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ANAND M. VIJH*

ABSTRACT

We examine the CBOE option market depth and bid-ask spreads. Absence of price effects surrounding large option trades suggests excellent market depth. However, bid-ask spreads for the CBOE options and the NYSE stocks are nearly equal, even though an average option is equivalent to less than half a stock plus borrowing. We explain this tradeoff between market depth and bid-ask spreads on the CBOE and the NYSE by differences in market mechanisms. We also show that the adverse-selection component of the option spread, which measures the extent of information-related trading on the CBOE, is very small.

THIS STUDY EXAMINES EMPIRICALLY the liquidity of the options market. In particular, we examine the tradeoff between market depth and market spread arising from differences in market mechanisms of the Chicago Board Options Exchange (CBOE) and the New York Stock Exchange (NYSE). Market depth is the ability of a market to absorb sudden increases in trading volume and is measured by the extent of a large trade's impact on the security's price. Market spread is the difference between the lowest ask and the highest bid prices at which dealers stand ready to trade a minimum-size order.

The basic theory motivating our analysis has been developed by a number of researchers, but perhaps most effectively by Ho and Macris (1985). They argue that increasing the number of dealers in a given security leads to greater market depth at the cost of wider bid-ask spreads. Their basic reasoning is as follows. Consider first the situation facing a specialist who is the only designated dealer in a particular security. The specialist uses the bid-ask spread to recover the cost of market-making and uses the position of the spread (i.e., the location of the spread midpoint) to control his or her costs arising from carrying an inventory of securities. For example, if the specialist has a large negative inventory, he or she raises both the bid and the ask prices, which encourages potential sellers and discourages potential buyers. Now compare a multiple dealer market, such as the CBOE, to the NYSE, where a single dealer (the specialist) makes the market in each stock. In a multiple dealer market, the collective ability of dealers to carry inventory to absorb imbalances in buying and selling activity is much higher. Also, the ability of any one dealer to move bid-ask prices is limited because he or she faces competition from other dealers who may have small inventories.

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Thus, increasing the number of dealers results in higher market depth; that is, the market can absorb large orders with little change in the price. However, this improvement in market depth occurs at a cost. All of the dealers together pay higher inventory costs for carrying more inventory; furthermore, fixed costs, such as the opportunity cost of dealers' time, increase in direct proportion to the number of dealers. Higher fixed and inventory costs lead to wider bid-ask spreads as the number of dealers increases.

There is a long history of empirical studies of both depth and bid-ask spreads in equity markets dating back to at least the Institutional Investor Study (1971). Important contributions on the topic of the NYSE market depth include studies by Kraus and Stoll (1972), Dann, Mayers, and Raab (1977), and Holthausen, Leftwich, and Mayers (1987). In addition, Branch and Freed (1977) and Glosten and Harris (1988) provide estimates of the NYSE bid-ask spreads. However, perhaps due to the more recent history of option trading on organized exchanges, the evidence on liquidity of the options markets is comparatively scarce. Many exchanges trade equity options today, but the CBOE has remained the leading options market since it began trading options in 1973. We focus on the NYSE stocks and the CBOE options in this study for two reasons: first, the market mechanisms on these two exchanges differ in ways most pertinent for the tradeoff between market depth and bid-ask spreads, and second, these exchanges are the leading markets for equities and equity options.

Besides the number of dealers allowed to compete for a given security, a market's liquidity is also influenced by the extent of information-related trading in that market. Since the first study of this issue by Bagehot (1971), many theoretical models have suggested that information trading increases transaction costs because dealers must recover from uninformed traders what they lose (on average) to informed traders. This incremental cost, commonly termed the adverse-selection component of bid-ask spread, may have an effect on bid-ask spreads quite apart from effects related to market mechanisms discussed above. Therefore, any attempt to study the relative liquidity of different markets with a view to understanding the effectiveness of different market mechanisms must take into account differences in liquidity due to information-related trading.

While the extent of information trading in the NYSE stocks has been the subject of intense scrutiny, comparatively little evidence exists for the CBOE options. Glosten and Harris (1988) and Stoll (1989) provide estimates of the adverse-selection component of the transaction costs on the NYSE, but there are no direct estimates of transaction costs arising from adverse selection on the CBOE.[1] It is sometimes argued that the leverage implicit in options is particularly attractive to informed traders. However, and for precisely the same reason,

[1] This topic, however, has been investigated in a different context. Manaster and Rendleman (1982) show that the CBOE closing prices (sometimes) predict the subsequent changes in stock prices. Vijh (1988) shows that their results may be explained by a selection bias. Bhattacharya (1987) also shows that Manaster and Rendleman's results almost disappear when transaction data are used. Neither Manaster and Rendleman nor Bhattacharya investigate how often stock prices lead option prices, so one cannot infer the relative information content of stock and option trades from their studies. In a recent paper, however, Stephan and Whaley (1989) examine both lead and lag relations between stock and option prices and show that stock prices lead option prices by fifteen to twenty minutes.

options are also attractive to noise traders—those traders who think they have superior information but actually have only a different opinion. Depending on their investment horizons, liquidity traders may or may not find options an alternative to stocks. The compositions of the investor populations on the two exchanges, in terms of information traders, noise traders, and liquidity traders, are difficult to ascertain. The relative influence of information trading on the two exchanges must therefore be empirically determined. This paper provides specific estimates of the impact of information trading on the liquidity of the CBOE options and compares these estimates with corresponding estimates for the NYSE stocks obtained by previous researchers.

The organization of the paper and the principal results are as follows. Section I estimates the depth of the CBOE options market. Both stock and option prices surrounding large option trades are surprisingly unaffected. Neither the bid-ask spread nor the location of the spread midpoint changes with a large option trade. Section II shows that the depth of the CBOE options market occurs at the cost of wider bid-ask spreads. Specifically, although an average option is equivalent to less than half a stock (an option can be replicated by "delta" stock plus bond, and the average option delta is less than 0.50), stock and option bid-ask spreads are nearly equal. Section III investigates the extent and nature of information trading on the CBOE. The asymmetry in information among option traders, as evidenced by the adverse-selection component of bid-ask spread, is found to be small in comparison with similar estimates for the NYSE stocks from Glosten and Harris (1988) and cannot explain why option spreads are so large. It is also shown that the information content of option trades is uncorrelated with trade size. Section IV summarizes the findings and implications of the paper.

Overall, we show that the CBOE options market offers greater depth but wider bid-ask spreads than the NYSE equities market. These differences apparently arise from the different market mechanisms on the CBOE and the NYSE. Contrary to popular belief, however, information effects in option trades are very small and do not have a substantial influence on option liquidity.

I. The CBOE Option Market Depth

Below, we ascertain the magnitude and duration of the price effects of large option trades on the CBOE. Whereas many studies show that block trades on the NYSE cause both temporary and permanent price effects, we show that the multiple-dealer market on the CBOE can absorb large trades without any effect on price.

