The Value of the Specialist:

Empirical Evidence from the CBOE

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Abstract

Using proprietary data and an event unique in the history of financial markets, this paper studies the value that a specialist system adds vis-à-vis a multiple market maker system. Specifically, we analyze the "natural experiment" of the institution of a specialist system for equity options on the Chicago Board Options Exchange (CBOE) in the second half of 1999. The extant literature predicts a decrease in spreads and an increase in depth due to the change to a specialist system on the CBOE. We find support for these hypotheses. These changes are more pronounced for lower volume securities and smaller trades. We also offer limited evidence that the market share of the CBOE increases in the period after the option class moves on to the specialist system suggesting increased competitiveness for the CBOE. The paper also analyzes the implications of the move arising from single listing of certain options and the lack of a national market system for options during the sample period.

The Value of the Specialist: Empirical Evidence from the CBOE

This paper studies an enduring issue related to optimal market structure. Using proprietary data and an event unique in the history of financial markets, the paper is able to address the deceptively simple question, does the specialist system add value?

Considerable theoretical and empirical literature has been devoted to this debate. However, previous empirical studies have either examined a matched sample of securities trading under two different trading systems, or examined equities that switched markets. Studies in the former group may suffer from errors induced through less than perfect matching. Studies in the latter group may contain biases due to externalities not related to the different trading systems used by the two markets.[1] This study examines the same securities on the same exchange under two different trading systems. We therefore provide the strongest test possible of the value of the specialist system.

Specifically, we analyze the "natural experiment" of the switch from a multiple market maker system to a specialist system for equity options on the Chicago Board Options Exchange (CBOE) during the second half of 1999. On June 29th, 1999 the CBOE Board approved a plan to assign specialists, called Designated Primary Market Makers (DPMs), for all equity options.[2] Option classes were transferred to the DPM system in stages between August and October 1999. The CBOE did not eliminate market makers. A specialist system was superimposed on the

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[1] For example, in studies examining stocks that switched from Nasdaq to the NYSE, there may be a certification effect. In other words, some investors may only invest in NYSE listed stocks because they view the listing process as a certification that the firm is of a certain caliber. Also studies comparing Nasdaq's market maker system to the NYSE's specialist system cannot separate market structure from the increased prevalence of preferencing that exists on Nasdaq (see Bessembinder (1999) for a discussion of this issue.

[2] DPMs on the CBOE have duties very similar to NYSE specialists. Each option class is assigned to one DPM who is then responsible for maintaining the limit order book. The DPM stands ready to trade in the assigned option classes and has many of the same associated functions as a specialist. Due to the similarity of their functions, we will use DPM and specialist interchangeably throughout the paper.

existing multiple market maker system. Thus, an analysis of the event allows us to estimate the incremental benefits or costs of a specialist system relative to a multiple market maker system.

The nature of the event also allows us to examine whether the CBOE trading system change impacted its competitiveness by examining changes in the CBOE's market share, after the adoption of the specialist system, for a group of options that were multiple listed over the entire sample period. In addition, we are able to examine the competitive response of other exchanges after the switch. Previous studies have been unable to examine this issue.

During the period of our study, no formal linkage existed between U.S. option exchanges.[3] Therefore, we are able to examine the extent to which orders routed to an options exchange were executed at prices inferior to those quoted by other exchanges (called a trade through). Ceteris paribus, we would not expect a statistically significant change in the number of trade throughs following the switch. However, one of the parameters a DPM can compete on is paying for order flow.[4] If specialists enter into order preferencing arrangements then we should see an increase in the number of trade throughs on the CBOE after the institution of the DPM system.

In summary, this paper's contributions to the literature are threefold: 1) we study the marginal impact of a specialist system on market quality and competition; 2) we examine competitive responses between exchanges following system changes; and 3) we provide an analysis of the importance of formal linkages between exchanges in terms of trade execution quality and preferencing.

[3] On October 19, 1999 the Securities and Exchange Commission (SEC) issued an order directing the options exchanges to file a national market system plan for linking the options markets (Securities Exchange Act Release No. 42029). Such a plan was filed by the U.S. options exchanges on January 19, 2000.

[4] CBOE has, in fact, started "taxing" its members 40 cents per option contract traded to build a financial base for the specialist to purchase order flow. SEC approved this move (Wall Street Journal, September 7, 2000).

In addition to academics this paper should be of interest to exchanges and regulators. For example, new exchanges setting up face the decision of instituting a trading system that makes them competitive with established exchanges. A recent example is the rise of Nouveau Marche in Paris, Neuer Markt in Frankfurt, Euro NM in Amsterdam and Brussels, and Nuovo Mercato in Milan. All these exchanges were set up to combat EASDAQ. The first three adopted a multiple market maker system while Nuovo Mercato organized its trading based on the specialist system. Our study has direct relevance for such exchanges. Regulators should be interested in the results of our paper since they decide on such things as formal linkages between exchanges.

Finally, a well functioning and credible stock exchange is essential to the growth of capital markets in any economy. Thus, the welfare effects of trading mechanisms are relevant. Benveniste, Marcus and Wilhelm (1992) provide theoretical predictions on the welfare effects of the specialist system that we are directly able to test in this paper. Thus, economies in the nascent stages of development will be able to draw lessons from our paper.

Our results indicate a statistically significant decrease in quoted spreads following the trading system switch, as well as a decrease in effective spreads for small sized trades vis-a-vis large trades. Depth, as measured by Kyle's lambda, undergoes a statistically significant increase. We find a competitive response from the other major options exchange, the AMEX, following the change in the CBOE's trading system. However, we also offer limited evidence that the CBOE gained market share as a result of the change in its trading system. In short, we find an improvement in market quality following the adoption of a specialist system on the CBOE.

We also find support for the hypothesis that preferencing increases in a specialist system that allows it.[5] Specifically, we find that the volume traded through and the loss due to trade

[5] In equity markets, the NYSE and AMEX do not pay for order flow or enter into other agreements with brokers. In contrast, the regional stock exchanges do.

throughs both experience a significant increase on the CBOE as a result of the move to a specialist system.

In the next section we provide a literature review. Section II develops our hypotheses, Section III provides institutional details of trading on the CBOE as well as a summary of the changes resulting from a move to the DPM system and describes the data, Section IV discusses the results and Section V concludes.

I. Literature Review

Theoretical studies of single versus multiple dealers have centered on two components of the bid-ask spread, one arising out of the risk of trading against an informed trader (asymmetric information) and the other arising out of deviations from an optimal portfolio (inventory).

Glosten (1989) models the amount of trading based on private information in a market as a critical ingredient to market structure. A specialist system is expected to work better when there is a significant adverse selection problem since a specialist takes a long-term view and does not expect to profit from every trade. Thus, a specialist can take a loss on a trade with an informed trader and use the information learned to profit on trades with uninformed traders.

Benveniste, Marcus and Wilhelm (1992) focus on the effect of the trading mechanism chosen on the level of asymmetry in information in the market. Their model extends Glosten (1989) by incorporating certain realities of the NYSE floor. Specifically the "active" specialist seeks to identify informed orders. The ability of a specialist to impose penalties on floor brokers encourages brokers to reveal information about their orders.[6] Knowing the information content

[6] These penalties could come in the form of refusal to offer price or depth improvement to orders from a floor broker who did not reveal his information. On the CBOE floor, since the same individuals can act as market makers and floor brokers, the DPM gains even more influence. For example, the DPM in allocating order flow to market makers can choose not to "hear" a particular market maker in some situations.

of a trade, the specialist is able to offer different prices to informed and uninformed trades. They show that such a mechanism dominates an equilibrium where the specialist sets the same price to all orders by offering better terms of trade not only to uninformed traders but also to informed traders. The improved terms for informed traders occur due to increased uninformed volume resulting from lower costs. They also find that brokers are expected to be more profitable because of specialist intervention.

The level of anonymity in security markets is empirically studied by Garfinkel and Nimalendran (1998). Specifically, they analyze the impact of insider trading on market maker behavior to test the hypothesis that the NYSE is less anonymous than Nasdaq due to the difference in their market structures. Their results support the notion that NYSE specialists are better able to discriminate between informed and uninformed orders, thus reducing the level of information asymmetry in the market.

These studies suggest that changing from a market maker system to a specialist system would decrease information asymmetry, which in turn suggests a reduction in spread width.

Ho and Macris (1985) argue that a multiple dealer market is likely to have higher bid-ask spreads than a single dealer market but is also more likely to quote higher depth. Their results hinge on the higher collective ability of multiple dealers to absorb any inventory imbalances. However, market makers carry higher inventories in aggregate thus bearing a higher inventory cost. Replication of operations also causes their combined fixed costs to be higher. Higher inventory and fixed costs leads to higher spreads in their model. This is also the result obtained by Ho and Stoll (1983).

Vijh (1990) empirically examines this hypothesis by comparing CBOE options with their underlying NYSE stocks. The comparison is done by noting that an option can be replicated by holding "delta" units of stocks plus a bond. He finds that CBOE options have higher spreads than their underlying stocks, but display much higher depth as well. Thus, his results support the hypothesis put forward by Ho and Macris (1985) and Ho and Stoll (1983).

Given that the CBOE did not eliminate any market makers, but superimposed a specialist system on the existing system, there can be assumed a net increase in dealers (existing market makers plus a specialist). Thus, the inventory control literature predicts an increase in depth.

Grossman and Miller (1988) develop a model that relates the demand for liquidity (immediacy) to the optimal market structure for an asset. Assets that generate an extreme demand for liquidity are traded in a multiple market maker system. Therefore, volume is linked to the optimal market structure. A specialist system is preferred, according to their model, when trading volume is low and a competitive market maker structure when volume is high.

