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Why do NASDAQ Market Makers Avoid Odd-Eighth Quotes?

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ABSTRACT

The NASDAQ multiple dealer market is designed to produce narrow bid-ask spreads through the competition for order flow among individual dealers. However, we find that odd-eighth quotes are virtually nonexistent for 70 of 100 actively traded NASDAQ securities, including Apple Computer and Lotus Development. The lack of odd-eighth quotes cannot be explained by the negotiation hypothesis of Harris (1991), trading activity, or other variables thought to impact spreads. This result implies that the inside spread for a large number of NASDAQ stocks is at least $0.25 and raises the question of whether NASDAQ dealers implicitly collude to maintain wide spreads.

THIS ARTICLE PROVIDES EMPIRICAL evidence on the degree of competition among dealers who make markets in the National Association of Securities Dealers Automated Quotation system (NASDAQ). Several hundred firms currently act as dealers in NASDAQ stocks, with the number of market makers per stock ranging from 2 to over 50. Individual dealers enjoy relatively free entry and exit, subject to a one-day delay before quotes can be posted. In a market where the inside spread is determined by the actions of multiple dealers, competitive spreads might be considered a natural outcome. However, our results suggest otherwise.

Unlike previous studies that compute summary measures of bid-ask spreads, we examine the entire distribution of dollar spreads using an extensive sample of inside bid and inside ask quotes for 100 of the most active

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NASDAQ stocks in 1991. We find that spreads of one-eighth are virtually nonexistent for a majority of this sample. The lack of one-eighth spreads can be traced to an absence of either inside bid or inside ask quotes ending in odd-eighths (1/8, 3/8, 5/8, and 7/8) for 70 of the 100 stocks. In contrast, a sample of 100 New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) firms of similar price and market value to our NASDAQ sample consistently use the full spectrum of eighths. The absence of odd-eighth quotes for the majority of the NASDAQ sample, including such active issues as Apple Computer, Intel, and Lotus Development, implies an inside spread of at least $0.25. We believe that this surprising result reflects an implicit agreement among market makers to avoid using odd-eighths in quoting bid and ask prices and that a large number of market makers per stock is not necessarily synonymous with competition.

The finding that market makers enforce a minimum spread of $0.25 by not posting odd-eighth quotes for a majority of large NASDAQ stocks may partially explain the higher trading costs for firms listed on NASDAQ documented in previous research. For example, Goldstein (1993) examines closing bid-ask spreads for both NYSE and NASDAQ stocks during 1990. He first adjusts NASDAQ spreads to reflect the fact that institutional traders do not always pay commissions on NASDAQ trades but must pay them on NYSE transactions. He then estimates a cross-sectional regression of adjusted spreads on price, market capitalization, volume, volatility, and a dummy variable for exchange listing and finds that spreads for stocks that meet NYSE listing requirements but trade on NASDAQ are $0.15 to $0.18 wider than similar NYSE-listed stocks.

Christie and Huang (1994) use all intraday quote changes and trades for the 60 days surrounding exchange listing to study a sample of stocks that moved from NASDAQ to either the NYSE or the AMEX during 1990. They find that quoted spreads decline by an average of $0.31 per share when stocks move to the AMEX and by $0.06 per share when stocks are listed on the NYSE. The average liquidity premium, measured as the difference between trade prices and the midpoint of the prevailing bid and ask quotes, declines by about $0.05 per share when stocks are listed on either exchange.[1]

Affleck-Graves, Hegde, and Miller (1994) present evidence that order-processing costs, the component of the spread that is unrelated to information asymmetry or dealer inventory positions, is larger for NASDAQ stocks than comparable NYSE firms. They claim that exchanges facilitate the matching of buy and sell orders by increasing competition between market participants and by reducing the need for direct dealer intervention. Similarly, Vijh (1990) compares the market depth and bid-ask spreads for NYSE stocks and Chicago

[1] Christie and Huang (1994) report that the source of the reduction in liquidity premiums for firms that move from the NASDAQ to the NYSE is shared equally by the improvement in quotes that originate from the NYSE rather than NASDAQ and the ability to trade inside the spread more frequently when the trades are executed on the NYSE.

Board Options Exchange (CBOE) options, which trade in a multiple-dealer market, and finds that, although the CBOE offers greater depth, the relative bid-ask spreads are appreciably wider than for NYSE stocks. He further shows that the wider spreads on the CBOE do not arise from differences in information asymmetries since the adverse selection component of the spread is similar across market structures.

The lack of odd-eighth quotes for the majority of NASDAQ stocks in our sample suggests that the organizational structures utilized by NASDAQ and the NYSE/AMEX differ in their effectiveness in promoting competitive spreads.[2] The NYSE or AMEX specialist is awarded an exclusive franchise to act as a dealer and auctioneer in each stock. In return, specialists are closely regulated and are bound by an affirmative obligation to maintain a "fair and orderly market." Although specialists have an exclusive franchise in their stocks, they face competition for order flow from floor traders on the exchange, from other exchanges, and from public limit orders. Limit order prices are part of the spread displayed to the market and take precedence over specialists' trades for their own account.[3]

In contrast to exchange specialists, NASDAQ dealers do not have an exclusive franchise to make a market in a stock and are not as closely regulated. The NASDAQ firms studied in this article trade on the National Market System (NMS). One of the few affirmative obligations imposed on dealers is that they must provide firm quotes on both sides of the spread with a depth of at least 1,000 shares per dealer. However, Chan, Christie, and Schultz (1995) find that market makers rarely post quotes that place them at both the inside bid and inside ask.

The fundamental premise of the NASDAQ system is that competition for order flow among dealers will produce narrow spreads. In contrast to the organized exchanges, NASDAQ limit orders are not exposed to the public and are executed if and only if the inside spread reaches the limit price. Thus, the public cannot use limit orders to compete directly with NASDAQ market makers, and inside quotes do not reflect the presence of limit orders. The

[2] Differences in the institutional organization of the dealer and specialist markets may also translate into intraday differences in the width of bid-ask spreads. For example, McInish and Wood (1992), Brock and Kleidon (1992) and Kleidon and Werner (1993) show that bid-ask spreads of listed stocks narrow steadily until early afternoon and then widen at the close. Similarly, Chan, Fong, and Stulz (1994) find that bid-ask spreads of NYSE stocks follow a U-shaped pattern over the day. However, they also find that the spreads of European stocks listed on the NYSE decline steadily over the day. Foster and Viswanathan (1993) examine the intraday behavior of the adverse selection component of the spread for NYSE stocks and find that it displays a U-shaped pattern over the day. In contrast, Chan, Christie, and Schultz (1995) show that bid-ask spreads of NASDAQ stocks decline throughout the day and are narrowest at the close of trading. Kleidon and Werner (1993) also find a similar pattern of declining spreads for London Stock Exchange stocks, which operates as a multiple dealer market.

[3] Harris and Hasbrouck (1992) analyze the types of NYSE orders handled by the automated SuperDot system for a sample of 144 stocks from November 1990 through January 1991. They find that 45 percent of day orders are limit orders and that limit orders are more common than market orders for trades of 500 shares or more.

competitive structure of the dealer market is summarized by Schwartz (1991, p. 58):

> *Dealers compete with each other, and have been reluctant to accept additional competition from the public order flow. The NASD depends on this interdealer competition to keep markets fair, orderly and liquid. ... Competing dealers face fewer regulatory restrictions than NYSE specialists because the NASD relies more on the constraints of a competitive environment to discipline dealer firms.*

While our evidence suggests that the structure of the NASDAQ market may permit tacit collusion among its dealers, we also consider alternative explanations. The first is provided by the negotiation hypothesis of Harris (1991), who suggests that the use of coarse price increments to minimize negotiation costs may explain the (far less severe) price clustering of NYSE/AMEX stocks. Since most small trades on NASDAQ are executed automatically, while large trades are negotiated, this hypothesis predicts that a smaller percentage of large than small trades should be transacted on odd eighths. However, we find that among NASDAQ stocks where odd-eighth quotes are rare, negotiated trades in excess of 1,000 shares are far more likely to be transacted on the odd eighths than trades of 1,000 shares or less.

We also provide evidence that the lack of odd eighths is unrelated to trading activity, equity value, and the number of market makers. While prices and return volatility have some ability to predict the firms that are quoted in odd eighths, the greatest predictive power lies in the historical use of odd eighths. Thus, our results suggest that the important factor in predicting the use of odd-eighth quotes is not the economic costs and risks of market making, but whether a practice of avoiding odd-eighth quotes is already established.

The rest of the article is organized as follows. Section I describes our samples of NASDAQ and NYSE/AMEX firms. Section II reports the differences in dollar spreads between the NASDAQ and the NYSE/AMEX samples. Section III traces the differences in spreads across exchanges to the frequency of odd-eighth quotes and examines whether these results can be reconciled by a negotiation explanation, the risks of market making, or tacit collusion among dealers. Section IV concludes the article and summarizes our findings.

I. Data and Sampling Procedures

The data consist of all trades and quote revisions in 1991 for 100 large, actively traded NASDAQ stocks and 100 NYSE/AMEX stocks of comparable price and end-of-year equity value. NASDAQ stocks are selected by first calculating the end-of-year capitalized market value of equity computed using prices and the number of outstanding shares from the Center for Research in Securities Prices (CRSP) for all NASDAQ stocks in 1991. The 50 largest

stocks are intentionally included in our sample, with the remaining 50 firms selected randomly from those with an equity value of at least $100 million. The final sample includes such actively traded firms as Apple Computer, MCI Communications, Lotus Development, Intel, St. Jude Medical, and Food Lion. NYSE/AMEX stocks that traded throughout 1991 are then matched with NASDAQ stocks using the average daily closing prices during 1991 and then the end-of-year capitalized value of equity.[4] NYSE and AMEX stocks include Caesers World, Kerr-McGee, Morton International, and Amdahl.