Our data base contains a complete time-stamped history of bid-ask quotes in addition to trade prices and quantities for stocks and options during March and April 1985. Only options on NYSE-listed stocks are included.[2] The bid-ask prices enable us to identify trades as buyer- or seller-initiated, and the record of

[2] The options data were obtained from the Berkeley Options Database tapes, and the stock transaction data were obtained from the AMEX. Both stock and option prices were electronically recorded from the tape and show a high degree of synchroneity. Options on 141 NYSE-listed stocks were traded on the CBOE during the period of this study.

simultaneous stock prices enables us to distinguish between information-related and inventory-related price effects.

To be included in this study, an option trade has to be equivalent to at least 250 round lots of stock. Since an option can be replicated by delta (hedge ratio) stock plus bonds, equivalent round lots of stock are obtained by multiplying the option trade size by the option delta. Only two other criteria are used in sample selection. First, because an option pricing function cannot be estimated reliably for very short-maturity or deep-in or out-of-the-money options, the selected large trades must have a time to maturity of greater than a week and the option delta must lie between 0.15 and 0.85. Second, straddles and combinations are excluded because they combine two or more options and limit the risk borne by the dealers. Imposition of these criteria produced a sample of 188 call and 11 put trades. The average large trade is equivalent to \$1.9 million worth of stock and represents two-thirds of the daily volume for all options on that stock.[3] We classify trades into three categories: (i) trades occurring in the upper half of the spread, presumed to be buyer-initiated, (ii) trades exactly at the middle, and (iii) trades in the lower half, presumed to be seller-initiated. There are 51, 53, and 95 trades in these three categories.

Our methodology is based on the following observations. First, if large option trades are motivated by superior information about future stock prices, they should be accompanied by a permanent change in both stock and option prices. Second, if dealers perceive that the inventory risk of large option trades requires an additional premium or discount, there should also be a temporary divergence between the stock and option prices. Measuring the latter price effect requires estimating a pricing function which gives option prices implied by the contemporaneous stock prices while ignoring effects of the large trade. This study uses the Black and Scholes (1973) formula with dividend correction to estimate the option pricing function from the previous day's data.

We first estimate the information-related permanent price effects of large option trades by examining the surrounding stock prices. Because the time it takes the stock price to reflect the information may vary across the sample (and because sometimes the market may learn about a large trade before it occurs), we examine stock prices from ten minutes before to thirty minutes after the large option trades. Let S_{tj} represent the stock price (midpoint of last quoted stock spread) t minutes after the jth large option trade. To test whether large trades are motivated by superior information concerning future stock prices, define

$$s_t = \sum_{j=1}^{n} S_{tj}/nS_{0j}.$$

Thus, the statistic s_t measures the average stock price at time t relative to S_{0j}, which is the stock price prevalent at $t = 0$, *just before* the large trade occurs. Ignoring the small expected return over thirty minutes (less than 0.0001), s_t should equal 1.0 for all t if there is no information in large trades. However, if large option trades are motivated by superior information, then s_t should increase with time for trades that would benefit from an increase in the stock price

[3] Alternatively, the average large trade represents the right to buy 72,300 shares, worth \$3.6 million. If the option is considered to be equivalent to delta stock, the average trade size is \$1.9 million.

(buyer-initiated calls and seller-initiated puts) and decrease for trades that would benefit from a decrease in the stock price (the converse).[4]

The results in Table I (also Figure 1) show that stock prices are unaffected by large option trades. Even after a lapse of thirty minutes, s_t equals 0.9992 or 1.0000 for trades that would benefit from an increase or a decrease in the stock price. For the average stock, these s_t values represent a deviation of −4 cents and 0 cents from the stock price prevailing before the large trade and are statistically insignificant. There is no evidence to suggest that large option trades are motivated by superior information about future stock prices.

Since the surrounding stock prices are unaffected, we next examine whether the inventory-related price effects of large option trades cause a deviation between the stock and option prices. We look at the five trades preceding and the five trades following large option trades. In the following discussion, the subscript j refers to one of these large trades, or *events*; $j = 1, 2, \cdots, n$, where n is the number of large trades. The subscript i denotes the event *transaction* time; e.g., $i = 0$ refers to the large trade (the event), and $i = -1$ refers to the immediately preceding trade in the same option. The *trade* price of the ith option trade surrounding the jth event is denoted by W^t_{ij}. For example, W^t_{0j} represents the trade price of the jth large trade, while W^t_{-1j} represents the immediately preceding trade price. Finally, W^b_{ij} and W^a_{ij} represent the option *bid* and *ask* prices effective at the time of the ith trade.

The following tests require three kinds of prices (trade, bid, and ask) observed for two related securities (stocks and options). To summarize notation, W and S denote the option and stock prices; the superscripts t, b, and a denote that the price is the trade, the bid, or the ask price; and the subscripts j and i denote the particular event (large trade) under consideration and the time relative to that event.

The null hypothesis states that large option trades cause no price effects that result in a deviation between the stock and option prices. In other words, option prices depend only on the contemporaneous stock prices. Assuming that the stock spread midpoint is an unbiased estimator of the "true" stock price, we use an option pricing function fitted from the previous day's data to calculate $W^*_{ij}(S_{ij})$, the "true" option prices implied by the contemporaneous "true" stock prices.[5] If large trades do not cause a deviation between the stock and option prices, then the observed option spread midpoint, $0.5 \times [W^b_{ij} + W^a_{ij}]$, should equal the implied true option price, W^*_{ij}. So we use the following test statistic to measure the price effects:

$$\text{effect on spread midpoint ("}q\text{"):} \quad T^q_i = \frac{100}{n} \sum_{j=1}^{n} \frac{1}{S_{ij}} [0.5 \times (W^a_{ij} + W^b_{ij}) - W^*_{ij}],$$

[4] (i) Because the time taken for stock prices to reflect the information (next quote after the stock market learns of the event) will vary across the sample, s_t will increase or decrease *gradually*, even though individual S_{tj}'s will jump. (ii) Strictly speaking, $E(s_t) > 1$ for $t < 0$ under the null hypothesis. Note that $E(s_t) = E[S_{tj}E(1/S_0 \mid S_{tj})] > E[S_{tj}/E(S_{0j} \mid S_{tj})] = 1$ for $t < 0$. However, for a small time interval, $E(s_t) = 1.00 + \text{var}(\xi_{tj})$, $t < 0$, where $S_{tj} = S_{0j}(1 + \xi_{tj})$. Over ten minutes, $\text{var}(\xi_{tj}) = 0.000007$ for the typical stock which has an annual volatility of 25 percent. Therefore, $E(s_t) \approx 1$.

[5] Note that $S_{ij} = 0.5 \times (S^b_{ij} + S^a_{ij})$. As in microstructure models, we assume that the trade price equals a "true" price, the dealer's best estimate of security value, plus half of the bid-ask spread.