Neal (1992) uses the Grossman and Miller model as the basis for his empirical comparison of execution costs on the CBOE and AMEX. During his sample period CBOE options are traded in a competitive market maker system while the AMEX uses a specialist system. Consistent with the predictions of his model, he finds that spreads on AMEX options are lower than that on CBOE options for low volume options, with little separating the two for high volume options.

Our study differentiates itself from Neal (1992), as it is able to control for all confounding factors, as well as being able to examine competitive responses. Neal analyzes single listed options on the CBOE and AMEX in his study and argues that the SEC allocation plan created a system with no systematic biases in the two groups of options studied. We have, however, the perfect control for firm specific characteristics as the same option classes moved from one regime to the other giving us the cleanest test possible of the value of the specialist system. Also, due to the nature of the event we study, we are able to examine the competitive response of the AMEX to the CBOE switch to a specialist system.

We analyze the effects on depth of a change in the market structure. Neal does not look at this aspect of liquidity. Lee, Mucklow and Ready (1993) suggest that spreads alone provide an incomplete picture of liquidity, since market makers often adjust both their spreads and depth to manage liquidity provision. Therefore, to be able to draw any conclusions, one has to study spread as well as depth effects. Since depths are not disseminated in options markets, no previous study has directly analyzed this dimension of liquidity in options. We use the lambda measure suggested by Kyle (1985) to measure depth. Finally, we use a more recent data set, which is more comprehensive in option classes covered as well as the length of the data period.

In equity markets, various studies have compared trading costs on similar stocks on the specialist based NYSE and the multiple market maker based Nasdaq. Huang and Stoll (1996) examine large capitalization firms and find that execution costs on Nasdaq were almost twice as high as that on NYSE in 1991. Bessembinder and Kaufman (1997) extend the analysis to smaller firms and find that NYSE has the greatest advantage in terms of execution costs for smaller firms and for small trades. Bessembinder (1998) examines companies that switch from Nasdaq to the NYSE and finds that they experience a significant reduction in trading costs. Bessembinder (1999) compares trade execution costs on Nasdaq and the NYSE after the implementation of the SEC imposed order-handling rules and finds that differences in execution costs persist. These studies lend support to the theoretical predictions discussed earlier but do not perfectly control for firm or market structure effects. As Bessembinder (1999) notes, it is not possible to fathom whether these differences in costs are due to structural differences between specialist and multiple market maker systems or the pervasive practice of order preferencing on Nasdaq which might curtail competition among market makers.[7] Studies that use data before these order-handling rules are imposed are not able to contribute towards this debate, as there is considerable evidence that Nasdaq spreads were kept artificially high.[8]

Our study does not suffer from the same constraints. The only change is in the trading structure that moved from a multiple market maker system to a specialist system. No confounding factors contaminate our results or make them difficult to interpret.

II. Hypotheses Development

Benveniste, Marcus and Wilhelm (1992) predict lower asymmetric information costs in specialist markets vis-à-vis multiple dealer markets since the specialist is able to extract information from market participants and set his spreads accordingly. Garfinkel and Nimalendran (1998) find lower anonymity on NYSE than on Nasdaq in support of this hypothesis. Recent studies have found that this component is significant for options markets and further that informed traders prefer options markets.[9] Therefore, a reduction in asymmetric information costs should accompany the adoption of the DPM system by the CBOE. This in turn suggests that spreads will decrease following the change in trading systems. In addition, the theoretical work of Grossman and Miller (1988) combined with empirical studies by Neal (1992) and Bessembinder and Kaufman (1997) suggest that this decrease is more likely in lower volume options than in higher volume options and for smaller trades.

Options markets have recently experienced a marked increase in competition beginning with the CBOE's listing of options on Dell Computer Corporation (traded only on the Philadelphia Stock Exchange prior to the CBOE listing on August 23, 1999). The notion cannot

[7] An additional difference between the exchanges may be a certification effect. See Footnote 1.
[8] See Christie and Schultz (1994)

be altogether dismissed that the change to the DPM system was to equip the CBOE to better handle competition. High volume options are likely to be the most lucrative and thus more likely to receive competition. To the extent that anticipated competition results in lower spreads, we would expect this impact to be greatest in high volume options.

H1: The institution of the DPM system on the CBOE leads to lower spreads for its listed options. Moreover, very low volume and very high volume options experience the highest decline. Small trades benefit more than large trades from the reduction in spreads.

Benveniste, Marcus and Wilhelm (1992) do not explicitly discuss the issue of depth on the two markets they considered. However, their model does predict improved terms of trade for investors in a specialist system. This would imply that depth is not adversely affected.[10] Thus, given the predicted relationship between the number of market makers and depth we construct our second hypothesis:

H2: Depth of the market increases due to the change in trading systems on the CBOE.

If market quality improves on the CBOE we would expect an increase in the CBOE's market share of trading in multiple listed options. Therefore, our third hypothesis:

H3: For multiple listed options, the CBOE is able to attract orders away from other markets by offering tighter spreads and higher depth.

During the period of our study options markets, unlike equity markets, did not have a national market system that prevented trading through a better quote on a competing exchange.[11] Therefore, preferencing arrangements did not have to match the BBO. If order preferencing arrangements gain increased significance after the move to the DPM system on the CBOE, then

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[9] Easley, O'Hara and Srinivas (1998) and Cao, Chen and Griffin (1999)

[10] There is anecdotal evidence that trading is more concentrated with the presence of the DPM.

[11] In fact, an SEC study analyzing data from June 26, 2000 still finds that 5% of all trades in the 50 most active multiple-listed equity options were executed at prices inferior to the best price quoted on a competing market.

we would expect to see an increased percentage of order flow routed to the CBOE for reasons other than best prices bid or offered. This leads us to the following hypothesis:

H4: The number of trade throughs increases after the institution of the DPM system on the CBOE.

In the next section we discuss certain institutional details and describe our data.

III. Institutional Background and Data

The DPM system first began on the CBOE as a pilot program in 1987 with 4 DPMs allocated a total of 11 equity option classes. The extent of the program was limited to low volume options that were thought not to have adequate liquidity to generate enough market maker interest. On June 29, 1999 the CBOE board approved a resolution expanding this program to all equity options. All option classes were converted to the DPM system between August and October 1999.

Prior to this change, most equity options on the CBOE traded under a multiple market maker system. An exchange employee, the Order Book Official (OBO), maintained the limit order book. The OBO was responsible for entering all eligible orders into the limit order book and disseminating the best bid and ask quotes from the book to the trading crowd in front of her station. The trading crowd was composed of floor brokers and market makers. The same individual could serve as a broker and a market maker, though not on the same day. On a given day a member chose whether he would act as a broker or a dealer in the market. This trading crowd provided liquidity in equity options on the CBOE.

Considering that the current SEC initiative on the trade through issue on options markets began in October 1999, we should expect a higher rate of trade throughs during our sample period.

The DPM is defined by CBOE Rule 8.80 "as a member organization that is approved by the Exchange to function in allocated securities as a Market-Maker, Floor Broker, and Order Book Official." Each option class is assigned to a particular DPM who now maintains the limit order book. Thus, the DPM has exclusive knowledge of the book. The DPM can act as both a broker and a dealer on the same day, a privilege denied to other market makers in the option class. The DPM is also guaranteed a portion of the order flow in the assigned options in return for maintaining an orderly market in the assigned options. If the DPM's quote is the first to set the best standing quote then he can participate in 100% of the incoming order flow. However, even when the DPM does not have time priority but matches the best quote, he is entitled to a pro rata share of the order flow (CBOE Rule 8.80(c)(7)(ii)).[12] The participation rate is a declining function of volume for single listed options and a constant 40 % for multiple listed options.[13]

When the DPM system was instituted, other market makers were not eliminated. They still form the trading crowd in front of the DPM's station. This is especially significant for our study as it lets us value the incremental benefit of the specialist system over the multiple market maker system.

A total of 583 option classes were placed in the DPM system between August 2, 1999 and September 23, 1999.[14] Typically, several option classes were assigned to one DPM firm. This period coincides with increased competition between option exchanges resulting in an increase in cross-listed options. To remove the confounding effect of the increased competition, we eliminate any option classes that became multiple listed during the sample period. In other

[12] The participation right does not apply when an order is executed against the public limit order book.
[13] The Modified Trading System (MTS) Committee decides the participation rate. At present, this participation right entitles the DPM an initial 40% participation right, a 30% participation right when average daily volume in the security over the previous calendar quarter reached 2501 contracts, and no guaranteed participation right when average daily volume in the security over the previous calendar quarter reached 5000 contracts.
[14] An option class includes all the series of options trading on a particular stock. The series differ by their strike prices and expiration dates.

words, we only included option classes there are single listed (or multiple listed) throughout the sample period. Our sample is thus reduced to 367 option classes. We then match stock symbols from the CBOE with CRSP stock symbols and eliminate any classes that do not have symbols on CRSP or where the company names do not match. Also, any option class where the underlying stock split or underwent a 50% change in prices during the sample period is eliminated. This further reduces our sample size to 263 option classes.