Table I provides the distribution of closing prices and end-of-year equity capitalizations for the two samples. Panel A provides the mean, minimum, maximum, and quartiles of the distribution of average closing prices across stocks. The average prices of NASDAQ stocks correspond closely to the average prices of the listed (i.e., NYSE/AMEX) stocks. Panel B describes the distribution of end-of-year equity capitalizations across stocks. While the two samples are very similar, NASDAQ stocks have slightly larger capitalizations, perhaps as a result of intentionally including the 50 largest NASDAQ stocks in the sample.

All trade and quote data are obtained from the Institute for the Study of Securities Markets (ISSM). Trade data contain both the transaction price and the number of shares, while quote data include all intraday inside quote revisions. Quotes that originate from the NASDAQ market reflect the inside bid and inside ask computed from the best individual dealer quotes, while NYSE/AMEX quotes are updated electronically by the specialist and can reflect either their own quotes or those of the limit order book. A series of filters are then applied to the intraday trades and quotes. Since ISSM assigns a negative value to suspicious trade prices, volumes and bid-ask quotes prior to releasing the data, we exclude all negative trades and quotes. In addition, we eliminate all locked or crossed-quotes (where the bid either equalled or exceeded the ask) since they are not sustainable. We also discard all quotes that originate in markets other than the exchange where the stock is listed. Thus, the quotes for firms that are listed on the NASDAQ originate from the dealer market, while the quotes for firms listed on the NYSE or AMEX emerge from their respective exchanges. An additional filter eliminates quote revisions that reflect a change in the depth (i.e., the number of shares for which the quote is valid) without affecting the inside bid or inside ask. We

[4] The matching procedures do not consider volume due to reporting differences on the NASDAQ versus the NYSE/AMEX. The batching procedure used at the open on the organized exchanges combines a number of trades that would have been observed separately on the NASDAQ/NMS. In addition, buy and sell orders involve separate transactions on the NASDAQ/NMS whereas the orders may cross in specialist markets. Imposing additional matching criteria beyond price and size is of limited importance in the present context since firm-by-firm comparisons are not made across trading structures. Indeed, our emphasis is not on the direct comparison of trading costs but, rather, the way stocks are quoted on NASDAQ versus the organized exchanges. In addition, our empirical results for the sample of NYSE/AMEX stocks are consistent with prior studies of dollar spreads, suggesting that our sample is representative of the population of exchange-listed stocks.

Table I

The Distribution of Average Daily Closing Prices and End-of-Year Market Capitalizations for the Samples of 100 NASDAQ and 100 NYSE/AMEX Firms in 1991

The samples are first matched using average prices, and then paired using market capitalizations.

	NASDAQ Stocks ($)	NYSE/AMEX Stocks ($)
Panel A: The Distribution of Average Prices		
Maximum	106.41	116.99
75th percentile	43.46	43.43
Median	30.08	30.21
25th percentile	17.92	17.94
Minimum	4.82	4.89
Mean	32.39	32.55
Panel B: The Distribution of End-of-Year Equity Capitalizations (in 000s)		
Maximum	19,724,624	15,781,525
75th percentile	2,299,012	2,187,686
Median	1,391,891	960,784
25th percentile	241,818	229,886
Minimum	100,716	101,928
Mean	1,905,336	1,784,705

impose this condition since the depth variable for NASDAQ stocks does not provide a measure of the depth across all dealers. Thus, all quotes studied in this paper reflect a revision in the inside bid and/or inside ask.

Since the market is open between 9:30 A.M. and 4:00 P.M. eastern time, eligible trades must be time-stamped during this interval.[5] Similarly, quotes must be posted during the regular trading hours. We exclude all trades that have condition codes other than a regular sale, and exclude all quotes that are not best bid and offer (BBO)-Eligible.[6] Finally, we eliminate the first trade after the open for NYSE and AMEX stocks, since a call market is used for opening trades, while an auction market is used for all subsequent trades.

[5] NYSE/AMEX trades time stamped between 4:00 P.M. and 4:05 P.M. may still represent regular trades since the crowd is permitted to trade until the price is resolved and the clerical reports completed. However, we exclude trades after the close from all exchanges since the duration of regular trades on the NASDAQ after the close is unclear, and we want to align the close of the markets in trading time.

[6] BBO-eligible quotes for NASDAQ stocks represent the actual BBO among all the market makers posting quotes for each security under normal trading conditions. BBO-eligible quotes for exchange-listed stocks indicate the inside spread posted by each exchange. Most BBO-ineligible quotes arise from trading halts or delayed openings.

II. A Comparison of Dollar Spreads for NASDAQ and NYSE/AMEX Stocks

This section establishes the differences in the dollar spreads for similar stocks that trade under different market structures. The data used to document these results consist of all 372,625 inside quotes for the NASDAQ sample and all 544,811 inside quotes for the sample of listed stocks during 1991. The distribution of dollar spreads for the two samples is shown in Figure 1. The figure indicates that the distribution of dollar spreads for NYSE/AMEX stocks is unimodal at \$0.25 per share. One-eighth and three-eighths spreads are equally common, while a spread of \$0.50 is observed among only 5 percent of all quotes. In contrast, the spreads for NASDAQ stocks are typically multiples of \$0.25. Hence NASDAQ spreads of \$0.25 and \$0.5 are both more common than spreads of \$0.375, and spreads of \$0.5 and \$0.75 are more common than spreads of \$0.625. Spreads of \$0.125 represent only 10 percent of NASDAQ spreads as compared to 25 percent for listed

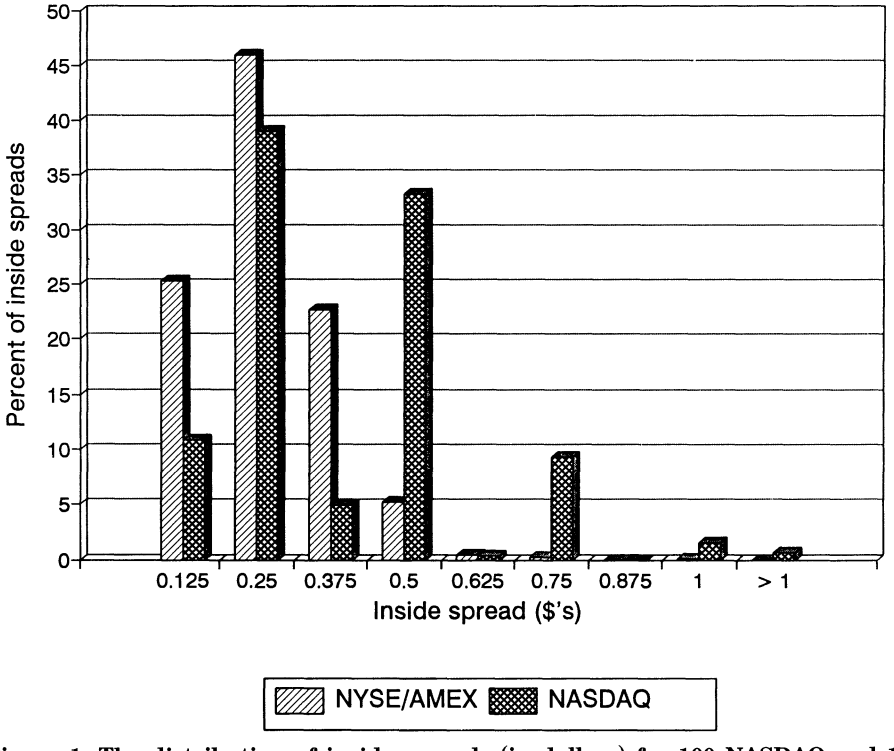


Figure 1. The distribution of inside spreads (in dollars) for 100 NASDAQ and 100 NYSE/AMEX securities of simialr price and end-of-year market capitalization. The distributions are computed using all inside quotes for all stocks in 1991. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. The horizontal axis shows the dollar inside spread. The vertical axis represents the percentage of all inside quote revisions that produce the specified spreads.

stocks. Thus, Figure 1 reveals a fundamental difference in the distribution of dollar spreads for NASDAQ and NYSE/AMEX firms.[7]

While Figure 1 shows that spreads of one-eighth are less common for NASDAQ than listed stocks, it does not convey how rare one-eighth spreads are for some NASDAQ stocks. Figure 2 shows the distribution of the percentage of quotes that produce a one-eighth spread across the 100 NASDAQ and 100 NYSE/AMEX firms, separately. The horizontal axis shows the percentage of all quotes that result in a one-eighth spread, while the height of the bar represents the number of firms with the specific percentage of one-eighth spreads. The figure shows that for most NASDAQ firms, fewer than 4 percent of the quotes result in a one-eighth spread. This pattern is shared by only two listed stocks. In contrast to the NASDAQ sample, between 5 and 40 percent of quote revisions result in a one-eighth spread for most listed stocks.

To provide specific examples of the frequency of one-eighth spreads for NASDAQ stocks, Panel A of Table II reports the percentage of spreads that are \$0.125, \$0.25, \$0.375, and \$0.50 for Apple Computer, Lotus Development, and MCI Communication. Although Apple and Lotus are among the most actively traded and highly visible NASDAQ firms, fewer than 1.5 percent of all quoted spreads are \$0.125. More striking is that a spread of \$0.50 is observed for almost half of the quotes for Apple and Lotus. However, some large and actively traded NASDAQ stocks have spreads that frequently narrow to one-eighth. For example, the distribution of dollar spreads for MCI is heavily concentrated at \$0.125 and \$0.25.