Table I

Stock Prices Surrounding Large Option Trades

This table examines whether large option trades are perceived to be motivated by superior beliefs about the stock price. Our sample includes all option trades on the CBOE during March and April 1985 which are equivalent to at least 25,000 shares of the underlying stock (one option is considered to be equivalent to delta stock) and which also satisfy the following criteria: 1) trade must not be part of a straddle or a combination, and 2) the option delta must lie between 0.15 and 0.85 and the time to maturity must exceed a week. Trades in the upper half of the spread are considered to be buyer-initiated, and trades in the lower half of the spread are considered to be seller-initiated. Thus, the 48 buyer-initiated call and six seller-initiated put trades will result in a profit for the initiator of the trade if the stock price rises, and the 89 seller-initiated call and three buyer-initiated put trades will result in a profit for the initiator of the trade if the stock price falls. Fifty-one call and two put trades otherwise satisfying the preceding criteria but occurring at the spread midpoint are not reported in this table. The stock price reaction is measured by s_t, which is the average value of stock price at time t (in minutes) relative to stock price at time $t = 0$ (just before the large option trade). Specifically, $s_t = \sum_{j=1}^{n} S_{tj}/nS_{0j}$, where S_{tj} is the stock price at t.

	48 Call and 6 Put Trades That Will Benefit from an Increase in the Stock Price		89 Call and 3 Put Trades That Will Benefit from a Decrease in the Stock Price	
Variable	Estimate	Std-error	Estimate	Std-error
s_{-10}	1.0002	0.0005	0.9989	0.0004
s_{-8}	1.0002	0.0004	0.9990	0.0004
s_{-6}	1.0002	0.0004	0.9992	0.0004
s_{-4}	1.0001	0.0004	0.9993	0.0003
s_{-2}	1.0001	0.0002	0.9996	0.0002
s_0	1.0000	0.0000	1.0000	0.0000
s_2	1.0000	0.0002	1.0000	0.0002
s_4	0.9999	0.0003	1.0001	0.0003
s_6	1.0001	0.0004	1.0003	0.0003
s_8	0.9998	0.0004	1.0004	0.0004
s_{10}	0.9998	0.0004	1.0004	0.0004
s_{12}	0.9994	0.0005	1.0003	0.0004
s_{14}	0.9996	0.0005	1.0001	0.0004
s_{16}	0.9995	0.0006	1.0002	0.0004
s_{18}	0.9996	0.0006	1.0004	0.0005
s_{20}	0.9995	0.0006	1.0000	0.0004
s_{22}	0.9993	0.0006	1.0001	0.0004
s_{24}	0.9993	0.0006	1.0002	0.0005
s_{26}	0.9992	0.0006	1.0002	0.0005
s_{28}	0.9991	0.0006	1.0001	0.0005
s_{30}	0.9992	0.0007	1.0000	0.0006

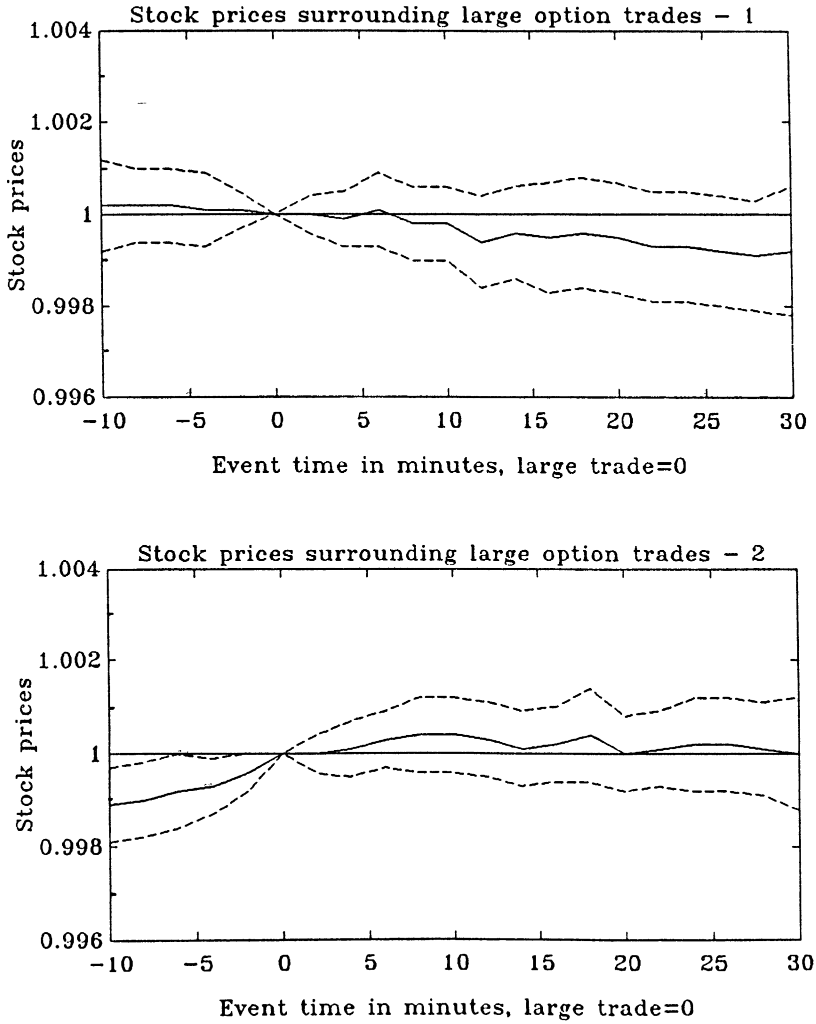

Figure 1. Stock price behavior around large option trades. This figure includes CBOE option trades during March and April 1985 which are equivalent to at least 25,000 shares, are not part of a straddle or a combination, and have an option delta between 0.15 and 0.85. The stock price reaction is measured by $s_t = 1/n \sum_{j=1}^{n} S_{tj}/S_{0j}$, where S_{tj} is the stock price at time t (in minutes), and S_{0j} is the stock price at $t = 0$, just before the large option trade occurred. The solid line represents s_t, and the broken line represents the two-sigma band around s_t. The top panel includes 48 buyer-initiated call and six seller-initiated put trades that will benefit from an increase in the stock price. The bottom panel includes 89 seller-initiated call and three buyer-initiated put trades that will benefit from a decrease in the stock price. Data points used in this figure are from Table I.

where n is the number of trades in the particular category. Note that T_i^q (and many other statistics to follow) are normalized by the stock price. Because option prices are so variable, and often close to zero, they are unsuitable for normalizing.

Under the null hypothesis of no price effects, T_i^q will equal zero for all i. The alternate hypothesis states that dealers incur significant costs in carrying a large negative inventory as the result of a large buy order. To control inventory costs, dealers raise both the bid and the ask prices, thus encouraging potential sellers and discouraging potential buyers. Under the alternate hypothesis, T_i^q will be positive for large buy orders and (using a similar argument) negative for large sell orders.

The first rows of Panels 1, 2, and 3 in Table II (also Figure 2) show the T_i^q values for $i = -5$ to $+5$, for each of the three trade categories, based on whether the trade was in the upper half of the spread, at the middle, or in the lower half. The slight but steady downward trend in T_i^q values across all categories simply reflects the loss in time value of the options. The typical standard error of T_i^q is 0.05, or 2.5 cents. Most T_i^q values lie within two standard errors around 0.00. The largest deviation from the two-standard-error band is 0.0240, or 1.2 cents. We conclude that the option middle prices surrounding large option trades are indistinguishable from what they would be in absence of the large trades.