We obtain our data from an anonymous trading firm, which provided us with Options Price Reporting Authority (OPRA) data acquired through one of the major data vendors. The OPRA is the disseminator of options price and quote data for all options markets. Thus, we have time stamped data on all trades and quotes generated on all options exchanges from July 26, 1999 to October 28, 1999 (66 trading days). OPRA does not currently provide data on quoted size. We restrict our study to normal trading hours for options (9.30 a.m. – 4.02 p.m.). We only include option classes that have 20 trading days of data before and after the date the option class was placed in the DPM system. Consistent with previous options studies, we focus our study on near term (less than 30 days to maturity) at the money (strike price within 10% of the spot price) call options since these options are typically the most actively traded options in a class.[15] Further, the rules of the CBOE impose different tick sizes for options trading below \$3 (\$1/16) and those trading above \$3 (\$1/8). To avoid any contamination of our results due to difference in minimum price moves we restrict our study to options trading below \$3 over the entire period.[16] Quotes representing spreads greater than \$2 are excluded, as they are likely to be incorrect entries. Our

[15] See Neal (1987, 1992).
[16] Ronen and Weaver (2000) discuss the effects of discreteness on spread reductions. In the context of our study, their model would imply that we would see a change only if the difference between the old quoted spread and new spread is higher than 1/16 for options trading below \$3 and higher than \$1/8 for options trading above \$3. Thus, we are more likely to be able to isolate the market quality impact of the change on options with prices below \$3.

final sample then contains 104 options classes, of which 44 are single listed on the CBOE and 60 are multiple listed with the CBOE as one of the trading venues.

In addition to calculating market quality measures for our entire sample, we separately examine options solely listed on the CBOE, as well as those multiple listed on exchanges in addition to the CBOE. For multiple listed options we construct Best Bid and Offer (BBO) quotes and compare them to individual exchange quotes. Crossed BBO quotes are excluded. We are thus able to draw direct comparisons between changes on the CBOE and competing exchanges. Since, the CBOE and AMEX are the major options exchanges we only present results for those two exchanges. Results are also presented separately for single and multiple listed securities. This facilitates an analysis of the impact of competition on market quality resulting from the adoption of the DPM system.

Grossman and Miller (1988) suggest that trading volume is related to optimal market structure. Therefore, we divide our sample into volume quartiles based on the number of contracts traded in the pre-period (20 days before the switch to DPM system).

IV. Results

In this section, we discuss our results. We separately discuss results for liquidity, market share, and trade throughs.

IV.A. Liquidity

As a first step, we analyze the impact on liquidity of the change in market structure. The most commonly used measure of liquidity is the quoted bid-ask spread. Table I presents the results for time weighted quoted dollar (Panel A) and percentage spreads (Panel B). Results are shown separately for single and multiple listed options. Results are provided for the overall sample as well as by volume quartile. In the case of multiple listing, spreads are calculated separately for quotes originating from the CBOE and those originating from the AMEX. BBO spreads are also calculated for multiple listed options.

Table I, Panel A. shows that for the 60 multiple listed stocks in our sample, AMEX and CBOE quoted dollar spreads are fairly equal in the pre-period (around 20 cents). However, after the change in trading system on the CBOE, spreads on the CBOE decline by about 7% (statistically significant at the 5% level). Similarly, quoted BBO dollar spreads also declined by approximately 8% and this decline is also statistically significant at the 5% level. However, AMEX spreads decline by less than 1% and this change is not statistically significant. The fact that CBOE spreads reduced by a statistically significant amount, while AMEX spreads did not is consistent with our hypothesis that the adoption of a specialist system on the CBOE improved market quality.

Interestingly, an even larger decline (about 9%) is found for single listed options on the CBOE. Perhaps DPMs were preparing for anticipated competition from other exchanges. Alternatively, it may be that the decline is largely confined to low volume options. This is consistent with the notion that specialists are most beneficial to low volume securities.

Examining the results for volume quartiles, we find that the observed decrease in CBOE spreads is evidenced across all quartiles. Statistically significant declines in CBOE spreads for multiple listed options are found in the lowest volume and largest volume quartiles. This U shaped pattern is consistent with the decline being a result from both increased competition (the highest volume quartiles) and the increased marginal benefits of a specialist to low volume securities. BBO spreads exhibit a similar pattern, while AMEX spreads show a statistically significant decline only for the highest volume quartile. The AMEX response is consistent with competition being most intense for highest volume options.

An analysis of percentage quoted spreads (expressed as a percentage of the midpoint of the bid and ask quotes, (Table I, Panel B.)) indicates a pattern similar to that observed for quoted dollar spreads. For the full sample of 60 multiple listed option classes, percentage spreads decline by 1.5 percentage points on the CBOE but the decline is not significant. BBO spreads do experience a significant decline while AMEX spreads do not. Again, single listed option classes on the CBOE experience a higher decline than multiple listed options (3.1 percentage points versus 1.5 percentage points). This is similar to the behavior of quoted dollar spreads. An analysis of volume quartiles reveals that the largest (and significant) declines occur in the lowest and highest volume quartiles for CBOE and BBO spreads on multiple listed options. The patterns are similar to those found for dollar spreads. For single listed stocks on the CBOE, the only statistically significant decline occurs in the lowest volume quartiles.

To be able to isolate the effects of the change in the trading system, it becomes essential to control for other confounding factors known to influence spreads. Using the findings of Neal (1992) as a starting point, we estimate the following equation:

$$S_{i,t} = \beta_0 + \beta_1 Price_{i,t} + \beta_2 NTrades_{i,t} + \beta_3 Volume_{i,t} + \beta_4 \sigma_{i,t} + \beta_5 PostDummy + \beta_6 SingleDummy + \varepsilon \qquad (1)$$

regressing the average value of spread in pre and post periods, $S_{i,t}$, on: pre and post averages of price of the option class i, $Price_{i,t}$; the number of trades in the option class, $Ntrades_{i,t}$; total share volume in the option class, $Volume_{i,t}$; the average standard deviation of daily return of the underlying stock, $\sigma_{i,t}$; a dummy variable indicating whether the observation belongs to the pre or the post period, $PostDummy_{i,t}$; and a dummy variable indicating whether an option is single or multiple listed, *SingleDummy*$_{i,t}$. Average price of the security, volatility and volume are frequently used as determinants of bid-ask spreads in studies of equity market microstructure, and are consistent with the factors considered by Neal (1992) for option spreads. Jones, Kaul and Lipson (1994) suggest that number of trades is a more significant explanatory variable for spreads than volume. We perform the regressions for the overall results for each category as well as by volume quartile for each category. Due to the small number of observations in the volume quartiles for CBOE single listed options, we combine that category with the CBOE multiple listed options and control for the generally higher spread level for single listed options by including the *SingleDummy* variable. The combined multiple and single listed CBOE categories are denoted Full Sample in the table.

These regressions are run for dollar as well as percentage quoted spreads for the CBOE, BBO quotes and the AMEX. The results are listed in Table II. For the CBOE regressions (Panel A.) all but one of the *PostDummy* coefficients are negative and the significance of the coefficients is generally the same as reported in Table I. (low volume and high volume quartiles). The results for BBO spreads also are consistent with those reported in Table I. Examining the coefficients for the AMEX regressions (Panel C.) reveals that none are significant and only six of ten are of the expected negative sign. This suggests that the results presented in Table I. are robust with respect to confounding factors and provide further support for our hypothesis that the adoption of a specialist system improves market quality.

The single dummy has a positive and significant coefficient for overall CBOE dollar spreads and for all BBO spread regressions, indicating that after controlling for differences in price, volume, volatility, and number of trades in the option class, single listed options still display higher spreads than multiple listed options. This is consistent with the results of Neal (1987) and speaks to the benefit of multiple listing of options.

We next examine changes in effective spreads. The study of effective spreads is useful since not all trades occur at the bid or ask quotes. Effective spreads are defined as twice the difference between the price of the trade and the midpoint of the contemporaneous bid and ask quotes. Table III, Panel A.1. summarizes the results for effective dollar spreads. Overall, effective dollar spreads decrease for CBOE (both multiple and single listed) and BBO quotes and increase for AMEX quotes. However, none of these changes are statistically significant. Although two volumes quartiles exhibit negative and statistically significant changes, no clear pattern emerges from examining the volume quartiles. The results for effective percentage spreads (Panel B.1.) are qualitatively similar to those for effective dollar spreads.

Bessembinder and Kaufman (1997) find that the NYSE offers a greater advantage to smaller sized trades. Thus, we divide our sample by trade size. We separately analyze trades of 1 to 10 contracts, 11 to 50 contracts, and more than 50 contracts (Table III, Panel A.2.).[17] We do not see a significant decline in effective dollar spreads across trade sizes.

Examining effective percentage spreads according to trade size (Table III, Panel B.2.), however, presents a different picture. Trades in the two lower size categories experience a decline while trades in the highest size category experience an increase on the CBOE. For trades up to 10 contracts the decline is significant at the 10% level of significance. While AMEX spreads show the same pattern in size, the declines are much smaller and insignificant throughout.

[17] Each contract represents 100 shares of the underlying stock.

The similarity to the CBOE in pattern, but not in magnitude, that we have seen on the AMEX is not unexpected. The two exchanges are the two biggest options exchanges and a reduction in trading costs on CBOE is likely to exert pressure on the AMEX specialists to remain competitive. That we find a more pronounced effect on the CBOE points to the strength of our results, at least for multiple listed options.

Table IV presents the results for control regressions for effective dollar and percentage spreads based on Equation 1. The findings here are not markedly different from the unconditional results in Table III. We also see that single listed options continue to have higher spreads than multiple listed options even after controlling for differences in option characteristics. The *PostDummy* parameter value for the CBOE and BBO regressions, is of the proper sign, but not significant. This is consistent with the results reported in Table III.

In summary, the results for spreads generally support our first hypothesis, that the adoption of a specialist system is associated with an improvement in market quality.