III. A Comparison of Odd-Eighth Quotes for NASDAQ and NYSE/AMEX Stocks

A. Are NASDAQ and Listed Stocks Quoted Differently?

The pattern of dollar spreads for NASDAQ firms noted in Figure 2 suggests that spreads of \$0.25 or multiples thereof are far more common than spreads that require the simultaneous use of odd- and even-eighth quotes. To assess whether the relative frequency of odd-eighth versus even-eighth quotes differs between NASDAQ and the NYSE/AMEX, we compute the percentage of all quotes that lie on each eighth, where the percentage is an average of the frequencies at the bid and the ask. The results are plotted in Figure 3. The figure indicates that the use of odd-eighth quotes is uniformly less frequent than even-eighths for NYSE/AMEX stocks. This finding is consistent with the results reported by Harris (1991). However, it is important to recognize that although the even-eighths appear to be favored relative to the odd-eighths, the percentage of odd-eighth quotes exceeds 10 percent at each odd eighth for NYSE/AMEX stocks. In stark contrast, fewer than 4 percent of the

[7] The width of the spread for NYSE/AMEX stocks reflects the quotes that originate from their respective exchange and does not represent the best consolidated quotation. Thus, the contrast between the distribution of spreads for NYSE/AMEX and NASDAQ stocks may be understated.

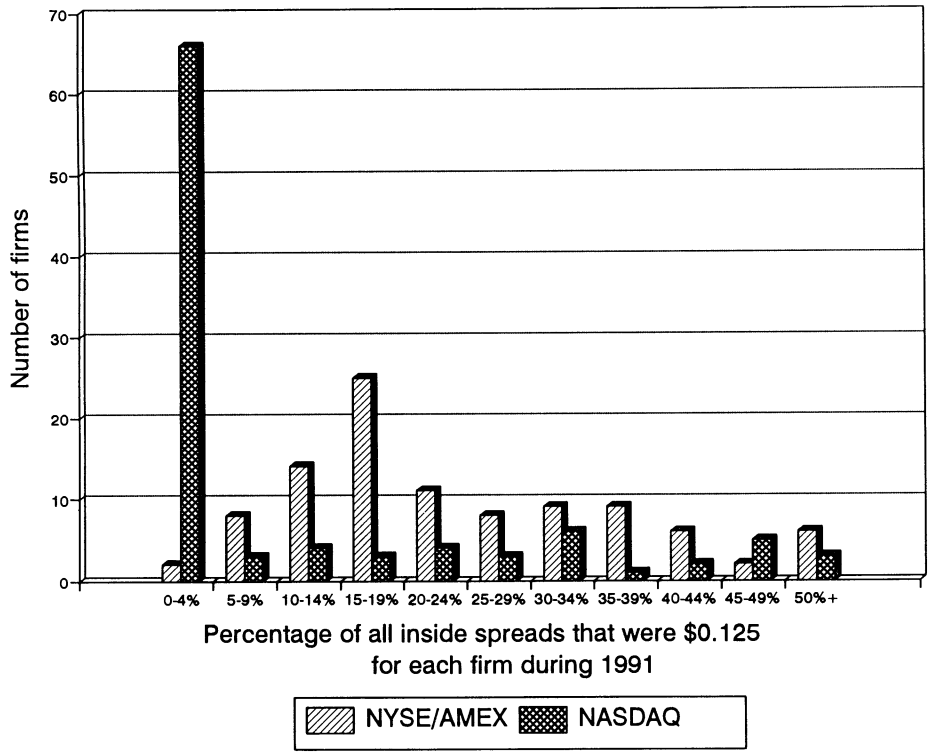


Figure 2. The percentage of inside spreads that are $0.125 for 100 NASDAQ and 100 NYSE/AMEX securities of similar price and end-of-year market capitalization. This figure contrasts the frequency of one-eighth spreads for stocks listed on the NYSE/AMEX versus stocks listed on NASDAQ in 1991. For each firm, we compute the percentage of quote revisions that produce a spread of $0.125 using all inside quotes. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. The height of the bar represents the number of firms whose frequency of one-eighth spreads corresponds to the percentages denoted on the horizontal axis. For example, for 66 of the 100 NASDAQ firms in our sample, fewer than 4 percent of all inside spreads are $0.125. In contrast, this small fraction of $0.125 spreads is shared by only 2 NYSE/AMEX stocks.

quotes for NASDAQ stocks fall on each of the odd eighths.[8] Thus, Figure 3 highlights a dramatic difference in the way that stocks are quoted on the NASDAQ relative to the NYSE/AMEX. NASDAQ stocks are, on average, far less likely to be quoted using odd eighths than firms listed on the NYSE or the AMEX.

[8] To ensure that our results are not an artifact of ISSM data errors, the analysis was replicated for a small subsample of NASDAQ stocks during a limited period during 1991 by using market maker quotes previously downloaded from the Bridge Quotation System. The frequency of odd-eighth quotes from the Bridge system are essentially identical to those reported in this article.

Table II

The Distribution of Dollar Spreads, Odd-Eighth Bid and Ask Quotes, and the Percentage of Large and Small Trades Executed on Odd Eighths for Selected NASDAQ Stocks

The table provides summary statistics for Apple Computer, Lotus Development, and MCI Communications. The distributions are calculated using all intraday quote updates posted in 1991. In Panel C, the percentages are calculated using all intraday trades executed in 1991 between 9:30 A.M. and 4:00 P.M. Large trades are defined as those trades exceeding 1,000 shares, while small trades are defined as those of 1,000 shares or less.

Panel A: The Proportion of \$0.125, \$0.250, \$0.375, and \$0.500 Spreads

	Dollar Spread			
Stock	\$0.125 (%)	\$0.250 (%)	\$0.375 (%)	\$0.500 (%)
Apple Computer	1.2	49.3	1.8	47.7
Lotus Development	1.3	49.3	2.0	47.3
MCI Communication	50.3	48.7	1.0	0.0

Panel B: The Percentage of All Bid and Ask Quotes with Odd-Eighth Price Fractions

Stock	Percentage of Bid Quotes at Odd Eighths	Percentage of Ask Quotes at Odd Eighths
Apple Computer	1.4	1.7
Lotus Development	1.7	1.6
MCI Communication	51.0	51.4

Panel C: The Percentage of Large and Small Trades that Are Executed at Odd Eighths

Stock	Small Trades (%)	Large Trades (%)
Apple Computer	9.2	23.6
Lotus Development	9.4	28.0
MCI Communication	47.2	49.3

To determine whether the infrequent use of odd-eighth quotes is shared by all NASDAQ stocks or is common to only a subset of firms, the percentage of odd-eighth quotes is calculated for each firm, where the percentage is an average of the frequencies at the bid and the ask. Figure 4 provides a histogram showing the number of NASDAQ stocks that share a similar percentage of odd-eighth quotes. The figure reveals that the lack of odd-eighth quotes is much more pronounced for some stocks than for others. For the majority of NASDAQ stocks in our sample, less than 2 percent of their quotes appear on all of the odd eighths *combined*. Thus, the lack of one-eighth spreads for some NASDAQ stocks is not surprising in light of the absence of odd-eighth quotes.

A closer examination of Figure 4 indicates that the distribution of odd-eighth quotes is bimodal, as the percentage is close to 0 or 50 percent for a majority of firms. To illustrate, Panel B of Table II reports the distribution of odd-eighth quotes at the bid and at the ask for Apple Computer, Lotus

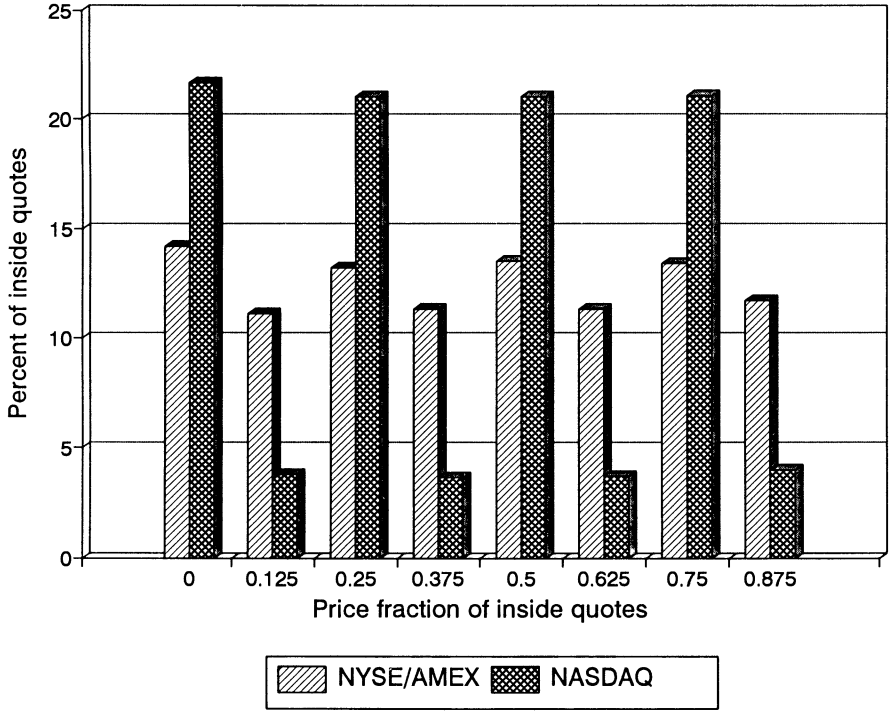


Figure 3. The distribution of price fractions across all inside quotes for 100 NASDAQ and 100 NYSE/AMEX securities of similar price and end-of-year market capitalization. The figure contrasts the percentage of price fractions that fall on each eighth for firms listed on the NYSE/AMEX versus firms listed on NASDAQ. The percentage is an average of the frequencies at the bid and ask, computed using all inside quotes for all stocks throughout 1991. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day.