Since both the stock prices and the option middle prices are unchanged, the only possible price effect of large option trades can be a higher bid-ask spread. We find some evidence that the quoted option spread (defined simply as the difference between quoted bid and ask prices) surrounding the large trades is somewhat higher than normal. The bid-ask spread preceding the large trade is higher than the median bid-ask spread for the same option series during the previous day in 76 cases, the same in 81 cases, and lower in 42 cases. Equality between the two is rejected by a nonparametric z-statistic of 3.13. In addition, we use the following parametric statistic to estimate the increase in quoted spread:

effect on quoted spread ("*qs*"): $$T_i^{qs} = \frac{100}{n} \sum_{j=1}^{n} \frac{1}{S_{ij}} [(W_{ij}^a - W_{ij}^b) - QTSP_j],$$

where $QTSP_j$ is the average of all quoted bid-ask spreads from the previous day. The third rows of Panels 1, 2, and 3 in Table II show that T_0^{qs} is greater than zero across all three trade categories, but it is significantly greater only for trades occurring at the quote midpoint. Perhaps the trade occurred at the midpoint because the quoted spread was too wide and could be negotiated to a lower value. We therefore examine *effective* spreads paid for large trades versus smaller trades.

Many trades on both stock and option markets occur inside the bid-ask quote. Hasbrouck (1988) points out that inside-the-spread trades are usually the result of bargaining, which leads to better prices. Therefore, if a trade occurs below (above) the quote midpoint, we assume that the trade price is the effective bid (ask) price. We then compute the effective spread paid for that trade as the difference between the effective bid (ask) and the quoted ask (bid) prices, which equals $\max[W_{ij}^t - W_{ij}^b, W_{ij}^a - W_{ij}^t]$. The increase in effective spread surrounding large option trades is measured by T_i^{es} as follows:

change in effective spread ("*es*"):

$$T_i^{es} = \frac{100}{199} \sum_{j=1}^{199} \frac{1}{S_{ij}} [\max(W_{ij}^t - W_{ij}^b, W_{ij}^a - W_{ij}^t) - EFSP_j],$$

Table II

Option Prices Surrounding Large Option Trades

This table examines the effect of a large option trade on the surrounding option prices. The sample includes all option trades on the CBOE during March and April 1985 which are equivalent to at least 25,000 shares of the underlying stock (one option is considered to be equivalent to delta stock) and which also satisfy the following criteria: 1) trade must not be part of a straddle or a combination, and 2) the option delta must lie between 0.15 and 0.85 and the time to maturity must exceed a week. To understand the many statistics reported here, let i denote event time. Thus, $i = 0$ is the large option trade and $i = -1$ refers to the preceding trade. Let W^a_{ij}, W^b_{ij}, and W^t_{ij} represent the ask, the bid, and the trade prices of the ith trade surrounding the jth observation of a large option trade. Let also W^*_{ij} represent the option price implied by the last quoted stock middle price and the option pricing information from the previous day. Then the first line of each panel reports the difference between the spread midpoint and the implied option price, measured by $T^q_i = (100/n) \sum_{j=1}^{n} [0.5 \times (W^a_{ij} + W^b_{ij}) - W^*_{ij}]/S_{ij}$. The second line reports the difference between the trade price and the implied price, measured by $T^t_i = (100/n) \sum_{j=1}^{n} (W^t_{ij} - W^*_{ij})/S_{ij}$. The third line reports the effect on quoted spread, measured by $T^{qs}_i = (100/n) \sum_{j=1}^{n} [(W^a_{ij} - W^b_{ij}) - QTSP_j]/S_{ij}$, where $QTSP_j$ is the average quoted spread from the previous day. Panel 4 reports change in the "effective" spread, measured by $T^{es}_i = (100/199) \sum_{j=1}^{199} [\max(W^t_{ij} - W^b_{ij}, W^a_{ij} - W^t_{ij}) - EFSP_j]/S_{ij}$, where $EFSP_j$ is the average effective spread from the previous day. If large option trades cause no price effects, then T^q_i, T^{qs}_i, and T^{es}_i should equal zero for all i. Also, T^t_i should equal 0.5 and −0.5 times the effective spread for $i = 0$ in Panels 1 and 3, and zero otherwise. All figures are expressed in percents and 0.01 equals roughly one-half cent.

	Statistic and Std-error†	Trade Relative to Large Option Trade										
		−5	−4	−3	−2	−1	**0**	1	2	3	4	5
		Panel 1. 48 call and 3 put trades in upper half of the spread (buyer-initiated), previous day's effective spread = 0.3										
T^q_i	0.06	0.0017	0.0044	0.0006	−0.0114	−0.0177	**−0.0892**	−0.0520	−0.0619	−0.0272	−0.0553	−0.0598
T^t_i	0.06	0.0184	0.0206	0.0330	−0.0087	0.0604	**0.0972**	0.0483	−0.0288	−0.0004	0.0155	0.0310
T^{qs}_i	0.05	0.0104	0.0307	0.0399	0.0190	0.0351	**0.0528**	0.0557	−0.0194	0.0147	−0.0115	−0.0118
		Panel 2. 51 call and 2 put trades at the spread midpoint (initiator uncertain), previous day's effective spread = 0.4										
T^q_i	0.05	0.0875	0.0942	0.1038	0.0800	0.0350	**−0.0734**	−0.0747	−0.1051	−0.0879	−0.1167	−0.1054
T^t_i	0.05	0.0524	0.0935	0.1144	0.0930	0.0612	**−0.0734**	−0.0587	−0.0368	−0.0267	−0.0383	0.0020
T^{qs}_i	0.04	0.0093	−0.0180	−0.0252	−0.0066	0.0384	**0.1320**	0.0534	0.0138	0.0208	−0.0173	−0.0208
		Panel 3. 89 call and 6 put trades in lower half of the spread (seller-initiated), previous day's effective spread = 0.53										
T^q_i	0.04	0.0461	0.0393	0.0411	0.0612	−0.0055	**−0.0634**	−0.0825	−0.0904	−0.0999	−0.0937	−0.1040
T^t_i	0.04	0.0554	0.0657	0.0005	−0.0010	−0.0860	**−0.3080**	−0.1527	−0.1208	−0.1170	−0.1399	−0.1114
T^{qs}_i	0.03	0.0334	0.0438	0.0455	0.0322	0.0547	**0.0448**	0.0452	0.0202	−0.0067	−0.0195	−0.0552
		Panel 4. 199 trades in all three categories above										
T^{es}_i	0.02	−0.0520	−0.0724	−0.0684	−0.0691	−0.0708	**−0.0386**	−0.0732	−0.0989	−0.0947	−0.1139	−0.1367

† The t-statistics can be obtained by dividing figures by the corresponding standard errors, except for T^t_0 (see above).