We next examine the impact of the adoption of a specialist system on another measure of liquidity – depth. OPRA does not disseminate data on depth making it difficult to directly analyze the depth of options markets.[18] Lee, Mucklow and Ready (1993) suggest that spreads alone provide an incomplete picture of liquidity, since market makers often adjust both their spreads and their depth to manage liquidity provision. In order to study the depth of the market, we use a more comprehensive measure of depth than quoted depth suggested by Kyle (1985) known as Kyle's lambda. Intuitively lambda measures the volume required to move price by a dollar and is an inverse measure of liquidity (the higher the lambda, the lower the liquidity and

[18] Market makers and DPMs in options markets are required to post quotes good for at least 1 contract for professional customers and 20 contracts for public customers. Orders from public customers are executed through CBOE's Retail Automated Execution System (RAES). Participation in RAES is voluntary and market makers choose every month whether to sign up for RAES or not.

vice versa). Kyle's lambda is a better measure of depth than quoted depth since it captures orders that are held by brokers, or undisclosed liquidity of market makers, which is not reflected in the limit order book. It also is a more comprehensive measure as it encompasses depth behind the best quote. Thus, if narrower spreads come at the expense of lower depth in the market, the lambda measure would be able to capture that fact. To calculate Kyle's lambda, we modify the following equation:

$$\Delta p_t = \lambda q_t + \varepsilon_t \tag{2}$$

where Δp_t is the change in price ($p_t - p_{t-1}$), q_t is the signed order flow (positive for buy orders and negative for sell orders) and ε_t is a random noise term. λ is an inverse measure of liquidity.

The modified equation to study the liquidity effects of the change in market structure is presented below:

$$\Delta p_t = (\lambda_0 + \lambda_1 D_t) q_t + \varepsilon_t \tag{3}$$

the only new term, D_t is a dummy, which takes on the value 1 for the post-period and 0 for the pre-period. λ_1 captures changes that occur in depth as a result of the change. A negative value for λ_1 would indicate a lower λ in the post period relative to the pre period. Since λ is an inverse measure of liquidity a lower value in the post period would imply an increase in depth. Similarly, a positive value would point towards a decrease in depth.

To identify buy and sell orders we use the Lee and Ready (1991) algorithm. We use contemporaneous quotes and trades to identify standing quotes. Trades at the ask are classified as customer buys, at the bid as customer sales, a price higher than the midpoint indicates a buy and one lower than the bid-ask midpoint a customer sale. For trades at the midpoint, we examine the last price change and classify the trades as buys for upticks and sales for downticks.

Table V presents the results separately for options markets as a whole, the CBOE and the AMEX.[19] When treating options markets as one system, all trades (regardless of where they occur) are compared with the BBO bids and asks to classify them as buys or sells. For examining depth on the CBOE, only trades that occurred on the CBOE are considered and compared with quotes originating from the CBOE. A similar procedure is adopted for the AMEX.

Examining the results for the (Signed Volume * Post) parameter in Table V, we find that options markets as a whole as well as the CBOE experience a significant increase in depth following the switch to the DPM system. The AMEX also experiences an increase but this change is not statistically significant. The increase in liquidity for options markets, as well as for the CBOE is statistically significant only for the lowest volume quartile. For AMEX options, the increase is significant only for the highest volume quartile. This would be consistent with a competitive response from the AMEX specialist to the shift in trading mechanism on the CBOE.

Thus, we find support for our second hypothesis that depth is at worst not adversely affected and at best increases following the adoption of a specialist system.

IV.B. Market Share

Given the results so far, we find that liquidity significantly improved on the CBOE. Quoted dollar and percentage spreads decreased significantly. Effective percentage spreads also declined, especially for small trades. Evidence on depth also points towards an increase in total depth offered on the CBOE. We see a limited competitive response on the AMEX but not of the same magnitude or uniformity as the CBOE. Assuming that investors take market quality into account in their order routing decision, we would expect to see some market share impact

[19] Consistent with other regressions run for this study, to overcome the small sample size for some CBOE single listed volume quartiles, we combine the CBOE multiple listed and single listed observations together.

following the change in trading mechanism on the CBOE. Quoted spreads here play the most important role, as these are the spreads visible to a customer deciding on a trading venue for his trade. As discussed above, these spreads experience a significant decline on the CBOE.

Table VI presents the results for the market share of the CBOE and AMEX in multiple listed options. The overall share of the CBOE (Panel A.) went up from 52.7% to 56.7%. At the same time, AMEX market share declined from 39.3% to 36% for these options. The increase in the CBOE market share is not significant at traditional levels of confidence. Examining the results for volume quartiles (Panel B.) reveals that the CBOE gained market share in all but the highest volume quartile. The AMEX, in contrast, lost market share in all volume quartiles. However, none of the results for volume quartiles are statistically significant at traditional levels. Therefore, we can offer only limited evidence that the move to a DPM system helped the CBOE gain market share.

IV.C. Trade Throughs

The lack of a national market system in options markets during our sample period makes execution quality an important issue. Trades routed to a particular exchange were not required to be executed at the best existing quote across exchanges, nor were market participants required to route orders to the exchange with the best quote. This allows us to test the hypothesis that order preferencing arrangements became more prevalent after the introduction of the DPM. If the hypothesis holds, then we should see an increase in orders being routed to an exchange due to reasons other than the best quote and hence an increased likelihood of trade throughs.

Table VII provides the results for multiple listed options on the CBOE and the AMEX. We list the average proportion of orders per option class that are traded through, the average proportion of volume traded through per option class, and the loss to investors as a result of the trade throughs. The loss is calculated as number of contracts for a trade that was executed at a price inferior to that quoted on another exchange multiplied by the difference in quotes on the two exchanges. Loss is represented in hundreds of dollars per option class. Thus, 11.9% of trades (for the 49 option classes with trade throughs) on the CBOE occurred at quotes inferior to those on a competing exchange in the pre-period and 14.4% in the post period. These trades represented 9.8% of total volume (for the 49 option classes where there were any trade throughs) in the pre-period and 16.6% in the post period. This constituted a loss of $1,617 per option class in the pre period and $2,622 per option class in the post period.[20]

Results show that orders traded through (as a percentage of total number of trades in the option), the percentage of volume traded through, and the loss due to the practice all undergo an increase after the institution of the DPM system. Further, volume traded through and loss experience a statistically significant increase. The direction is similar for the AMEX options but none of the increases are significant. Thus, we conclude that the adoption of a specialist system on the CBOE resulted in an increase in preferencing arrangements.

V. Conclusion

The search for the market structure that provides the best market quality to investors and maximizes exchange competitiveness traces its genesis to the very beginning of market microstructure literature. The issue has gained new relevance in recent years due primarily to the advent of new technologies bringing with them the increased threat of competition to established exchanges. One of the first decisions new exchanges setting up face is the trading system to use

[20] Only those trades that occurred at the quoted bid or ask, on the executing exchange, are included for trade through analysis.

in their marketplace. The choice is crucial as they try to gain market share. Older exchanges, gearing up for competition, face similar decisions. Our analysis contributes to this decision-making process by studying the value of the specialist form of trading. The institution of the DPM system on the CBOE (similar to the NYSE specialist) lets us evaluate the incremental benefits or costs of such a system as compared to a multiple market maker system.

We find a significant decrease in spreads and a significant increase in depth due to the change to a specialist system on the CBOE. These changes are more pronounced for lower volume securities and smaller trades. The results support our hypotheses drawn from related literature.

We also offer limited evidence that market share of the CBOE increases in the period after the option class moves on to the DPM system relative to the period before.

These results indicate a benefit to traders in their terms of trade and an increase in the competitiveness of the CBOE.

We also find that single listed options have higher spreads than multiple listed options. Thus, the increase in multiple listings in options markets is likely to have led to an increase in market quality. This issue deserves a detailed look.

Finally, we consider the implications of a lack of a national market system in options markets on our analysis. Consistent with our apriori expectations, we find an increase in the number and volume of trade throughs, as well as an increase in the loss that traders bear due to this practice.

References:

Benveniste, L.M., A.J. Marcus and W.J. Wilhelm, 1992, "What's Special about the Specialist?" *Journal of Financial Economics*, 32, 61-86

Bessembinder, H. and H. Kaufman, 1997, "A Comparison of Trade Execution Costs for NYSE and Nasdaq Listed Stocks," *Journal of Financial and Quantitative Analysis*, 32, 287-310

Bessembinder, H., 1998, "Trading Costs and Return Volatility: Evidence from Exchange Listings," New York Stock Exchange Working Paper #98-02

Bessembinder, H., 1999, "Trade Execution Costs on Nasdaq and the NYSE: A Post-Reform Comparison," *Journal of Financial and Quantitative Analysis*, 34 (3), 387-407

Cao, C., Z. Chen and J.M. Griffin, 1999, "Informed trading in the options markets," Working Paper, Pennsylvania State University

Christie, W. and P. Schultz, 1994, "Why do Nasdaq Market Makers Avoid Odd Eighth Quotes?" *Journal of Finance*, 49, 1813-1840

D. Easley, M. O'Hara and P.S. Srinivas, 1998, "Option Volume and Stock Prices: Evidence on Where Informed Traders Trade," *Journal of Finance*, 53(2), 431-465

Garfinkel, J.A. and M. Nimalendran, 1998, "Market Structure and Trader Anonymity: An Analysis of Insider Trading," Working Paper, University of Florida

Glosten, L.R., 1989, "Insider Trading, Liquidity, and the Role of the Monopolist Specialist," *Journal of Business*, 62, 211-235

Grossman, S.J. and M.H. Miller, 1988,"Liquidity and Market Structure," *Journal of Finance*, 43(3), 617-633

Ho, T. and H.R. Stoll, 1983, "The Dynamics of Dealer Markets under Competition," *Journal of Finance*, 28, 1053-1074