Development, and MCI Communications. Fewer than 2 percent of all bid or ask quotes fall on odd eighths for both Apple and Lotus, while more than half of the bid or ask quotes are on odd eighths for MCI.[9]

The concentration of odd-eighth quote frequencies near 0 and 50 percent suggests that the intermediate percentages between 10 and 40 percent may indicate firms whose market makers ceased or initiated quoting on odd eighths during 1991. To examine whether the pattern of quoting on odd eighths changed during the year for these firms, Figure 5 plots the cumulative monthly percentage of quotes that appear on odd eighths for the five most active of these stocks. As the figure indicates, the percentage of odd-eighth quotes for each stock began the year near 50 percent. However, the percentage of odd-eighth quotes for each stock collapsed to near 0 percent at

[9] The absence of odd-eighth quotes for Apple and Lotus is not restricted to the sample period studied in this article. Using data obtained from the Bridge Quotation System, we found that these stocks continued to be quoted solely in even eighths on January 28, 1994.

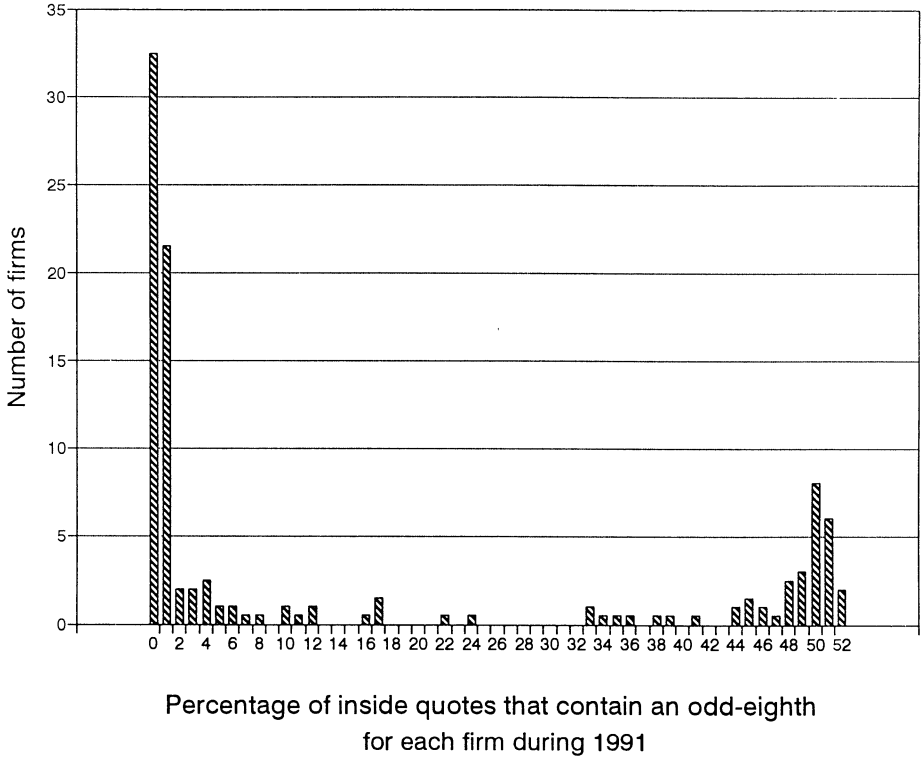


Figure 4. The frequency of odd-eighth quotes across the sample of 100 NASDAQ securities. The frequency of odd-eighth quotes is computed as an average of the frequencies at the bid and the ask, using all inside quotes throughout 1991. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. The horizontal axis represents the percentage of all quotes that result in an odd-eighth quote. The height of the bar represents the number of firms with the specific percentage of odd-eighth quotes in 1991.

different times during 1991, with virtually no odd-eighth quotes present by December. Thus, whatever factors induced market makers to use odd eighths in quoting these stocks early in 1991 vanished during the year.[10]

While Figures 3 and 4 establish the lack of odd-eighth quotes for a majority of NASDAQ firms, the number of odd-eighth quotes may exaggerate their

[10] While the five firms studied in Figure 5 cease using odd eighths during 1991, a few of the less active stocks with an intermediate fraction of odd-eighth quotes initiated using odd eighths during the year. We also attempt to identify a common event that could explain why market makers altered the way that they quoted these stocks during 1991. However, an examination of the *Wall Street Journal Index* provides no clues as to the underlying reason why market makers initiated or ceased using odd eighths. We do observe significant average price increases among firms whose market makers ceased using odd eighths, consistent with the hypothesis that higher priced firms would have wider spreads. However, we also note similar price increases for stocks whose dealers began using odd-eighth quotes during 1991. Thus, we are unable to identify a consistent explanation for the decision by market makers to alter their use of odd-eighth quotes.

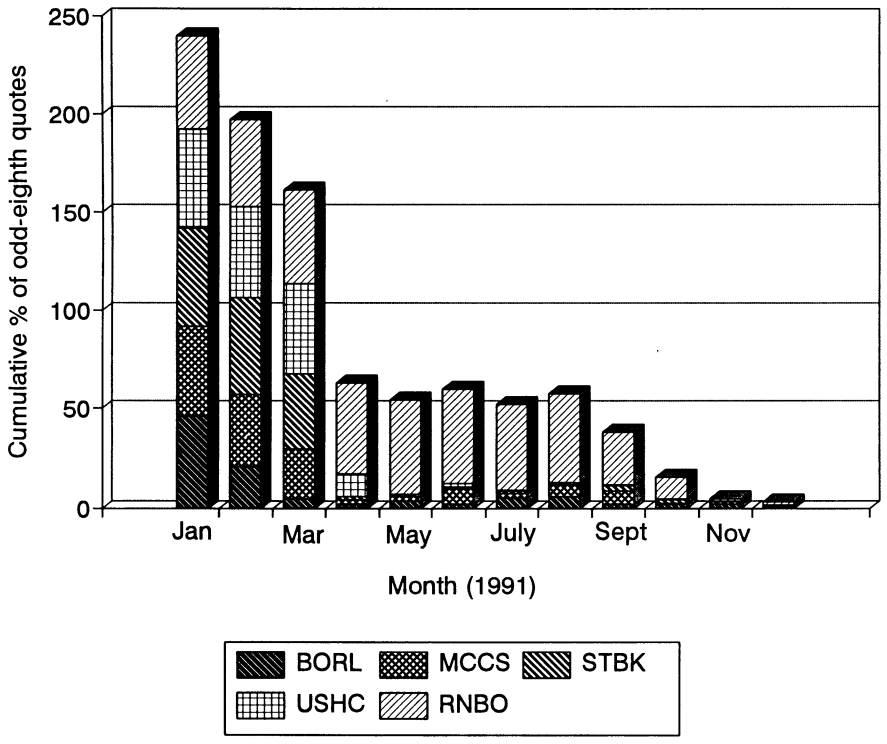
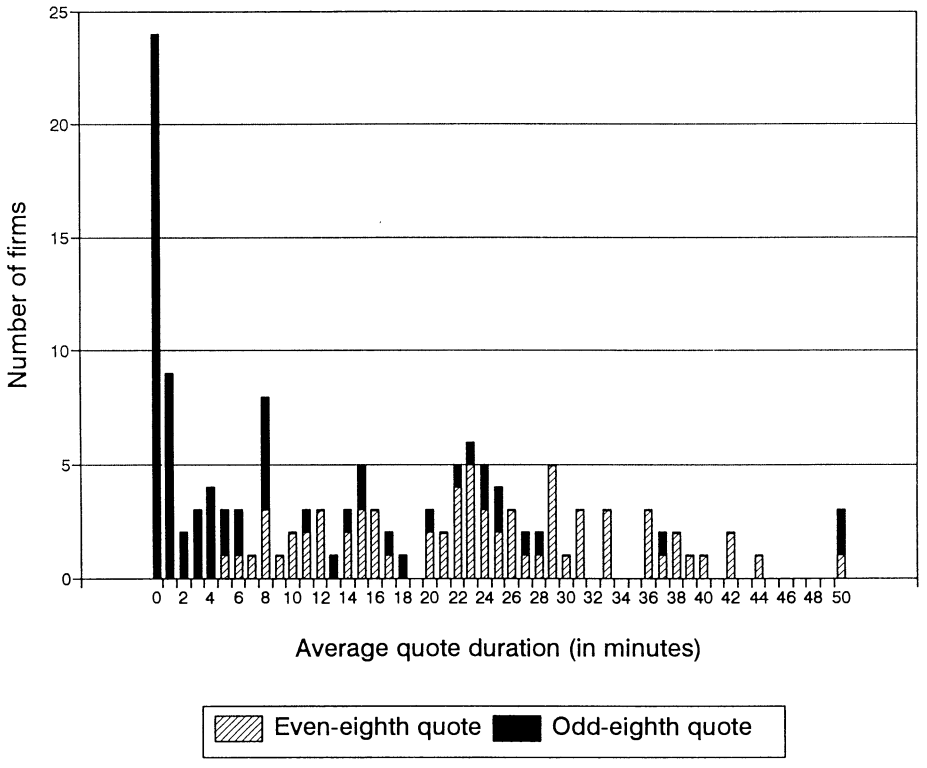


Figure 5. The monthly frequency of odd-eighth quotes for 5 NASDAQ firms whose market makers ceased using odd eighths in 1991. The percentage of odd-eighth quotes represents an average of the frequency of odd-eighth quotes at the inside bid and inside ask. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. The firms used in the figure are: Borland International Inc. (BORL), Medco Containment Services (MCCS), United States Healthcare Inc. (USHC), State Street Boston Corp. (STBK), and Rainbow Technologies Inc. (RNBO). The vertical axis represents the cumulative frequency of odd-eighth quotes summed across the 5 firms. Thus, the cumulative frequency of close to 250 percent in January indicates that odd-eighth quotes represented close to 50 percent of the price fractions for each of these firms at the start of the year. This cumulative frequency collapses to near zero by December 1991.

limited importance if they are effective for shorter time intervals than are even-eighth quotes. To examine this issue, we calculate the average time that odd-eighth quotes (at either the bid or ask) and even-eighth quotes (at both the bid and ask) are in effect. The analysis separately considers the 70 (30) NASDAQ stocks whose market makers rarely (routinely) use odd eighths, where market makers are defined as quoting in odd eighths if at least 25 percent of all the quotes include an odd eighth.