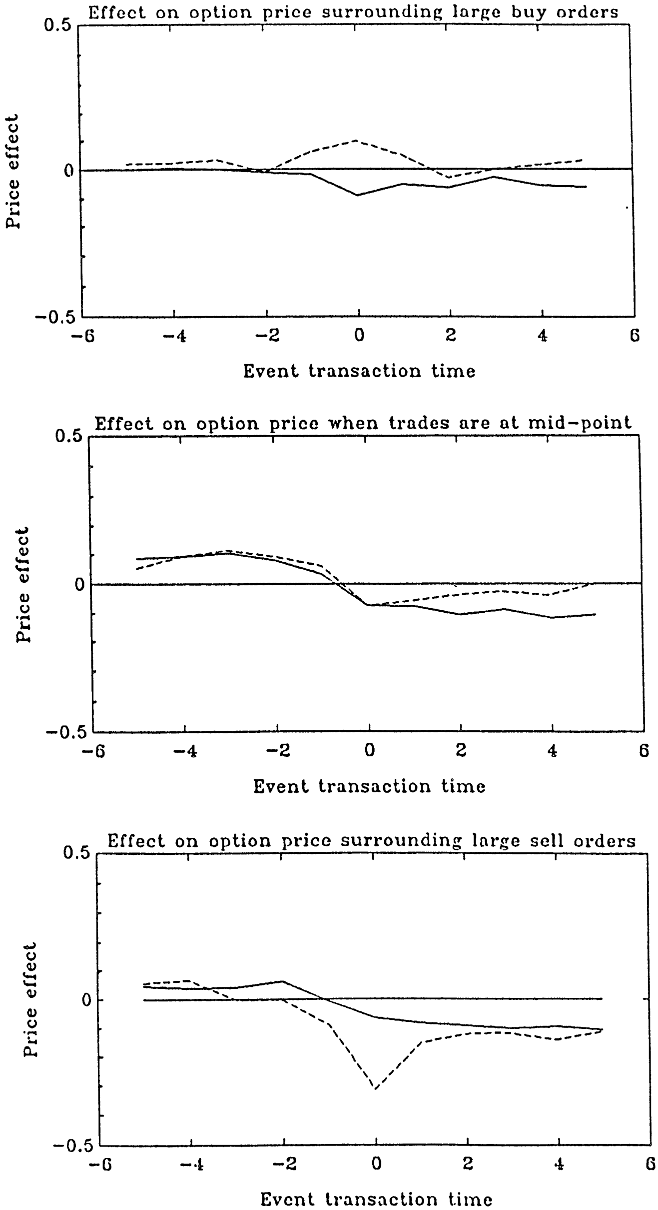

Figure 2. Price effects in the CBOE option market surrounding large option trades. This figure includes option trades during March and April 1985 which are equivalent to at least 25,000 shares, are not part of a straddle or a combination, and have an option delta between 0.15 and 0.85. The samples used in the three panels include 48 call and three put trades initiated by buyers, 51 call and two put trades occurring at the spread midpoint which may have been initiated by buyer or seller, and 89 call and six put trades initiated by sellers. The solid line in each panel shows the position of the spread midpoint for the five trades preceding and following the large option trade. The position of the spread midpoint is measured by $T_i^q = \sum_{j=1}^{n} [0.5 \times (W_{ij}^a + W_{ij}^b) - W_{ij}^*]/nS_{ij}$. The broken line shows the position of the trade price, measured by $T_i^q = \sum_{j=1}^{n} (W_{ij}^t - W_{ij}^*)/nS_{ij}$. Both T_i^q and T_i^t are expressed as percents. Data points used in this figure are from Table II.

where $EFSP_j$ is the average effective spread similarly estimated from all trades on the previous day.[6] The last row of Table II gives the T_i^{es} values. Surprisingly, the effective spread for trades surrounding the large trade is lower than on the previous day. There is no obvious explanation for the higher quoted but lower effective spreads around large option trades. The effective spread paid for a large trade is higher than the effective spread paid for the surrounding trades but lower than on the previous day, although by only 0.0386, or 1.9 cents. It may be that in some cases the large trade occurred because the dealers were then accepting lower spreads.

Our investigation shows that large option trades on the CBOE do not cause any price effects or command any premium specific to the large trade. Figure 2 shows that, in fact, large buy (sell) orders occur in the middle of buying (selling) activity yet have no price impact. This inference is based on the following statistics:

$$\text{trade price minus } \textit{implied} \text{ spread midpoint} = T_i^t = \frac{100}{n} \sum_{j=1}^{n} \frac{1}{S_{ij}} [W_{ij}^t - W_{ij}^*];$$

trade price minus *observed* spread midpoint

$$= \frac{100}{n} \sum_{j=1}^{n} \frac{1}{S_{ij}} [W_{ij}^t - 0.5 \times (W_{ij}^b + W_{ij}^a)]$$

$$= T_i^t - T_i^q.$$

During periods when buy orders outnumber sell orders, $T_i^t - T_i^q$ will be positive, and vice versa. Note that $T_i^t - T_i^q$ is positive around large buy orders and negative around large sell orders.

Although we expected price effects on the CBOE to be small, given the multiple-dealer structure, the complete absence of price effects surrounding large option trades is surprising. One may argue that their absence can be explained by a selection bias.[7] If large orders are taken up by one dealer when inventory and information effects are perceived to be insignificant, and broken up among two or more dealers when these effects are significant, then price effects will occur only when there is a sequence of two or more large trades. Because existing databases do not identify when a large order has been broken up, a rigorous test of this proposition is difficult. Regardless of the selection criteria used to detect related trades, both type I error (not detecting a sequence of trades resulting from breaking up a large order) and type II error (showing trades as related when they are not) will be substantial. Keeping these limitations in mind, we repeated our tests using a set of 108 observations, each consisting of two or more large trades (at least 100 option contracts) reported within an interval of five minutes. The results (not reported) show that even a sequence of two or more large trades on the CBOE does not cause price effects.

Our tests indicate that the CBOE options market has great depth. Unlike studies of NYSE stocks by Kraus and Stoll (1972), Dann, Mayers, and Raab

[6] If effective spreads were computed separately for the three categories, one would find that figures for categories 1 and 3 are overstated because trades at the middle have been excluded.

[7] I am obliged to the referee for pointing out this and several other necessary cross-checks.

(1977), and Holthausen, Leftwich, and Mayers (1987), our study finds no evidence of temporary or permanent price effects surrounding large option trades on the CBOE. The absence of inventory-related price effects can be explained by the multiplicity of dealers. Ho and Macris (1985) show that, when transaction prices are determined by order-processing and inventory carrying costs, increasing the number of dealers leads to greater market depth at the cost of wider bid-ask spreads. Because of competition among dealers, prices do not change simply because one dealer has a large positive or negative inventory. However, there is no obvious explanation for the lack of superior information motivating large option trades.

II. The Stock and Option Bid-Ask Spreads

We have shown that the CBOE options market has great depth. If this depth results from allowing many dealers to compete for the order flow in a security, then the option bid-ask spreads would be expected to be large relative to stock spreads. Below, we show that this is indeed the case.

To compare bid-ask spreads across active stocks and active options, we choose a subset of data consisting of every constant stock-price interval (time over which both the stock bid and ask prices remain unchanged) during which there is at least one stock trade and one option quote followed by a trade. Thus, stock and option bid-ask spreads too wide to attract a trade are excluded. There are 94,704 such constant stock price intervals over March and April 1985. Many of these constant stock price intervals, however, include two or more different options which have a quote followed by a trade, in which case a quote for each option is included. Our sample used for comparing stock and option bid-ask spreads includes 94,704 stock and 161,589 option quotes and 434,262 stock and 593,165 option trades.