Ho, T.S.Y. and R.G. Macris, 1985, "Dealer Market Structure and Performance," in Y. Amihud, T.S.Y. Ho and R.A. Schwartz, Eds: *Market Making and the Changing Structure of the Securities Industries* (Lexington Books)

Huang, R. and H. Stoll, 1996, "Dealer Versus Auction Markets: A Paired Comparison of Execution Costs on Nasdaq and the NYSE," *Journal of Financial Economics*, 41, 313-358

Jones, C., G. Kaul and M. Lipson, 1994, "Transactions, Volume and Volatility," *Review of Financial Studies*, 4, 571-595

Kyle, A., 1985, "Continuous Auctions and Insider Trading," *Econometrica*, 53, 1315-35

Lee, C., and M. Ready, 1991, "Inferring Trade Direction from Intraday Data," *Journal of Finance*, 41, 733-746

Lee, C., B. Mucklow and M. Ready, 1993, "Spreads, Depths and the Impact of Earnings Information: An Intraday Analysis," *Review of Financial Studies*, 6 345-374

Neal, R., 1987, "Potential Competition and Actual Competition in Equity Options," *Journal of Finance*, 42(3), 511-531

Neal, R., 1992, "A Comparison of Transaction Costs between Competitive Market Maker and Specialist Market Structures," *Journal of Business*, 65(3), 317-334

Ronen, T. and D.G. Weaver, 2000, "'Teenies' Anyone?" *Journal of Financial Markets*, Forthcoming

Vijh, A.M., 1990, "Liquidity of the CBOE Equity Options," *Journal of Finance*, 45(3), 1157-1179

TABLE I

TIME WEIGHTED DOLLAR AND PERCENTAGE SPREADS

This table summarizes the results for changes in quoted dollar (Panel A) and percentage spreads (Panel B.) following the CBOE's change in trading systems. The CBOE instituted a specialist system for all its equity options between August and September 1999. The pre-period covers 20 trading days before the option class switched over to the specialist system and the post-period covers 20 trading days immediately after the switch date. The switch date is not included in either sample. The numbers are calculated for each option class and then summarized cross-sectionally. Similarly, the change in spreads is calculated for each underlying stock and then aggregated across the sample. Results are presented for single and multiple listed options as well as volume quartiles. Separate results are presented for the CBOE, AMEX and the National Best Bid and Offer (BBO) quotes. BBO quotes are calculated for multiple listed stocks from the highest bid and lowest ask outstanding at the time. The sample consists of near term, at the money options trading below $3 only. t-statistics are italicized.

A. Dollar Spreads

	Overall	Volume Quartiles			
		1(Low)	2	3	4(High)
CBOE - Multiple Listed					
Pre	0.1991	0.2217	0.1926	0.2029	0.1875
Post	0.1859	0.2002	0.197	0.1929	0.1628
Change	-0.0132	-0.0215	0.0044	-0.01	-0.0247
t-statistic	*-2.56***	*-2.38***	*0.42*	*-1.5*	*-2.26***
N	60	12	16	13	19
BBO - Multiple Listed					
Pre	0.1126	0.1241	0.108	0.1154	0.1074
Post	0.1036	0.1107	0.1128	0.1176	0.0817
Change	-0.0091	-0.0134	0.0048	0.0022	-0.0257
t-statistic	*-2.3***	*-1.93****	*0.64*	*0.32*	*-3.58**
N	60	12	16	13	19
AMEX - Multiple Listed					
Pre	0.2025	0.2258	0.1970	0.2152	0.1849
Post	0.2005	0.2122	0.2042	0.2285	0.1708
Change	-0.0019	-0.0136	0.0070	0.0130	-0.0141
t-statistic	*-0.28*	*-1.25*	*0.81*	*0.53*	*-2.57***
N	60	12	16	13	19
CBOE- Single Listed					
Pre	0.2224	0.2109	0.2259	0.2283	0.2294
Post	0.2019	0.1944	0.2044	0.2007	0.2157
Change	-0.0205	-0.0165	-0.0215	-0.0276	-0.0137
t-statistic	*-4.01**	*-1.69*	*-1.99****	*-2.9***	*-1.14*
N	44	14	10	13	7

B. Percentage Spreads

	Overall	Volume Quartiles			
		1(Low)	2	3	4(High)
CBOE - Multiple Listed					
Pre	24.1%	27.0%	25.6%	22.6%	22.0%
Post	22.6%	20.1%	27.6%	24.7%	18.4%
Change	-1.5%	-7.0%	2.1%	2.1%	-3.6%
t-statistic	*-1.31*	*-2.65***	*1.14*	*0.63*	*-2.6***
N	60	12	16	13	19
BBO - Multiple Listed					
Pre	15.3%	16.9%	16.4%	13.8%	14.4%
Post	12.8%	11.2%	17.0%	13.8%	9.7%
Change	-2.5%	-5.7%	0.6%	0.0%	-4.8%
t-statistic	*-2.17***	*-2.4***	*0.39*	*0.01*	*-3.22**
N	60	12	16	13	19
AMEX - Multiple Listed					
Pre	25.0%	26.4%	27.9%	23.1%	23.2%
Post	24.0%	23.2%	29.9%	22.5%	20.7%
Change	-1.0%	-3.2%	2.0%	-0.6%	-2.4%
t-statistic	*-0.75*	*-1.58*	*0.65*	*-0.27*	*-1.04*
N	60	12	16	13	19
CBOE- Single Listed					
Pre	27.7%	28.4%	27.2%	28.7%	24.9%
Post	24.6%	23.8%	28.4%	23.8%	22.3%
Change	-3.1%	-4.6%	1.1%	-5.0%	-2.5%
t-statistic	*-1.96****	*-2.32***	*0.27*	*-1.53*	*-0.85*
N	44	14	10	13	7

* denotes significance at 1% level
** denotes significance at 5% level
*** denotes significance at 10% level

TABLE II

CONTROL REGRESSIONS FOR QUOTED SPREADS

This table summarizes the results of control regressions for quoted dollar and percentage spreads. The regression equation estimated is

$$S_{i,t} = \beta_0 + \beta_1 \Pr ice_{i,t} + \beta_2 N\_Trades_{i,t} + \beta_3 Volume_{i,t} + \beta_4 \sigma_{i,t} + \beta_5 PostDummy + \beta_6 SingleDummy + \varepsilon$$

regressing the average value of spread in pre and post periods, $S_{i,t}$, on pre and post averages of price of the option class, $Price_{i,t}$, number of trades in the option class, $Ntrades_{i,t}$, total share volume in the option class, $Volume_{i,t}$, average standard deviation of daily return of the underlying stock, $\sigma_{i,t}$, a dummy variable indicating whether the observation belongs to the pre or the post period, $PostDummy_{i,t}$, and a dummy variable indicating whether an option is single or multiple listed, $SingleDummy_{i,t}$ (not used in the regressions for the AMEX, as all those option classes are multiple listed). The numbers are calculated for each underlying stock and cross-sectional regressions are run to obtain the results. The CBOE instituted a specialist system for all its equity options over August and September 1999. The pre-period covers 20 trading days before the option class switched over to the specialist system and the post-period covers 20 trading days immediately after the switch date. The switch date is not included in either sample. Separate results are presented for CBOE (N=104), National Best Bid and Offer (BBO) (N=104), and AMEX (N=60) average quotes. BBO quotes are calculated for multiple listed stocks as the highest bid and lowest ask outstanding at a time. The sample consists of near term at the money options, trading below $3 only. t-statistics, testing the significance of the coefficient, are given below the coefficients in italics.

A. CBOE

QUOTED DOLLAR SPREADS: CBOE

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.1888	0.007530	-0.0000359	1.12E-06	0.1743	-0.01729	0.01668	0.20	8.16
	*21.58**	*2.53***	*-2.01***	*1.12*	*1.00*	*-3.7**	*3.23**		
VLM 1 (Low)	0.1718	0.029160	0.0000830	-1.93E-05	0.4340	-0.01887	-0.00162	0.23	2.29
	*8.31**	*2.8***	*0.41*	*-1.44*	*1.24*	*-1.85****	*-0.15*		
VLM 2	0.1656	0.015320	-0.0001509	5.98E-06	0.5150	-0.00934	0.01835	0.19	1.77
	*9.39**	*1.99***	*-1.13*	*0.98*	*1.25*	*-0.89*	*1.56*		
VLM 3	0.1827	0.006110	-0.0000998	4.30E-06	0.5641	-0.02025	0.02155	0.20	1.92
	*9.44**	*0.87*	*-1.37*	*0.72*	*1.40*	*-2.31***	*2.26***		
VLM 4 (High)	0.2072	0.005690	-0.0000090	-7.52E-08	-0.6647	-0.02226	0.03281	0.45	6.11
	*11.54**	*1.31*	*-0.48*	*-0.07*	*-1.68***	*-2.54***	*2.83***		

QUOTED PERCENTAGE SPREADS: CBOE

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.3853	-0.064310	0.0000090	-8.37E-07	-1.0104	-0.01648	0.01862	0.38	20.69
	*18.91**	*-9.29**	*0.22*	*-0.36*	*-2.49***	*-1.52*	*1.55*		
VLM 1 (Low)	0.3689	-0.068990	-0.0001459	1.29E-05	-0.5034	-0.04555	0.0191	0.32	3.53
	*8.62**	*-3.20**	*-0.34*	*0.47*	*-0.69*	*-2.16***	*0.88*		
VLM 2	0.4527	-0.104960	0.0002015	-2.64E-06	-2.0173	0.01080	0.05418	0.48	6.99
	*9.68**	*-5.14**	*0.57*	*-0.16*	*-1.85****	*0.39*	*1.74****		
VLM 3	0.3682	-0.092820	-0.0003843	1.19E-05	1.3257	-0.01011	0.05278	0.48	6.85
	*7.27**	*-5.03**	*-2.01***	*0.77*	*1.26*	*-0.44*	*2.11***		
VLM 4 (High)	0.3807	-0.034250	-0.0000079	-5.17E-07	-2.0709	-0.03008	-0.01281	0.63	12.83
	*14.41**	*-5.37**	*-0.28*	*-0.33*	*-3.55**	*-2.33***	*-0.75*		

