percentage effective spreads is greater for mixed- than for even-eighths stocks.

Referee

"The author's second claim is more relevant. It states that some of the decline in spreads in Barclay's paper was due to several very high-spread stocks that were traded infrequently. This claim has the potential to reduce the extent of the spread decline, but it is also already present in Barclay's paper. Since there are relatively few of these firms (see Figure 2A in this paper), looking at the median should correct for these outliers. The effect is indeed smaller: instead of the mean decline in the half quoted spread from 33 to 14 cents in avoiding stocks, the median decline is from 26 to 13 cents. This is roughly the extent of the effect due to the second claim; hardly enough to get anybody excited. Incidentally, this is similar to what was found in other studies of the effects of the avoidance on the spread."

Response

The referee asserts that the effect of large spreads on a relatively few even-eighth stocks with half quotes greater than .75 can be dealt with effectively by using medians. First, this is not correct, since including these stocks in the even-eighths sample necessarily increases the medium decrease in percentage effective spreads. Second, as shown in the paper, there is good economic reason to examine these stocks separately. This examination shows that these stocks are particularly subject to adverse selection by informed investors that results in market makers increasing asks and decreasing bids, thereby widening spreads. As discussed and shown in the paper, this adverse selection does not apply to the NYSE/Amex, where bids and asks are set by limit orders or bettered by specialists.

Referee

"Finally, there is a problem of looking at the Effective spreads only. It is well known that even before the New OHR, institutions could negotiate their trades and could also trade on ECNs within the quoted spread. Thus the quoted spreads were relevant for the small trades, which were submitted via the SOES system or preferenced/internalized. The effective spread on all trades essentially captures the degree to which the stock is traded by institutions, rather than the degree of increased trading costs for the small trades."

Response

The referee objects to effective spreads, because, "quoted spreads were relevant for the small trades." The effective spreads then are the same as the quoted spreads, and hence are included in the metric used. But, the referee continues: "The effective spread on all trades essentially captures the degree to which the stock is traded by institutions, rather than the degree of increased trading costs for the small trades." First, Barclay did not claim that collusion affected only small trades made at the quote. Second, I could report the numbers for the percentage half quote. The numbers would be different, but the same relationship is shown. So, if this objection can be dealt with completely. [Indeed, I have now included in the paper analyses of percentage quoted half spreads, as the referee urges. The results are similar to those reported for percentage effective half spreads.]

Referee

"Overall, one needs a much stronger argument than what is found in this paper to claim that the part of the market, in which the quoted spreads:

- declined over 50% from May 1994 till the Spring of 1997 (before the tick size decline),
- instantaneously dropped by 27% when the New OHR went into effect, was competitive prior to that. I am not convinced."

Response

Finally, the referee points to a decline in quoted spreads from May 1994 until Spring 1997 and when the OHR went into effect as evidence that these changes were due to a cessation of collusion among NASDAQ market makers to widen spreads. First, this is a non-sequitor, as this change does not relate to Barclay's thesis, that spreads dropped more on even-quoted stocks than on mixed-quoted stocks when they moved from NASDAQ to NYSE/Amex. Second, the change over the time period does not account for other factors having changed. Third, and most importantly, the referee ignores the analysis in the paper that compares the pre- and post-Christie-Schultz data, both univariate and multivariated, which is inconsistent with a collusion having been stopped.