Table III gives the frequency distribution of the size of stock and option bid-ask spreads that were followed by at least one trade. Averaged across the sample, the quoted stock spread is 23.7 cents. In comparison, the average quoted option spread is ten percent lower, at 21.3 cents.[8] The option spread is also more variable than the stock spread.[9]

[8] Sometimes two or more quotes for the same option may occur during a constant stock price interval (CSPI). It may be argued that in such cases combining bid and ask prices from different dealers can yield spreads that are tighter than the spreads from either dealer. Vijh (1987) shows that combining the minimum ask and maximum bid prices from different quotes over a CSPI gives an average quoted option spread of 15.11 cents as compared with 21.3 cents if averaged over separate quotes. Vijh (1987) also shows that the minimum-ask–maximum-bid considerably underestimates the option spread; it is negative or zero once out of six times (implausible), and one out of four option trades lies outside this estimator of spread. Because a quote is valid only for the moment after it is spoken, and only 2.5 percent quotes are followed by a different quote within 15 seconds, last quoted bid-ask prices are the best estimate of dealers' guaranteed prices. Furthermore, to make sure that options are not over-represented in comparison with stocks, which have exactly one quote per CSPI, we also choose only one quote randomly when there are multiple quotes for the same option during a CSPI.

[9] With a view to estimating liquidity, this paper provides only aggregate estimates of bid-ask spread. Vijh (1987) shows that the variation in option spreads can be explained in terms of a few option parameters.

Table III

Quoted Stock and Option Bid-Ask Spreads

This table compares the quoted bid-ask spread across the CBOE options and the NYSE stocks during March and April 1985. To compare bid-ask spreads across only active stocks and active options, we choose a subset of data consisting of every constant stock-price interval (time over which both the stock bid and ask prices remain unchanged) during which there is at least one stock trade and one option quote followed by a trade. We find 94,704 distinct constant stock price intervals. Our procedure excludes stock and option bid-ask quotes too wide to attract a trade. Many of these constant stock price intervals, however, include two or more different options which have a quote followed by a trade, in which case a quote for each option is included. Our sample used for comparing stock and option bid-ask spreads includes 94,704 stock and 161,589 option quotes. Stock prices are quoted as multiples of an eighth of a dollar. However, option prices may be quoted as multiples of a sixteenth of a dollar if the quoted price is less than three dollars.

Quoted Bid-Ask Spread in Dollars	Frequency	
	Stocks	Options
1/16	—	19.7
2/16	35.2	32.1
3/16	—	5.0
4/16	48.0	22.6
5/16	—	0.5
6/16	11.2	8.4
8/16	4.8	10.5
>8/16	0.8	1.2
Total	100.0	100.0

The quoted spreads measure the difference between the best prices at which dealers *guarantee* to buy or sell the minimum trading unit, which is 100 shares (a round lot) or the option to buy or sell 100 shares (an option contract). However, traders can sometimes obtain better prices by bargaining, in which case the actual or effective spreads are lower than the quoted spreads. Also, sometimes buy and sell orders from different traders reach the floor simultaneously, in which case the orders are crossed without dealer participation, and the effective spread is zero.

Hasbrouck (1988) investigates several inside-the-quote trades on the NYSE and finds that these trades are usually the result of the trader being able to bargain for better prices and are only rarely the result of crossing orders from the floor. This finding is also confirmed by his discussions with the NYSE specialists. We expect crossing orders to be even less frequent on the CBOE, given the greater heterogeneity of options. In the following discussion, we assume that all inside-the-quote trades on the CBOE and the NYSE result from bargaining between traders and dealers. This assumption results in the *measured* effective spreads being larger than the *actual* effective spreads, but more so for stocks than options because more trades occur inside the stock spread (shown below) and because crossing orders on the NYSE are more likely than on the CBOE.

Table IV shows how stock and option trades are distributed relative to the last quoted bid-ask prices. Only 25.40 percent of option trades occur inside the option spread, whereas 35.14 of the stock trades occur inside the stock spread. It appears that option dealers generally quote the best prices they can offer, possibly in order to preclude competition. The difference between the effective and the quoted bid-ask spreads will therefore be smaller for options than for stocks.

We estimate the effective spreads as follows. If a dealer buys (sells) at a certain price, by definition that price is the effective bid (ask) price. If a trade occurs below (above) the quote midpoint, we assume that it was the dealer's purchase (sale), and therefore the trade price is the effective bid (ask) price. Then it follows that

$$\text{effective spread} = \max[\text{trade price} - \text{quoted bid}, \text{quoted ask} - \text{trade price}].$$

Table IV

Distribution of Stock and Option Trade Prices over the Bid-Ask Spread

This table examines the frequency of inside-the-quote trades during March and April 1985 for evidence on effective spreads for the CBOE options and the NYSE stocks. The sample used is the same as in Table III. We choose a subset of data consisting of every constant stock-price interval (time over which both the stock bid and ask prices remain unchanged) during which there is at least one stock trade and one option quote followed by a trade. We find 94,704 distinct constant stock price intervals. Our procedure excludes stock and option bid-ask quotes too wide to attract a trade. Many of these constant stock price intervals, however, include two or more different options which have a quote followed by a trade, in which case a quote for each option is included. Our sample includes 434,262 stock and 593,165 option trades. Every trade price is compared with the immediately preceding bid-ask spread to obtain the frequencies reported in this table.

	Percentage of Trades	
Description	Stocks	Options
Trade price is . . .		
1. Higher than the ask price	0.29	2.51
2. Equal to the ask price	32.86	40.94
3. Between the ask price and the spread midpoint	3.30	4.46
4. Equal to the spread midpoint	28.63	17.11
5. Between the spread midpoint and the bid price	3.21	3.83
6. Equal to the bid price	31.29	29.21
7. Lower than the bid price	0.42	1.94

Given the distribution of stock and option trades with respect to the last quoted bid-ask prices from Table IV, the effective option spread equals 0.916 times the quoted spread, or 19.5 cents. In comparison, the effective stock spread is 20.0 cents. Although the average option is equivalent to a levered position in less than half of a stock and costs one-tenth as much as the stock, the effective stock and option spreads are nearly equal. Alternatively stated, a trader pays twice the bid-ask spread for options as for an equivalent position in stock.

In Section I we showed that the options market can absorb large trades without any premium or price effects. Now we find that options dealers do charge higher bid-ask spreads to recover costs of market-making. We argue that a tradeoff between these two major components of liquidity should be expected. Multiple-dealer markets have higher fixed costs, such as the opportunity cost of dealers' time. The greater market depth resulting from the market's ability to carry higher overall inventory increases the variable inventory costs. The heterogeneity of options compounds these costs because it forces dealers to monitor the prices and inventories of several related yet different options on a stock. Furthermore, the sources of revenue to option dealers are restricted to the bid-ask spread. Stoll (1985) shows that the NYSE specialists derive a substantial part of their revenues from brokering for limit orders. In comparison, the limit order book on the CBOE is separately handled by an employee of the exchange, thus depriving the dealers of a source of both revenue and information.