* denotes significance at 1% level
** denotes significance at 5% level
*** denotes significance at 10% level

B. BBO

QUOTED DOLLAR SPREADS: BBO

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.1222	0.002590	-0.0000162	1.04E-07	-0.1608	-0.01370	0.09851	0.75	99.19
	*15.03**	*0.94*	*-0.98*	*0.11*	*-0.99*	*-3.16**	*20.53**		
VLM 1 (Low)	0.0933	0.017280	-0.0000379	-8.61E-06	0.3890	-0.01557	0.09087	0.63	12.78
	*4.16**	*1.53*	*-0.17*	*-0.59*	*1.02*	*-1.41*	*8.02**		
VLM 2	0.1193	0.010750	-0.0001087	3.74E-06	-0.3872	-0.00488	0.09565	0.78	25.89
	*7.8**	*1.61*	*-0.94*	*0.70*	*-1.09*	*-0.54*	*9.38**		
VLM 3	0.1114	0.006560	-0.0000657	6.75E-06	-0.1025	-0.01364	0.09803	0.78	25.85
	*6.15**	*0.99*	*-0.96*	*1.21*	*-0.27*	*-1.66*	*10.96**		
VLM 4 (High)	0.1400	-0.003710	0.0000102	-1.14E-06	-0.4960	-0.02202	0.11477	0.84	38.71
	*8.80**	*-0.97*	*0.61*	*-1.22*	*-1.41*	*-2.84**	*11.17**		

QUOTED PERCENTAGE SPREADS: BBO

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.2906	-0.055090	0.0000448	-2.87E-06	-1.3082	-0.02120	0.10826	0.56	42.63
	*15.61**	*-8.71**	*1.18*	*-1.35*	*-3.52**	*-2.14***	*9.86**		
VLM 1 (Low)	0.2622	-0.057670	-0.0001318	1.25E-05	-0.6476	-0.04068	0.11223	0.52	8.17
	*5.83**	*-2.55***	*-0.30*	*0.43*	*-0.85*	*-1.83****	*4.95**		
VLM 2	0.3602	-0.082180	0.0000251	-4.37E-07	-2.5081	0.00390	0.13656	0.62	12.22
	*9.14**	*-4.77**	*0.08*	*-0.03*	*-2.73**	*0.17*	*5.19**		
VLM 3	0.2648	-0.086800	-0.0001982	2.49E-05	-0.2316	-0.01561	0.14256	0.66	14.54
	*6.29**	*-5.66**	*-1.25*	*1.93****	*-0.26*	*-0.82*	*6.87**		
VLM 4 (High)	0.2824	-0.032960	0.0000299	-2.67E-06	-1.5854	-0.03851	0.07767	0.66	14.72
	*9.11**	*-4.40**	*0.92*	*-1.46*	*-2.31***	*-2.55***	*3.88**		

C. AMEX

QUOTED DOLLAR SPREADS: AMEX

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.2081	-0.000528	0.0000079	-1.56E-06	0.0550	-0.00151		0.11	2.74
	*14.6**	*-0.10*	*0.29*	*-1.03*	*0.19*	*-0.17*			
VLM 1 (Low)	0.2256	-0.012070	0.0005211	-4.32E-05	0.3966	-0.01449		0.20	0.69
	*5.40**	*-0.47*	*0.66*	*-0.71*	*0.64*	*-0.82*			
VLM 2	0.1990	0.016460	-0.0000642	-7.12E-06	-0.2612	0.01053		0.11	0.62
	*10.08**	*1.39*	*-0.33*	*-1.00*	*-0.52*	*0.79*			
VLM 3	0.1947	0.049010	-0.0000466	-1.87E-05	-0.0671	-0.00092		0.22	1.13
	*3.37**	*1.88****	*-0.21*	*-1.24*	*-0.06*	*-0.03*			
VLM 4 (High)	0.2224	-0.005960	0.0000174	-1.68E-06	-0.3819	-0.01367		0.22	1.72
	*9.37**	*-1.08*	*0.71*	*-1.22*	*-0.73*	*-1.07*			

QUOTED PERCENTAGE SPREADS: AMEX

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	SHARE VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.4009	-0.081370	0.0000821	-4.79E-06	-0.6070	-0.00541		0.49	20.64
	*16.57**	*-9.19**	*1.78****	*-1.87****	*-1.24*	*-0.36*			
VLM 1 (Low)	0.4503	-0.148790	0.0007440	-5.86E-05	0.2174	-0.03392		0.58	3.86
	*6.74**	*-3.59**	*0.58*	*-0.60*	*0.22*	*-1.2*			
VLM 2	0.5127	-0.181280	0.0002726	-1.37E-06	-0.9231	0.01694		0.68	9.99
	*10.00**	*-5.88**	*0.53*	*-0.07*	*-0.71*	*0.49*			
VLM 3	0.3550	-0.101890	0.0000719	5.89E-07	0.4130	0.01326		0.61	6.34
	*7.65**	*-4.87**	*0.40*	*0.05*	*0.49*	*0.59*			
VLM 4 (High)	0.4218	-0.057810	0.0000564	-4.32E-06	-1.3991	-0.02263		0.60	8.82
	*9.35**	*-5.54**	*1.22*	*-1.65*	*-1.41*	*-0.93*			

TABLE III

EFFECTIVE DOLLAR AND PERCENTAGE SPREADS

This table summarizes the results for changes in effective dollar (Panel A) and percentage spreads (Panel B) following the CBOE's change in trading systems. The CBOE instituted a specialist system for all its equity options over August and September 1999. The pre-period covers 20 trading days before the option class switched over to the specialist system and the post-period covers 20 trading days immediately after the switch date. The switch date is not included in either sample. The numbers are calculated for each option class and then summarized cross-sectionally. Similarly, the change in spreads is calculated for each underlying stock and then aggregated across the sample. Contemporaneous trades and quotes are used to calculate effective spreads. Results are presented for single and multiple listed options as well as volume quartiles. Effective spreads are also presented on the basis of trade size (Panels A.2. and B.2.). Separate results are presented for CBOE, National Best Bid and Offer (BBO), and AMEX quotes. quotes are calculated for multiple listed stocks as the highest bid and lowest ask outstanding at the time. The sample consists of near term at the money options trading below $3 only. t-statistics are italicized.

A.1. Effective Dollar Spreads – Volume Quartiles

	Overall	Volume Quartiles			
		1(Low)	2	3	4(High)
CBOE - Multiple Listed					
Pre	0.1754	0.185	0.1847	0.1679	0.1666
Post	0.1703	0.1921	0.167	0.1703	0.1593
Change	-0.0051	0.0071	-0.0177	0.0024	-0.0073
t-statistic	*-0.89*	*0.51*	*-1.44*	*0.31*	*-0.66*
N	60	12	16	13	19
BBO - Multiple Listed					
Pre	0.1521	0.168	0.1545	0.1479	0.1428
Post	0.1517	0.1681	0.1576	0.1544	0.1345
Change	-0.0004	1E-04	0.0031	0.0065	-0.0083
t-statistic	*-0.06*	*0.01*	*0.33*	*0.81*	*-0.89*
N	60	12	16	13	19
AMEX - Multiple Listed					
Pre	0.1745	0.1602	0.1767	0.1881	0.1707
Post	0.1759	0.1597	0.1892	0.2129	0.1479
Change	0.0014	-0.0005	0.0125	0.0248	-0.0228
t-statistic	*0.10*	*-0.02*	*0.75*	*0.69*	*-3.36**
N	60	12	16	13	19
CBOE- Single Listed					
Pre	0.2361	0.21	0.198	0.2096	0.1876
Post	0.2199	0.2102	0.197	0.1829	0.2037
Change	-0.0162	0.0002	-0.001	-0.0267	0.0161
t-statistic	*-0.79*	*0.01*	*-0.08*	*-3.32**	*1.24*
N	44	14	10	13	7

A.2. Effective Dollar Spreads – Trade Size

Size Categories	1-10 Contracts	11-50 Contracts	Greater than 50
CBOE			
Pre	0.2051	0.1905	0.1789
Post	0.2031	0.1887	0.1713
Change	-0.002	-0.0018	-0.0076
T-Statistic	*-0.35*	*-0.25*	*-0.39*
N	104	100	46
BBO			
Pre	0.1699	0.1692	0.1544
Post	0.1669	0.1584	0.1446
Change	-0.003	-0.0108	-0.0098
T-Statistic	*-0.63*	*-0.98*	*-0.88*
N	104	100	46
AMEX			
Pre	0.1756	0.1739	0.1737
Post	0.1801	0.1698	0.1595
Change	0.0045	-0.0041	-0.0142
T-Statistic	*0.45*	*-0.36*	*-0.5*
N	55	52	18

* denotes significance at the 1% level of significance
** denotes significance at the 5% level of significance
*** denotes significance at the 10% level of significance