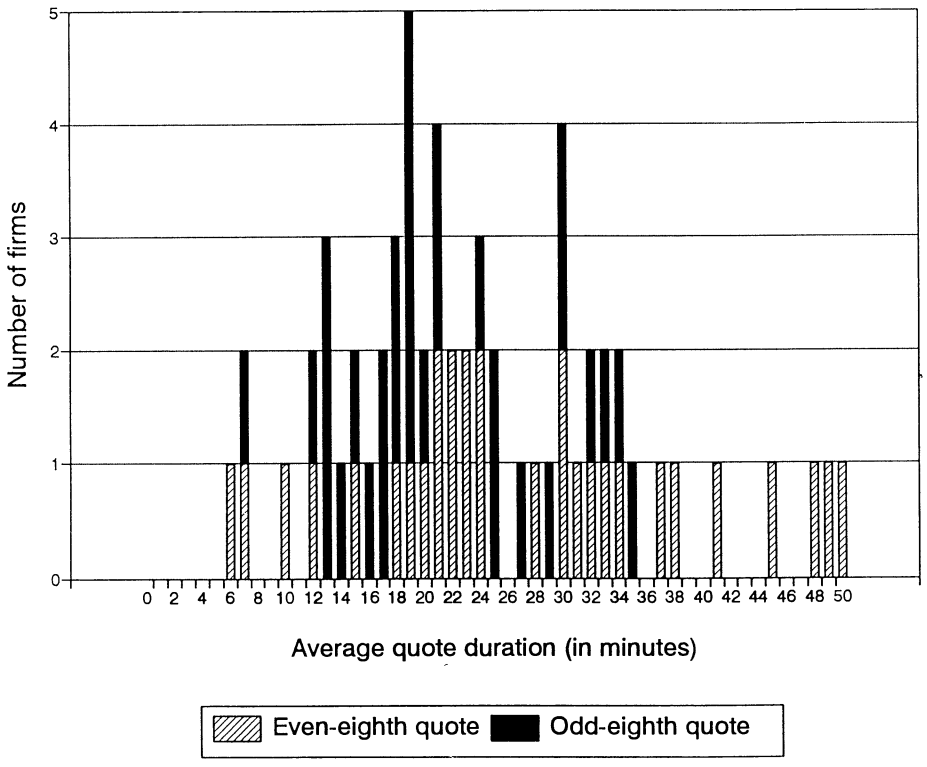
The results are presented in Figure 6. The horizontal axis denotes the mean quote duration (in minutes) for each stock. The height of the bar depicts the number of stocks sharing each average quote duration. Panel A, which

presents the results for the 70 issues whose market makers rarely use odd eighths, indicates that for most stocks the average length of time that an odd-eighth quote is effective is less than 2 minutes. In contrast, the mean duration of even-eighth quotes is between 20 and 35 minutes. Thus, the ability to transact at odd-eighth quotes is even rarer than Figures 3 and 4 imply. Panel B, which presents the results for the 30 issues whose market



(A)

Figure 6. The distribution of the average duration of standing quotes for the sample of 100 NASDAQ stocks. The figure presents the distribution across firms of the average time (in minutes) that inside quotes remain unchanged for odd-eighth and even-eighth quotes during 1991. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. An even-eighth quote is defined as a quote where both the inside bid and inside ask fall on an even eighth. An odd-eighth quote contains an odd eighth at the inside bid and/or inside ask. The average quote duration for even-eighth and odd-eighth quotes is computed for each stock. Panel A (B) presents the distribution of quote durations across the 70 (30) NASDAQ stocks whose market makers avoid (use) odd eighths. Market makers are designated as avoiding odd eighths if fewer than 25 percent of inside quotes include an odd eighth in 1991. The height of the bar indicates the number of firms whose even-eighth or odd-eighth quote durations correspond to the values indicated on the horizontal axis. For example, the distribution in Panel A indicates that the average quote duration for odd-eighth quotes was less than 3 minutes for 35 of the 70 firms. In comparison, the average quote duration for even-eighth quotes was never less than 3 minutes for any of these 70 stocks.



(B)

Figure 6.—*Continued.*

makers routinely use odd eighths, shows that the mean duration of odd-eighth and even-eighth quotes is quite similar.

Finally, to assess whether the more active stocks (as measured by the total number of trades in 1991) are more likely to be quoted in odd eighths, we calculate the percentage of odd-eighth quotes separately for the 50 most active and the 50 least active stocks in our sample. The results are plotted in Figure 7. The figure shows that trading activity is unable to predict which firms are quoted in odd eighths. Although the fraction of stocks whose market makers use odd eighths for 40 to 50 percent of their quotes is higher for the more active firms, the vast majority of firms in both groups are traded by market makers that avoid odd eighths.

In summary, the differences in spreads, and therefore trading costs, between a majority of NASDAQ and listed securities can be traced to a departure by NASDAQ dealers from using all potential price fractions. In a competitive market with multiple market makers competing for order flow, the almost complete absence of odd-eighth quotes is an enigma. The rest of the article attempts to further understand the nature of this result and pursues possible explanations for its existence.

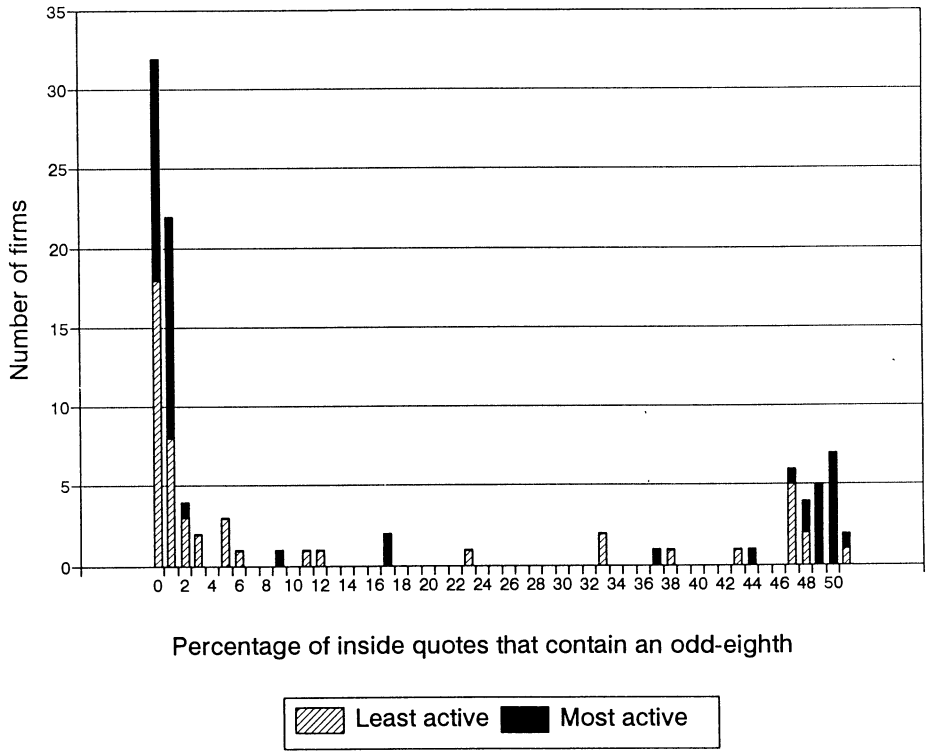


Figure 7. The frequency of odd-eighth quotes for the 50 most active and 50 least active NASDAQ stocks in our sample. The frequency of odd-eighth quotes is computed for each firm using all inside quotes throughout 1991. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. The horizontal axis represents the percentage of all inside quotes that result in an odd-eighth price fraction. The height of the bar represents the number of firms with the specific percentage of odd-eighth quotes. Trading activity is measured by the total number of trades in 1991.

B. The Avoidance of Odd-Eighth Quotes and the Costs of Negotiation

Harris (1991) documents price clustering for NYSE stocks, where prices ending on even dollar amounts are more common than prices ending on halves; halves are more common than odd quarters; and odd quarters are more common than odd eighths. Figure 4 indicates that clustering is present for the NYSE/AMEX quotes in our sample, where odd-eighth quotes constitute between 40 and 50 percent of the total.[11] Harris (1991) suggests that price clustering may serve to lower the costs of negotiation. By using coarse price increments, the time needed to agree on a price and the likelihood of a misunderstanding are minimized. Harris further states that individual deal-

[11] Harris notes that clustering is more pronounced for NASDAQ stocks than listed stocks, but when examining NASDAQ stocks he examines the proportion of prices at whole dollars rather than the frequency of odd and even eighths.

ers have an incentive to use coarse price increments to establish "a reputation as low-cost negotiators because they play a repeated game."