Given these substantial costs and limited sources of revenue, it would be surprising if the CBOE options outperformed the NYSE stocks on both major dimensions of market liquidity. In that case, either options as a security would dominate stocks on both dimensions of liquidity, or the CBOE's market structure would be strictly preferable to the NYSE's market structure, or both. Given the continued popularity of both stocks and options and the existence of both kinds of market mechanism, our finding of a tradeoff between market depth and bid-ask spreads when choosing between the CBOE options and the NYSE stocks is not surprising.

III. Information Trading on the CBOE

We have shown that the bid-ask spread is the major transaction cost facing option traders on the CBOE. We have argued that the CBOE's market mechanism and the heterogeneity of options can explain these higher option spreads. However, large option spreads could also be the result of active information trading on the CBOE. Microstructure models show that the bid-ask spread consists of two components: a transitory component and an adverse-selection component. The transitory component represents the dealer's compensation for costs incurred in processing orders and carrying an inventory. The adverse-selection component arises because of the presence of information traders and represents the dealer's compensation for losses to informed traders.

Below, we investigate whether adverse selection is a major factor behind large option spreads. The absence of price effects surrounding large option trades provides evidence against active information trading. However, one must recognize that ours was a *biased* sample, a set of only 199 of the largest trades. The very largest trades may be motivated by factors other than superior information, such as an institution wanting to earn premium income by selling call options protected by its stock holdings. Therefore, the following tests of the information content of option trades employ a comprehensive data set consisting of every transaction, regardless of trade size, for twenty of the most active options on the CBOE during March and April 1985. The relation between asymmetric information and trade size is specifically examined.

We start with how stock and option prices are related in perfect capital markets and then modify the relation to include the effects of information in option trades. The Black and Scholes no-arbitrage condition states that, in perfect capital markets,

$$dW = \Delta dS + r(W - \Delta S)dt, \tag{1}$$

where W and S represent the *true* option and stock prices and Δ is the option delta. Now suppose there are $i = 1, 2, \cdots, M$ bid-ask quotes for the option under consideration. Let t_i denote the time when the ith option quote occurs. Thus, (t_{i-1}, t_i) represents the time interval between the $(i-1)$th and the ith quotes. Let W_{t_i} represent the midpoint of the ith bid-ask quote. Then, assuming that bid-ask prices are symmetric around the true price, $W_{t_i} - W_{t_{i-1}}$ equals the change in true option price over (t_{i-1}, t_i). Using equation (1), price changes over the time period (t_{i-1}, t_i) are related as follows:

$$W_{t_i} - W_{t_{i-1}} = \Delta_{t_{i-1}} (S_{t_i} - S_{t_{i-1}}) + r(W_{t_{i-1}} - \Delta_{t_{i-1}} S_{t_{i-1}})(t_i - t_{i-1}). \tag{2}$$

Equation (2) is now modified to include the effect of information in option trades. Based on Glosten and Milgrom (1985), if the information contained in option trades over the time interval (t_{i-1}, t_i) revises market makers' estimates of the true option price by I_{t_i}, then, assuming that the stock price does not reflect this information immediately, the change in option price is given by

$$W_{t_i} - W_{t_{i-1}} = \Delta_{t_{i-1}} (S_{t_i} - S_{t_{i-1}}) + r(W_{t_{i-1}} - \Delta_{t_{i-1}} S_{t_{i-1}})(t_i - t_{i-1}) + \mathrm{I}_{t_i}. \tag{3}$$

Equation (3) assumes that S_{t_i}, the last quoted stock price (a few minutes) before t_i, does not include the information in option trades over the time interval (t_{i-1}, t_i). Whereas the stock prices eventually must contain the information in option trades, it is reasonable to assume that the process involves a small delay. We analyze only the most active options to ensure that the effect of information in option trades is not mitigated by the simultaneous presence of S_{t_i} in equation (3). Table V lists twenty stocks underlying the most active options during March and April 1985. The average time between successive quotes for the most active option on each of these stocks each day is given in the second column of Table V.[10] The typical time interval is five minutes, which will later be shown to be less than the time it takes for stock prices to reflect the impact of option floor activity.

[10] Thus, for ALS (Allied Stores), $W_{t_i} - W_{t_{i-1}}$ was measured as the change in price between successive quotes for ALS/6/55 (call with June expiration and exercise price of $55) on March 21, which happened to be the most active option for the day. On March 22, ALS/6/60 prices were used since it was now the most active option, etc.

Over small intervals, the second term in equation (3),

$$r(W_{t_{i-1}} - \Delta_{t_{i-1}} S_{t_{i-1}})(t_i - t_{i-1}),$$

is much smaller than the other terms and can be dropped.[11] Next, we decompose the information in option trading activity over the interval (t_{i-1}, t_i) as follows:

$$I_{t_i} = I^+_{t_i} - I^-_{t_i}, \tag{4}$$

where $I^+_{t_i}$ and $I^-_{t_i}$ are the total information in option trades over (t_{i-1}, t_i) that would benefit from an increase and a decrease in the stock price, respectively. Because an option trader possessing positive information about the stock price buys calls or sells puts, I_{t_i} is aggregated over all related (i.e., any of the multiple options written on the same stock) buyer-initiated call and seller-initiated put trades. We denote the number of such trades over the time interval (t_{i-1}, t_i) by $N^+_{t_i}$. Similarly, $I^-_{t_i}$ is aggregated over the $N^-_{t_i}$ trades which all benefit from a decrease in the stock price (namely, all related buyer-initiated put and seller-initiated call trades). Trades in the upper half of the last quoted spread are treated as buyer-initiated and those in the lower half as seller-initiated. Finally, to allow for the possibility of information being a function of the trade size, we specify the information content of the jth option trade as $\beta_1 + \beta_2 v_j$ (a log specification is tried later), where v_j is the trade size and β_1 and β_2 are constants. Then,

$$I^+_{t_i} = \sum_{j=1}^{N^+_{t_i}} (\beta_1 + \beta_2 v_j) = \beta_1 N^+_{t_i} + \beta_2 V^+_{t_i},$$

and

$$I^-_{t_i} = \sum_{j=1}^{N^+_{t_i}} (\beta_1 + \beta_2 v_j) = \beta_1 N^-_{t_i} + \beta_2 V^-_{t_i}. \tag{5}$$

Because information is measured by aggregating trades in several related but different options on the stock and because every trade may be going to a different dealer, the specification in equation (5) will also abstract from inventory-related price changes. Equation (3) can now be modified to

$$[W_{t_i} - W_{t_{i-1}}] - \Delta_{t_{i-1}}(S_{t_i} - S_{t_{i-1}}) = \beta_0 + \beta_1(N^+_{t_i} - N^-_{t_i}) + \beta_2(V^+_{t_i} - V^-_{t_i}) + \epsilon_{t_i}. \tag{6}$$