B.1. Effective Percentage Spreads – Volume Quartiles

	Overall	Volume Quartiles			
		1(Low)	2	3	4(High)
<u>CBOE - Multiple Listed</u>					
Pre	19.8%	20.7%	23.2%	17.2%	18.3%
Post	18.7%	19.0%	22.0%	16.1%	17.4%
Change	-1.2%	-1.6%	-1.1%	-1.2%	-0.9%
t-statistic	*-1.07*	*-0.61*	*-0.42*	*-0.78*	*-0.5*
N	60	12	16	13	19
<u>BBO - Multiple Listed</u>					
Pre	17.3%	17.3%	20.2%	15.3%	16.2%
Post	16.9%	16.9%	21.0%	16.3%	14.0%
Change	-0.3%	-0.4%	0.8%	1.0%	-2.2%
t-statistic	*-0.41*	*-0.23*	*0.4*	*0.77*	*-1.52*
N	60	12	16	13	19
<u>AMEX - Multiple Listed</u>					
Pre	19.2%	17.1%	21.2%	17.6%	19.8%
Post	19.6%	16.8%	23.1%	21.7%	17.1%
Change	0.5%	-0.3%	1.9%	4.0%	-2.7%
t-statistic	*0.53*	*-0.08*	*1.07*	*1.49*	*-1.32*
N	60	12	16	13	19
<u>CBOE- Single Listed</u>					
Pre	23.6%	27.7%	21.4%	23.5%	18.9%
Post	22.0%	23.2%	24.4%	20.0%	19.8%
Change	-1.6%	-4.5%	3.0%	-3.5%	0.8%
t-statistic	*-1.21*	*-1.59*	*1.02*	*-1.83***	*0.41*
N	44	14	10	13	7

* denotes significance at the 1% level of significance
** denotes significance at the 5% level of significance
*** denotes significance at the 10% level of significance

B.2. Effective Percentage Spreads – Trade Size

Size Categories	1-10 Contracts	11-50 Contracts	Greater than 50
CBOE			
Pre	22.6%	25.4%	18.9%
Post	20.9%	23.1%	23.2%
Change (% points)	-1.7%	-2.4%	4.3%
T-Statistic	*-1.86****	*-1.31*	*1.39*
N	104	100	46
BBO			
Pre	19.0%	21.2%	16.8%
Post	17.5%	19.5%	17.8%
Change (% points)	-1.5%	-1.7%	0.9%
T-Statistic	*-2.29***	*-1.12*	*0.52*
N	104	100	46
AMEX			
Pre	18.5%	22.2%	17.4%
Post	17.8%	21.6%	21.3%
Change (% points)	-0.7%	-0.6%	3.9%
T-Statistic	*-0.11*	*-0.36*	*1.43*
N	55	52	18

* denotes significance at the 1% level of significance
** denotes significance at the 5% level of significance
*** denotes significance at the 10% level of significance

TABLE IV
CONTROL REGRESSIONS FOR EFFECTIVE SPREADS

This table summarizes the results of control regressions for effective dollar and percentage spreads. The regression equation estimated is

$$S_{i,t} = \beta_0 + \beta_1 Price_{i,t} + \beta_2 N\_Trades_{i,t} + \beta_3 Volume_{i,t} + \beta_4 \sigma_{i,t} + \beta_5 PostDummy + \beta_6 SingleDummy + \varepsilon$$

regressing the average value of spread in pre and post periods, $S_{i,t}$, on pre and post averages of price of the option class, $Price_{i,t}$, number of trades in the option class, $Ntrades_{i,t}$, total share volume in the option class, $Volume_{i,t}$, average standard deviation of daily return of the underlying stock, $\sigma_{i,t}$, a dummy variable indicating whether the observation belongs to the pre or the post period, $PostDummy_{i,t}$, and a dummy variable indicating whether an option is single or multiple listed, $SingleDummy_{i,t}$ (not used in the regressions for the AMEX, as all those option classes are multiple listed). The numbers are calculated for each underlying stock and cross-sectional regressions are run to obtain the results. the CBOE instituted a specialist system for all its equity options over August and September 1999. The pre-period covers 20 trading days before the option class switched over to the specialist system and the post-period covers 20 trading days immediately after the switch date. The switch date is not included in either sample. Contemporaneous trades and quotes are used to calculate effective spreads. Results are presented for the full sample as well volume quartiles. Separate results are presented for the CBOE, AMEX and the National Best Bid and Offer (BBO) quotes. BBO quotes are calculated for multiple listed stocks as the highest bid and lowest ask outstanding at a time. The sample consists of near term at the money options, trading below $3 only. t-statistics, testing the significance of the coefficient, are given below the coefficients in italics.

A. CBOE

EFFECTIVE DOLLAR SPREADS: CBOE

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.1343	0.025200	-0.0000216	7.62E-08	0.2344	-0.00698	0.02407	0.33	16.32
	*13.78**	*7.61**	*-1.09*	*0.07*	*1.21*	*-1.34*	*4.18**		
VLM 1 (Low)	0.0945	0.065100	-0.0001764	-1.45E-05	0.6315	-0.00116	0.03069	0.43	5.62
	*3.90**	*5.33**	*-0.74*	*-0.92*	*1.53*	*-0.1*	*2.51***		
VLM 2	0.1342	0.037840	-0.0002721	7.94E-06	0.3753	-0.01319	0.00593	0.33	3.65
	*6.23**	*4.02**	*-1.67*	*1.06*	*0.75*	*-1.03*	*0.41*		
VLM 3	0.1254	0.034970	0.0000567	-2.34E-06	-0.1853	-0.01507	0.01987	0.62	12.01
	*8.40**	*6.43**	*1.01*	*-0.51*	*-0.60*	*-2.23***	*2.7*		
VLM 4 (High)	0.1189	0.020740	-0.0000052	-3.03E-07	0.2877	-0.00259	0.03356	0.49	7.29
	*6.70**	*4.84**	*-0.28*	*-0.29*	*0.73*	*-0.3*	*2.93**		

EFFECTIVE PERCENTAGE SPREADS: CBOE

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.2919	-0.040050	0.0000018	-2.37E-07	-0.7676	-0.00997	0.02854	0.27	12.16
	*16.15**	*-6.52**	*0.05*	*-0.11*	*-2.13***	*-1.03*	*2.68***		
VLM 1 (Low)	0.2917	-0.038320	-0.0002777	1.08E-05	-0.6204	-0.02119	0.04861	0.18	1.68
	*5.40**	*-1.41*	*-0.52*	*0.31*	*-0.68*	*-0.79*	*1.78****		
VLM 2	0.3788	-0.069840	0.0000425	4.73E-06	-1.9836	-0.00042	0.02577	0.38	4.61
	*8.89**	*-3.76**	*0.13*	*0.32*	*-2.00****	*-0.02*	*0.91*		
VLM 3	0.2464	-0.041460	0.0000178	4.00E-06	-0.4587	-0.01812	0.05425	0.52	8.08
	*9.85**	*-4.55**	*0.19*	*0.52*	*-0.88*	*-1.6*	*4.40**		
VLM 4 (High)	0.2312	-0.019610	-0.0000393	1.78E-06	0.0073	-0.00244	0.00078	0.32	3.53
	*8.79**	*-3.09**	*-1.42*	*1.14*	*0.01*	*-0.19*	*0.05*		

B. BBO

EFFECTIVE DOLLAR SPREADS: BBO

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.1164	0.020670	-0.0000184	-1.08E-07	0.3076	-0.00416	0.04596	0.40	22.53
	*11.74**	*6.13**	*-0.91*	*-0.09*	*1.55*	*-0.79*	*7.85**		
VLM 1 (Low)	0.0500	0.074210	-0.0001012	-1.59E-05	0.9447	-0.00849	0.05495	0.47	6.76
	*1.81****	*5.32**	*-0.37*	*-0.89*	*2.01****	*-0.62*	*3.93**		
VLM 2	0.1184	0.026760	-0.0000934	2.11E-06	0.2283	0.00303	0.02841	0.38	4.63
	*6.18**	*3.20**	*-0.64*	*0.32*	*0.51*	*0.27*	*2.22***		
VLM 3	0.0929	0.034910	-0.0000240	5.79E-06	0.0208	-0.01305	0.04192	0.70	17.76
	*6.38**	*6.58**	*-0.44*	*1.30*	*0.07*	*-1.98****	*5.84**		
VLM 4 (High)	0.1194	0.012870	0.0000106	-1.19E-06	0.0534	-0.00261	0.05429	0.55	9.07
	*6.88**	*3.07**	*0.58*	*-1.17*	*0.14*	*-0.31*	*4.85**		

EFFECTIVE PERCENTAGE SPREADS: BBO

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.2680	-0.039670	0.0000306	-2.10E-06	-0.7670	-0.00483	0.04925	0.35	18.17
	*16.27**	*-7.09**	*0.91*	*-1.12*	*-2.34***	*-0.55*	*5.07**		
VLM 1 (Low)	0.2281	-0.025280	-0.0002330	1.21E-05	-0.2312	-0.02161	0.08084	0.27	2.74
	*4.54**	*-1.00*	*-0.47*	*0.37*	*-0.27*	*-0.87*	*3.19**		
VLM 2	0.3479	-0.068970	0.0001272	1.42E-06	-1.9952	0.01423	0.04411	0.45	6.22
	*9.66**	*-4.39**	*0.47*	*0.11*	*-2.38***	*0.67*	*1.84****		
VLM 3	0.2130	-0.045830	-0.0001441	2.03E-05	-0.0754	-0.00714	0.0714	0.63	12.55
	*9.17**	*-5.41**	*-1.65*	*2.85**	*-0.16*	*-0.68*	*6.23**		
VLM 4 (High)	0.2377	-0.020390	0.0000167	-1.58E-06	-0.7560	-0.01158	0.02122	0.40	5.01
	*9.47**	*-3.37**	*0.63*	*-1.07*	*-1.36*	*-0.95*	*1.31*		