This negotiation hypothesis provides testable implications for the relation between trade size and price clustering for NASDAQ stocks. Since this hypothesis requires that trades be negotiated between dealers, the analysis explicitly distinguishes between negotiated and automated executions. Orders of 1,000 shares or less are seldom negotiated but are executed automatically through the Small Order Execution System (SOES). These orders are allocated sequentially among dealers posting inside quotes or preferenced to a market maker who has agreed in advance to execute preferenced trades at the inside market. In contrast, larger orders are directly negotiated between the dealer and the stockbroker acting as agent for the buyer or seller. If quotes are restricted to even eighths to minimize the costs of negotiation, large trades should *not* be transacted on the odd eighths, particularly for firms that are not typically quoted in odd eighths. Alternatively, if the benefits of negotiation for trades that exceed 1,000 shares outweigh the potential costs, market makers may use the full range of possible prices. Under this interpretation, negotiated trades are more likely to involve an odd eighth as market makers attempt to obtain a price that lies inside the posted even-eighth quotes.

Whether the potential benefits outweigh the costs and produce a greater or lesser concentration of odd-eighth trade prices is an empirical issue, which is resolved in Figure 8. Panel A displays the frequency of odd-eighth transaction prices for the 70 stocks whose market makers rarely use odd eighths. The figure indicates that large trades are *far more likely* to occur on odd eighths than are small trades. Indeed, the two distributions of large versus small trades on odd eighths barely overlap. Panel B, which provides the results for the 30 issues whose dealers regularly use odd eighths, shows no discernable difference between the distribution of large and small trades on odd eighths. Thus, when stocks are quoted in even eighths, dealers will execute trades on odd eighths more frequently when the trades are negotiated rather than executed automatically. Therefore, the negotiation hypothesis appears incapable of explaining the lack of odd-eighth quotes for the majority of our sample.

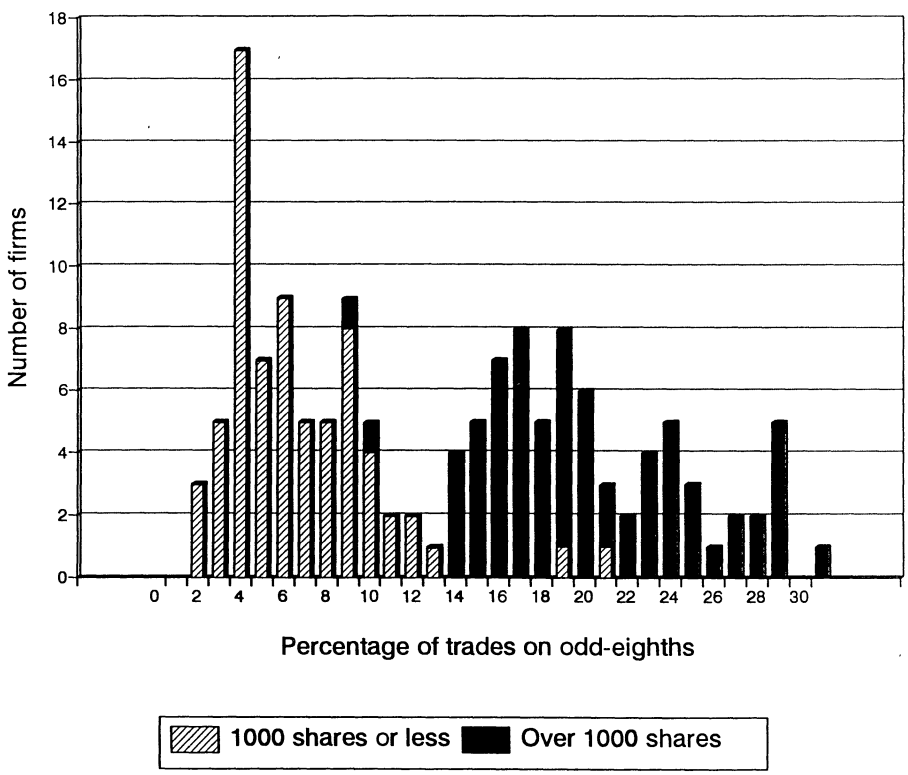
Panel C of Table II provides specific examples of the use of odd-eighth prices for large versus small transactions for three selected NASDAQ firms. For Apple and Lotus approximately 10 percent of small trades are transacted on an odd eighth. In contrast, close to 30 percent of large trades occur on an odd eighth. MCI continues to display characteristics that are similar to listed stocks, with little difference noted in the use of odd eighths for small or large trades.

These results also provide evidence on the costs of transacting from the perspective of trades rather than quotes. The lack of odd-eighth quotes would be unimportant if trades were evenly distributed across all eighths. However, Figure 8 reveals an inordinate number of trades on even rather than odd

eighths, especially for trades of 1,000 shares or less. Thus, effective spreads, as well as quoted spreads, are affected by the lack of odd eighths.

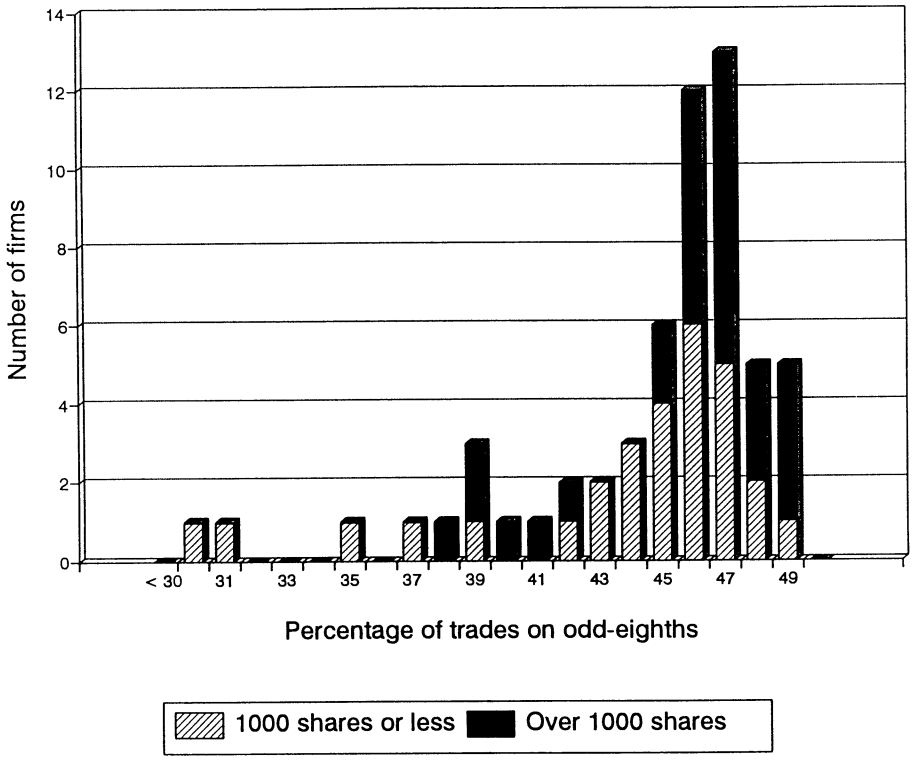
C. Can the Economic Determinants of Spreads Explain the Lack of Odd-Eighth Quotes?

Cross-sectional differences in the use of odd-eighth quotes across firms may be explained by the underlying economic factors that are thought to determine bid-ask spreads. Spreads may be inversely related to volume if greater volume implies that dealers can unwind risky positions more quickly. Studies by Goldstein (1993), Neal (1992), and Stoll (1978) provide empirical support for this conjecture. Greater volatility implies that dealers face higher inven-



(A)

Figure 8. The distribution of the percentage of large and small trades executed on odd eighths across the sample of 100 NASDAQ stocks. We include all trades that are executed between 9:30 A.M. and 4:00 P.M. for the NASDAQ sample throughout 1991. Small trades are defined as 1,000 shares or fewer, whereas large trades exceed this threshold. The horizontal axis represents the percentage of all trades that were executed on an odd eighth, while the height of the bar represents the number of firms sharing the specific percentage of odd-eighth trades. Panel A (B) presents the evidence for the 70 (30) NASDAQ stocks whose market makers avoid (use) odd eighths. Market makers are designated as avoiding odd eighths if fewer than 25 percent of inside quotes include an odd eighth in 1991.



(B)

Figure 8.—*Continued.*

tory risk and greater losses from trading against informed traders. Benston and Hagerman (1974), Stoll (1978), Neal (1992), and Goldstein (1993) show that wider spreads are also associated with higher standard deviations of returns. Other variables that have been previously shown to affect spread width include market capitalization and, for dollar spreads, the stock price.

To assess whether these variables can help explain the cross-sectional differences in the propensity of market makers to use odd-eighth quotes, we again partition firms based on whether their market makers used or avoided odd eighths. For each stock, we estimate the annual average of the daily closing price, daily size (stock price times shares outstanding), daily trading volume, the daily number of market makers, and the standard deviation of daily returns estimated from the midpoint of the daily closing bid and ask prices.[12] We also include dummy variables to indicate whether trades were

[12] Another variable that might be potentially important in predicting the firms whose market makers use odd eighths is the distribution of market concentration. Stocks where the trading volume is concentrated among a small subset of market makers would be more likely to be quoted solely in even eighths. Unfortunately, the distribution of market concentration among dealers could not be identified with our data sources.

executed on a regional exchange and whether listed options were traded in 1991. These latter two factors are predicted to increase the probability that a stock would be quoted in odd eighths, as they imply competition from other sources to trade the stock or securities that are close substitutes for the stock. We then estimate logistic regressions that predict the probability of a firm being quoted using odd eighths. In a separate regression, we include a dummy variable that indicates whether odd-eighth quotes were used in January 1991.