* denotes significance at the 1% level of significance
** denotes significance at the 5% level of significance
*** denotes significance at the 10% level of significance

C. AMEX

EFFECTIVE DOLLAR SPREADS: AMEX

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.1599	0.015040	0.0000088	-1.66E-06	-0.0678	0.00161		0.10	2.29
	*8.83**	*2.28***	*0.26*	*-0.87*	*-0.19*	*0.14*			
VLM 1 (Low)	-0.0169	0.111980	-0.0003033	4.21E-06	1.1366	-0.00699		0.32	1.33
	-0.22	*2.37***	*-0.21*	*0.04*	*1.01*	*-0.22*			
VLM 2	0.1476	0.051610	-0.0002360	-2.16E-05	0.2078	0.01719		0.51	4.87
	*6.43**	*3.85**	*-1.07*	*-2.67***	*0.36*	*1.12*			
VLM 3	0.2589	0.028760	0.0000323	-2.64E-05	-1.4827	0.00608		0.17	0.8
	*3.50**	*0.86*	*0.11*	*-1.37*	*-1.11*	*0.17*			
VLM 4 (High)	0.1592	0.009960	0.0000105	-1.24E-06	0.0267	-0.02260		0.36	3.38
	*7.96**	*2.15***	*0.51*	*-1.07*	*0.06*	*-2.09***			

EFFECTIVE PERCENTAGE SPREADS: AMEX

	INTERCEPT	AVERAGE PRICE	NUMBER OF TRADES	VOLUME (TOTAL)	VOLATILITY (SD OF RETURNS)	POST DUMMY	SINGLE DUMMY	R-SQUARE	F-STAT
FULL SAMPLE	0.2787	-0.044740	0.0000546	-3.52E-06	-0.3881	0.00831		0.23	6.29
	*11.09**	*-4.88**	*1.15*	*-1.33*	*-0.77*	*0.54*			
VLM 1 (Low)	0.0914	0.044140	-0.0025900	1.81E-04	1.5374	-0.03378		0.11	0.36
	0.83	*0.65*	*-1.24*	*1.13*	*0.95*	*-0.73*			
VLM 2	0.3164	-0.094550	0.0001811	-1.07E-05	0.1973	0.02108		0.42	3.37
	*6.87**	*-3.52**	*0.41*	*-0.66*	*0.17*	*0.68*			
VLM 3	0.3282	-0.075670	-0.0001825	-1.45E-05	0.6142	0.04416		0.42	2.86
	*4.43**	*-2.27***	*-0.64*	*-0.76*	*0.46*	*1.23*			
VLM 4 (High)	0.3376	-0.035330	0.0000554	-4.36E-06	-1.2820	-0.02577		0.44	4.69
	*7.83**	*-3.54**	*1.25*	*-1.74****	*-1.36*	*-1.11*			

* denotes significance at the 1% level of significance
** denotes significance at the 5% level of significance
*** denotes significance at the 10% level of significance

TABLE V
DEPTH AS MEASURED BY KYLE'S LAMBDA

This table summarizes the results for regressions run to obtain the measure of depth known as Kyle's lambda. The regression equation is of the form:

$$\Delta p_t = (\lambda_0 + \lambda_1 D_t) q_t + \varepsilon_t,$$

where Δp_t is the change in price ($p_t - p_{t-1}$), q_t is the signed order flow (positive for buy orders and negative for sell orders and ε_t is a random noise term. D_t is a dummy variable that takes on the value 1 for the post-period and 0 for the pre-period. λ_1 captures changes that occur in market liquidity as a result of the change in market structure. λ is an inverse measure of liquidity. The lambda estimates are calculated for each option class separately and aggregated cross-sectionally are run to obtain the results. The CBOE instituted a specialist system for all its equity options over August and September 1999. The pre-period covers 20 trading days before the option class switched over to the specialist system and the post-period covers 20 trading days immediately after the switch date. The switch date is not included in either sample. Contemporaneous trades and quotes are used to assign trades to quotes. Lee and Ready's (1991) algorithm is used to classify trades as buyer or seller initiated. Results are presented for the full sample as well as for volume quartiles. Separate results are presented for the CBOE, AMEX and the National Best Bid and Offer quotes (BBO). BBO quotes are calculated for multiple listed stocks as the highest bid and lowest ask outstanding at a time. The sample consists of near term at the money options, trading below $3 only. t-statistics, testing the significance of the coefficient, are given below the coefficients in italics. The coefficients are multiplied by 1,000.

	Number of Option Classes	Signed Volume		Signed Volume*Post	
		Parameter	t-statistic	Parameter	t-statistic
FULL SAMPLE	104	1.73	*5.86**	-1.06	*-2.07***
Volume Quartile 1 (Low)	26	3.06	*5.13**	-2.18	*-1.93****
Volume Quartile 2	26	2.67	*2.67***	-2.25	*-1.30*
Volume Quartile 3	26	1.05	*5.46**	-0.12	*-0.32*
Volume Quartile 4 (High)	26	0.50	*4.22**	-0.02	*-0.05*
CBOE	104	1.80	*5.87**	-1.22	*-2.32***
Volume Quartile 1 (Low)	26	2.97	*5.75**	-2.19	*-1.91****
Volume Quartile 2	26	2.76	*2.48***	-2.34	*-1.32*
Volume Quartile 3	26	1.34	*4.57**	-0.35	*-0.83*
Volume Quartile 4 (High)	26	0.47	*5.95**	-0.35	*-0.52*
AMEX	60	2.40	*3.21**	-1.14	*-1.37*
Volume Quartile 1 (Low)	12	9.24	*1.55*	-7.54	*-1.16*
Volume Quartile 2	16	1.93	*5.13**	0.54	*0.65*
Volume Quartile 3	13	1.80	*3.12**	-0.69	*-0.66*
Volume Quartile 4 (High)	19	1.08	*3.40**	-0.63	*-1.94****

* denotes significance at the 1% level of significance
** denotes significance at the 5% level of significance
*** denotes significance at the 10% level of significance

TABLE VI

MARKET SHARE

This table analyzes the market share impact of the switch in trading mechanism on the CBOE. Market share is calculated as the percentage of total volume that traded on a particular exchange in our sample. The CBOE instituted a specialist system for all its equity options over August and September 1999. The pre-period covers 20 trading days before the option class switched over to the specialist system and the post-period covers 20 trading days immediately after the switch date. The switch date is not included in either sample. Market share is calculated for each option class as the percentage of total volume in the option traded on a particular exchange, and then summarized cross-sectionally. Similarly, the change in market share is calculated for each underlying stock and then aggregated across the sample. Results are presented for the two dominant exchanges in our sample (and in the US options markets), the CBOE and the AMEX. The sample consists of near term at the money options trading below $3 only.

A. Percentage Share of Total Volume Traded – Overall

	N	Pre	Post	Change (% points)	T-Statistic
Multiple Listed					
CBOE	60	52.7%	56.7%	4.0%	*1.44*
AMEX	60	39.3%	36.0%	-3.3%	*-1.36*

B. Percentage Share of Total Volume Traded – Volume Quartiles

Volume Quartiles	1(Low)	2	3	4(High)
CBOE				
Pre	59.8%	52.7%	50.8%	49.5%
Post	64.3%	56.8%	61.0%	48.7%
Change (% points)	4.5%	4.1%	10.2%	-0.7%
T-Statistic	*0.70*	*0.68*	*1.48*	*-0.20*
N	12	16	13	19
AMEX				
Pre	30.5%	37.7%	35.2%	48.4%
Post	28.5%	34.8%	29.8%	45.5%
Change (% points)	-2.0%	-2.9%	-5.4%	-2.9%
T-Statistic	*-0.32*	*-0.75*	*-0.76*	*-0.76*
N	12	16	13	19

* denotes significance at the 1% level of significance
** denotes significance at the 5% level of significance
*** denotes significance at the 10% level of significance

TABLE VII

TRADE THROUGHS

This table analyzes the instances where a particular exchange "traded through" (execute an order at inferior prices) a better quote at a competing exchange. The CBOE instituted a specialist system for all its equity options over August and September 1999. The pre-period covers 20 trading days before the option class switched over to the specialist system and the post-period covers 20 trading days immediately after the switch date. The switch date is not included in either sample. Numbers are calculated for each option class and then summarized cross-sectionally. Similarly, the changes are calculated for each underlying stock and then aggregated across the sample. Results are presented for the two dominant exchanges in our sample (and in the US options markets), the CBOE and the AMEX. The sample consists of near term at the money options trading below $3 only. The table presents the number and volume of trade throughs as a percentage of all trades in an option in our sample. The loss is calculated as number of contracts for a trade that was executed at a price inferior to that quoted on another exchange multiplied by the difference in quotes on the two exchanges. Loss is represented in hundreds of dollars per option class.

	N	Pre	Post	Change (% points)	T-Statistic
CBOE					
Number of Trades	49	11.9%	14.4%	2.5%	*1.50*
Volume	49	9.8%	16.6%	6.8%	*2.81**
Loss	49	16.17	26.22	10.05	*1.83****
AMEX					
Number of Trades	30	8.0%	8.8%	0.8%	*0.95*
Volume	30	8.2%	10.5%	2.3%	*1.28*
Loss	30	27.19	35.28	8.09	*0.84*

* denotes significance at the 1% level of significance
** denotes significance at the 5% level of significance
*** denotes significance at the 10% level of significance