Panel A of Table III reports the maximum likelihood estimates of the coefficients from the logistic regressions, along with their standard errors. The first regression uses the full sample, while the second regression is confined to the period between July and December. Since we estimate the regressions over different periods, the monthly proportion of odd-eighth quotes is averaged separately across months for the two regressions. This averaging classifies 71 of the 100 stocks as not routinely quoted in odd eighths in each period. The results for these two regressions indicate that the coefficients on price and variance are statistically significant at the 5 percent level. Thus, the probability that a stock will be quoted in odd eighths declines with the stock price and return variability. However, the remaining coefficients are insignificantly different from zero in each of the first two regressions.

To demonstrate the logistic model's ability to correctly classify stocks as being quoted or not being quoted in odd eighths, we first partition the sample using the criterion of whether the model predicts a probability of odd-eighths use that is greater or less than 50 percent. We then examine whether this criterion accurately partitions the sample into firms that do or do not use odd eighths. The results are contained in the first two rows of Panel B in Table III. Of the 71 stocks whose market makers rarely use odd eighths, 65 (64) are correctly classified using the probabilities estimated from the first (second) regression. Of the 29 stocks whose market makers routinely used odd eighths, 15 are correctly classified. While the probabilities supplied by the model correctly classify 80 percent of the 100 stocks, a naive prediction that no stocks are quoted in odd eighths correctly classifies 71 percent. These results suggest that the logistic model's ability to predict whether a stock will be quoted in odd eighths is limited, particularly in classifying stocks where odd-eighth quotes are routinely used.[13]

Since the economic fundamentals used in our logistic regressions do not explain the mysterious absence of odd-eighth quotes, the third regression in Panel A in Table III includes a dummy variable, "Past," which equals 1 for

[13] The regressions are replicated for a subsample of 96 firms where we can identify the percentage of outstanding shares owned by institutions at the end of 1991, as reported in the *Standard and Poor's Stock Guide*. A higher percentage of ownership among institutions might force market makers to post wider spreads (and avoid the use of odd eighths) if the dealers perceived an increased probability of informed trades. However, the estimated t-statistic for this variable is under 1.0.

Table III

Results of Logistic Regressions that Predict the Probability that Stocks are Quoted Using Odd Eighths

We classify stocks as being quoted in odd eighths if the average monthly proportion of quotes on odd eighths is at least 25 percent. The dependent variable takes a value of 1 for stocks that are quoted in odd eighths. The independent variables used in the logistic regression are as follows. Volume is in 100,000s of shares, daily. Size is measured as the equity capitalization in multiples of $1 million. Variance is measured using daily returns calculated from the midpoint of the closing bid-ask spread. Price is defined as the average of the bid-ask midpoint measured over all quotes. Number of Dealers during 1991 is computed by weighting the number of market makers by the proportion of days that number appeared in 1991. Volume, Size, Variance, Price, and the number of market makers are obtained from the Center for Research in Securities Prices NASDAQ tape. Listed Options is a dummy variable that takes the value of 1 for firms with listed options during 1991. Dual listed is a dummy variable that equals 1 for firms whose shares were traded on the regional exchanges. Past is a dummy variable that takes the value of 1 if the firm had been quoted using odd eighths in January. The regression estimates are presented in Panel A. The logistic regressions estimate a probability that a stock will be quoted in odd eighths. We define stocks as being correctly classified by the model in Panel B if the stock is (is not) quoted in odd eighths and the model assigns a probability of at least 0.5 (less than 0.5) that the stock is quoted in odd eighths. na means not applicable.

Panel A: Coefficient Estimates

		Regression Coefficient and Standard Errors (in parentheses)							
Regression	Sample Period (1991)	*Price*	*Size* ($ millions)	*Volume* (100,000s)	*Variance*	*Number of Dealers*	*Listed Options*	*Dual Listed*	*Past*
1	Full year	−0.157**	−0.00010	−0.00017	−8.573**	0.127	1.326	−0.588	na
		(0.042)	(0.00046)	(0.00159)	(3.370)	(0.073)	(1.040)	(1.048)	
2	July–December	−0.173**	−0.00012	−0.00016	−9.014*	0.117	1.418	−0.462	na
		(0.044)	(0.00042)	(0.00165)	(3.524)	(0.069)	(1.055)	(1.104)	
3	July–December	−0.252*	0.000943	−0.00109	−9.373	−0.014	2.608	0.369	13.138**
		(0.111)	(0.000864)	(0.00262)	(5.811)	(0.164)	(2.171)	(2.377)	(3.686)

Panel B: Classification Accuracy

		Stocks Not Quoted in Odd Eighths		Stocks Quoted in Odd Eighths	
Regression	Sample Period (1991)	Correctly Classified	Incorrectly Classified	Correctly Classified	Incorrectly Classified
1	Full year	65	6	15	14
2	July–December 1991	64	7	15	14
3	July–December 1991	64	7	24	5

* Significantly different from 0 at the 5 percent level.
** Significantly different from 0 at the 1 percent level.

firms where odd eighths had been used in January. The results show that the coefficient for "Past" is 13.14. The standard error of 3.69 indicates that the coefficient is significant at the 1 percent confidence level. The price variable retains its negative coefficient, but is now statistically significant only at the 5 percent level. More importantly, the third row of Panel B shows that classification is much improved with the knowledge of whether odd-eighth quotes had been used in January, particularly for those stocks that are regularly quoted in odd eighths. Specifically, the model now correctly classifies 24 of the 29 firms whose market makers use odd eighths, whereas the regressions that excluded "Past" correctly predicted only 15 of these 29 firms.

To further study the persistence in the avoidance of odd-eighth quotes, we examine the frequency of odd- and even-eighth quotes for NASDAQ stocks that split during 1991. A total of 20 stocks split 3–2, 2–1, or 3–1 from February through November. In the month prior to the split, odd eighths comprised less than 3 percent of the quotes for 16 of the stocks, and more than 42 percent of the quotes for the remaining 4. In the month after the split, there were no significant changes in the proportion of odd-eighth quotes for any of the 20 stocks despite large price declines. These results suggest that if market makers restrict their quotes to quarters, they will continue to do so even when characteristics of the stock change.

D. Tacit Collusion Among Market Makers as an Explanation for the Lack of Odd-Eighth Quotes

Game theory suggests that collusion among NASDAQ market makers may arise despite the large number of dealers in a given market. Market makers interact frequently and over long periods of time with the same population of other market makers. Thus, in setting quotes, NASDAQ dealers are essentially engaged in an infinitely repeated game. Furthermore, current and historical quotes of all market makers are available to all dealers, making it a game of complete and perfect information. The well-known "folk theorem" (see Friedman (1971)) states that under such conditions, and given that the future costs to each player of deserting the equilibrium exceed the immediate gains, collusion is a possible equilibrium. In this context the absence of odd-eighth quotes is not surprising. In situations where agents collude, round numbers can be used as "focal points" to coordinate prices (see Fudenberg and Tirole (1993), pages 19 to 21).

The screen-based trading system used by NASDAQ renders the market sufficiently transparent that dealers who move within the accepted spread are readily observed. Other dealers can easily punish an offender by selecting from a number of alternative sanctions. One sanction is to have brokers divert customer orders away from a violator with the best posted but non-sanctioned price, thereby depriving the violator from receiving the trades.[14]

[14] In addition, market makers can elect to execute their retail customers' orders using the inside bid or ask prices. In this case, the orders are never entered into the NASDAQ execution systems, and the offending dealer has no opportunity to receive the trade.

This is easily accomplished since brokers are allowed to "preference" customer orders to any specific dealer who has agreed in advance to execute trades at the best quoted bid or ask price, independent of their posted quotes. Alternatively, if a violator has agreed to accept preferenced orders, brokers can preference customer orders to the violator on the wrong side of the spread. That is, if the offending dealer has the best quoted ask, sell orders can be directed to that dealer, who is required to execute them at the inside bid. Although the size of the preferenced orders will be 1,000 shares or less per trade, the cumulative effect of forcing a violator to accept these orders from multiple dealers can be significant. A third method for punishing dealers who move within the accepted spread is to direct customer trades to the offending dealer when the trades are perceived to be motivated by information rather than liquidity needs. An important feature of these sanctions is that they do not impose any costs on the brokers who initiate the preferenced orders. Finally, since NASDAQ market makers typically make markets in many stocks, sanctions can be applied in markets for other stocks or by withholding business in other areas (e.g., underwriting).

The presence of tacit collusion among market makers would suggest that odd-eighth quotes that narrow the existing spread would be rare. To examine whether odd-eighth spreads reflect an increase or decrease in the inside spread, Figure 9 plots the proportion of quotes that narrow the spread through the use of an odd eighth for the 70 firms whose dealers routinely avoid them. The analysis is confined to odd-eighth spreads that are \$0.375 or wider, since quotes that produce spreads of \$0.125 must always narrow the inside spread given the minimum tick size of one eighth for our sample of firms. The implicit collusion hypothesis predicts that the proportion of odd-eighth spreads that are narrower than the previous spread should be relatively low. Consistent with this prediction, Figure 9 indicates that an odd-eighth spread is far more likely to reflect an increasing rather than a narrowing spread.

While this article does not provide conclusive evidence of tacit collusion among market makers, we are unable to offer any other plausible explanation for the lack of odd-eighth quotes. In particular, using an odd eighth to better a spread should result in an instant increase in order flow through SOES to the firm posting the improved quote. Thus, it is difficult to understand why, in the absence of tacit collusion, at least a few of the 50-plus market makers of Apple Computer do not use odd-eighth quotes to attract orders. Furthermore, the increased use of odd eighths for large trades is consistent with a market where dealers agree to maintain wide spreads for smaller customer orders but negotiate larger trades on the odd eighths when trading with a fellow dealer. The exceptionally short duration of odd-eighth quotes arises naturally in the presence of implicit agreements among dealers to rely on the even eighths. Under the hypothesis that our results arise from the presence of an implicit understanding among market makers to not post odd-eighth quotes, our evidence suggests that once tacit agreements are established,

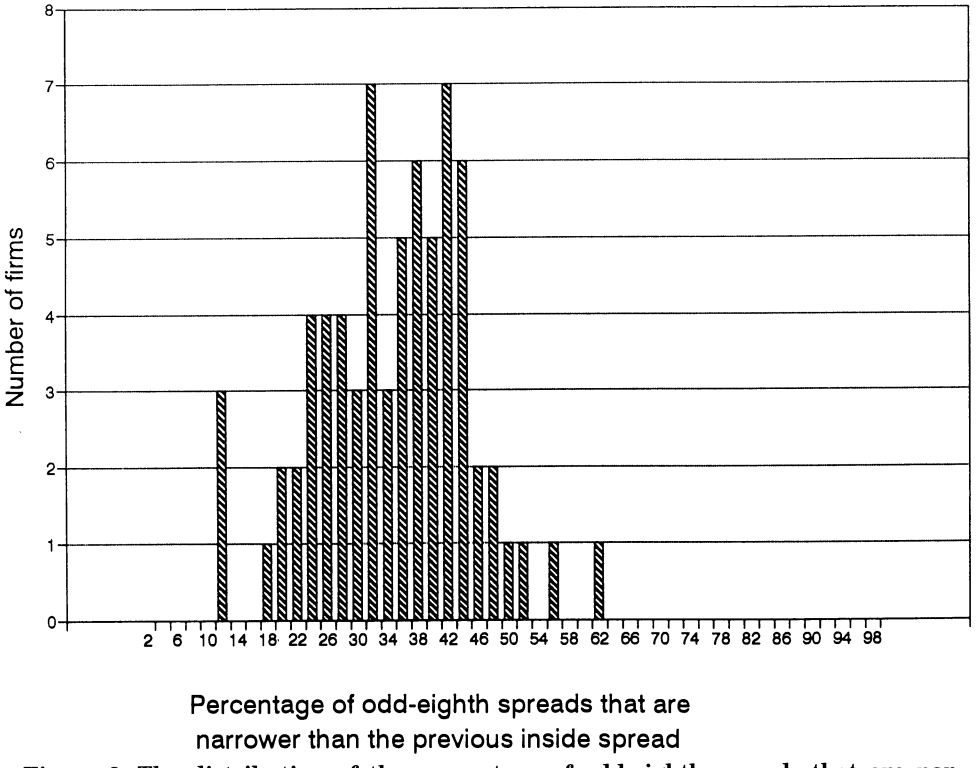


Figure 9. The distribution of the percentage of odd-eighth spreads that are narrower than the previous spread across the sample of 70 NASDAQ stocks whose market makers avoid odd-eighth quotes. Market makers are designated as avoiding odd eighths if fewer than 25 percent of inside quotes include an odd eighth. The figure depicts the percentage of odd-eighth spreads of at least \$0.375 that are narrower than the previous spread. The frequency of odd-eighth spreads is computed for each firm using all inside quotes throughout 1991. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. The horizontal axis represents the percentage of all quotes that result in an odd-eighth spread of at least \$0.375. The height of the bar represents the number of firms with the specific percentage of odd-eighth spreads.

they can be maintained despite changes in market conditions and the number and identity of dealers making markets in these stocks.

It is possible that the higher trading costs imposed on investors through spreads of at least \$0.25 may reflect structural characteristics unique to a dealer market that translate into higher costs of market making. Since the total order flow is fragmented across market makers, each dealer observes the order flow directed to that dealer alone. Thus, dealers face increased risks of being "picked off" by informed traders who disperse their trades across numerous dealers. In addition, NASDAQ spreads may be wider than spreads of listed stocks since individual market makers minimize the costs associated

with posting locked or crossed quotes.[15] While these explanations suggest that spreads may be wider for NASDAQ stocks than listed stocks on average, they do not explain why one-eighth spreads almost never appear for some of the most active NASDAQ stocks or why some firms are quoted in odd eighths while others are not.

An additional explanation for the persistence of wide spreads among the majority of the NASDAQ sample considers the dynamics of dealer competition in the absence of a time precedence rule (see Harris (1990)). The NASDAQ market does not enforce (and is not designed to enforce) time precedence among its dealers. Spreads may remain wide if dealers who are willing to supply liquidity by posting quotes inside the existing spread are unable to capture the increased order flow from the price improvement. This inability to capture trades exists since other dealers can match their quote or preference orders to dealers who will match the new price. Thus, little incentive exists for individual dealers to improve the spread since such actions would have a very small effect on their ability to attract trades. However, the lack of time precedence also eases the ability of market makers to punish violators, since orders can be easily channeled away from the offending dealer. In addition, the lack of time precedence cannot explain why dealers collectively elected to quote stocks without using odd eighths.

It is important to note that these results do not provide a complete description of the differences between listing on NASDAQ and on the organized exchanges. Hundreds of firms that meet exchange listing requirements elect to remain on the NASDAQ for many years. In equilibrium, additional benefits to listing on the NASDAQ may offset the higher costs that we document for the majority of our sample. Indeed, our results suggest a number of areas for potentially fruitful research. In particular, what determines why certain firms are quoted only in even eighths, and what factors prompt market makers to cease or begin quoting in odd eighths? Further, what are the sources of the additional benefits that accrue to firms that remain listed on the NASDAQ to offset the costs established in this article?

Our results also have implications for the debate concerning the minimum tick size under consideration by the Securities and Exchange Commission, the NASD and the NYSE. For some stocks, the minimum tick size of one-eighth may be larger than necessary, and the movement to a minimum tick size of one-sixteenth may result in narrower spreads and lower trading costs. Harris (1994) presents evidence that suggests the adoption of a one-sixteenth tick size would reduce bid-ask spreads by an average of 38 percent for NYSE stocks, although the depth at these quotes would also decline. Our results strongly suggest that these reductions in spreads would not extend to

[15] A related explanation for wider NASDAQ spreads concerns the activity of "SOES Bandits." Since the SOES permits automatic execution of trades for 1,000 shares or less, these traders could exploit cross-sectional discrepancies in dealer quotes to simultaneously buy and sell shares and profit from locked or crossed quotes. Thus, individual dealers need to maintain wider spreads to compensate for losses to the "SOES Bandits." See Stoll (1992) and the December 21, 1993 edition of the *Wall Street Journal* for a more detailed description of these traders.

most stocks listed on NASDAQ. Since the spreads for a large number of NASDAQ stocks in our sample fail to narrow to under $0.25, it seems unlikely that smaller minimum tick sizes would promote narrower spreads.

IV. Summary and Conclusions

While previous studies rely on comparisons of summary measures of bid-ask spreads across markets, we examine the entire distribution of dollar spreads for 100 NASDAQ stocks and compare these results with a sample of 100 NYSE/AMEX firms. Our concern rests not with a direct comparison of trading costs across trading structures, but with how stocks in these different markets are quoted. The volume of data is extensive and includes all trades and quote updates for the entire year of 1991. We find that, unlike NYSE/AMEX stocks, the majority of NASDAQ stocks are virtually never quoted with a spread of $0.125, and that spreads of $0.375 and $0.625 are less common than the surrounding even-eighths spreads. The wider spreads for NASDAQ stocks are directly linked to a pervasive and anomalous distaste for posting bid or ask quotes on odd eighths. We find that when odd-eighth quotes do appear among firms whose market makers rarely use odd eighths, the quotes have the appearance of a mirage since their expected duration is less than 2 minutes, while even-eighth quotes can be expected to last for at least 20 minutes.

The lack of odd-eighth quotes could serve to minimize the costs of negotiation between market makers for executing large trades. However, our results contradict this explanation, since we find that larger trades, which are negotiated, are far more likely to occur on odd eighths than trades of 1,000 shares or less, which are typically executed automatically. Thus, the negotiators appear to gravitate towards odd eighths despite the lack of odd-eighth quotes posted by the same set of dealers. Our logistic regressions indicate that variables previously shown to affect the width of bid-ask spreads have little power in identifying the firms whose market makers avoid or utilize odd eighths. Rather, the variable with the greatest power in classifying firms along this dimension is whether market makers had established a tradition of exclusively using odd-eighth quotes.

In summary, the almost complete absence of odd-eighth quotes for 70 percent of the NASDAQ sample, including such heavily traded stocks as Apple Computer and Lotus Development, imposes obvious and real costs on investors. The results are particularly surprising since they emerge from a dealer market where the inside spread represents the best consolidated quote from as many as 60 market makers. One possible explanation for our results is that we are observing the quote-setting behavior that emerges when individual market makers implicitly agree to maintain spreads of at least $0.25 by not posting quotes on odd eighths. This inference is strengthened by the persistence of this result through time and across stocks and the simulta-

neous adoption of odd-eighth quotes by NASDAQ market makers when the practice of quoting stocks exclusively in even eighths was made public (see Christie, Harris, and Schultz (1994)).

We are unable to envision any scenario in which 40 to 60 dealers who are competing for order flow would simultaneously and consistently avoid using odd-eighth quotes without an implicit agreement to post quotes only on the even price fractions. However, our data do not provide direct evidence of tacit collusion among NASDAQ market makers. Such inferences would require direct observation of market-maker intervention forcing the withdrawal of nonsanctioned quotes, punishing a dealer who posts nonsanctioned quotes by diverting orders away from that dealer, diverting orders to the offending dealer that would be unwelcome (i.e., information-based trades or trades that would aggravate the violators inventory position), or withholding business in other areas. In light of the absence of odd-eighth quotes and the subsequent inability of spreads to narrow to less than \$0.25 for a majority of actively traded NASDAQ stocks, additional research into the source of the apparent lack of competitiveness of the NASDAQ market appears warranted.

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