Let

$$y_{t_i} = (W_{t_i} - W_{t_{i-1}}) - \Delta_{t_{i-1}}(S_{t_i} - S_{t_{i-1}}), \quad N_{t_i} = N^+_{t_i} - N^-_{t_i}, \quad \text{and} \quad V_{t_i} = V^+_{t_i} - V^-_{t_i}.$$

Then,

$$y_{t_i} = \beta_0 + \beta_1 N_{t_i} + \beta_2 V_{t_i} + \epsilon_{t_i}. \tag{7}$$

[11] In the Black and Scholes framework, the stock price follows a geometric diffusion process described by $dS = \mu S\, dt + \sigma S \xi \sqrt{dt}$, where S is the stock price, μ and σ are diffusion parameters, and ξ is a normal random variable. As $dt \rightarrow 0$, the second term on the right-hand side becomes much larger than the first one. Therefore, over small periods, dS and dW are the order of $\sigma S \sqrt{dt}$. It can also be shown that $r(W - \Delta S)dt$ (continuous-time version of the second term in equation (3)) equals $rKe^{-rt}N(d_2)dt$, which is of a lower order than dS or dW over small intervals (i.e., as $dt \rightarrow 0$).

Table V

Adverse Selection in Option Trades

This table estimates the adverse information conveyed by an option trade on the CBOE. The dataset consists of twenty of the most active CBOE stocks during March and April 1985. Suppose that a bid-ask quote for the option in question is recorded at time t_{i-1} and the next quote is recorded at t_i. The change in option price after accounting for the change in stock price is given by $y_{t_i} = (W_{t_i} - W_{t_{i-1}}) - \Delta_{t_i}(S_{t_i} - S_{t_{i-1}})$, where W, S, and Δ represent the option price, the stock price, and the option delta. N_{t_i} (V_{t_i}) represents the number of option trades (option contracts) over (t_{i-1}, t_i) that would benefit from an increase in the stock price minus trades (contracts) that would benefit from a decrease in the stock price. Assuming that adverse information increases linearly with the option trade size, the first regression in Panel A tests the following model:

$$y_{t_i} = \beta_0 + \beta_1 N_{t_i} + \beta_2 V_{t_i} + \epsilon_{t_i}.$$

Finding β_2 to be insignificant, the second regression in Panel B tests

$$y_{t_i} = b_0 + b_1 N_{t_i} + e_{t_i}.$$

The third regression in Panel C tests the same specification as the second regression, but only over the period from three days before to one day after an earnings announcement. Coefficients are estimated using the OLS technique, but the t-statistics are calculated using Hansen's (1982) correction. Intvl gives the average length of the period (t_{i-1}, t_i) in minutes.

Stock		Panel A				Panel B			Panel C		
STK	Intvl	β_0	β_1	β_2	R^2	b_0	b_1	R^2	b_0	b_1	R^2
ALS	8.00	−0.0022	0.0028	0.000009	0.0057	−0.0023	0.0029	0.0056			
		−1.30	2.84*	0.95		−1.33	3.00*				
ARC	9.11	−0.0002	−0.0002	0.000081	0.0091	0.0022	0.0014	0.0020			
		−1.61	−0.16	1.69		1.24	1.44				
BMY	8.48	0.0018	0.0017	−0.000042	0.0047	0.006	0.0014	0.0036			
		0.49	3.03*	−1.94		0.61	2.52*				
C	4.08	0.0128	0.0018	−0.000045	0.0232	0.0123	0.0019	0.0320	−0.0010	0.0038	0.0699
		6.45	3.62*	−2.68*		6.61	4.09*		−0.74	5.27*	
CBS	1.86	−0.0007	−0.0002	0.000131	0.0037	−0.0009	0.0014	0.0011			
		−0.82	−0.17	2.34*		−1.05	2.00*				
EK	4.73	−0.0007	0.0010	−0.000014	0.0031	−0.0007	0.0009	0.0029			
		−1.42	2.26*	−0.75		−1.31	2.13*				0.0039
F	3.84	−0.0013	0.0010	−0.000003	0.0042	−0.0014	0.0010	0.0042	−0.0007	0.0014	
		−2.67	2.83*	−0.19		−2.88*	3.34*		−0.74	1.50	

Table V—*Continued*

Stock		Panel A				Panel B			Panel C		
STK	Intvl	β_0	β_1	β_2	R^2	b_0	b_1	R^2	b_0	b_1	R^2
GD	9.37	0.0004	0.0013	0.000117	0.0041	0.0005	0.0021	0.0023			
		0.20	1.15	1.64		0.30	2.01*				
GM	3.32	0.0006	0.0040	−0.000012	0.0777	0.0015	0.0033	0.0564	−0.0000	0.0005	0.0016
		0.85	5.60*	−0.50		1.91	4.92*		−0.00	0.89	
GW	9.31	0.0114	0.0016	0.000006	0.0015	0.0011	0.0017	0.0015			
		3.88	0.85	0.09		3.87*	1.02				
HON	5.76	0.0016	0.0006	0.000144	0.0053	0.0014	0.0019	0.0021	−0.0025	0.0035	0.0050
		1.70	0.50	2.29*		1.52	1.65		−1.12	1.25	
HWP	5.24	0.0001	0.0007	0.000020	0.0025	0.0001	0.0008	0.0022			
		0.15	1.57	1.00		0.10	2.03*				
IBM	2.15	−0.0026	0.0019	0.000001	0.0282	−0.0025	0.0019	0.0252	−0.0005	0.0002	0.0003
		−3.60	8.11*	0.09		−3.49*	8.74*		−0.35	0.44	
ITT	4.71	−0.0004	0.0003	0.000029	0.0048	−0.0005	0.0007	0.0020	−0.0005	0.0002	0.0004
		−0.68	0.72	2.61*		−0.86	1.83		−0.46	0.36	
PEP	8.67	−0.0008	−0.0001	0.000092	0.0022	−0.0011	0.0005	0.0006	−0.0000	−0.0015	0.0069
		−0.47	−0.12	1.88		−0.69	1.08		−0.00	−2.19*	
RCA	5.35	−0.0009	0.0010	0.000027	0.0036	−0.0010	0.0012	0.0023			
		−1.18	2.00*	1.90		−1.28	2.40*				
REV	8.24	0.0016	0.0008	0.000030	0.0061	0.0014	0.0011	0.0044			
		1.60	1.69	1.79		1.46	2.52*				
ROK	8.34	0.0047	0.0011	0.000084	0.0023	0.0045	0.0016	0.0018	−0.0020	0.0046	0.0141
		2.34	0.79	0.74		2.28*	1.27		−0.13	2.01*	
SY	3.11	−0.0008	0.0012	−0.000001	0.0035	−0.0007	0.0013	0.0013			
		−1.00	2.35*	−0.57		−1.00	2.72*				
XRX	10.45	0.0007	0.0002	0.000015	0.0003	0.0005	0.0003	0.0002	0.0019	0.0001	0.0001
		0.78	0.29	0.37		0.56	0.55		1.01	0.07	

* Significant at the 5 percent level.

We estimated equation (7) using the ordinary-least-squares (OLS) technique. Because future values of regressors N_{t_i} and V_{t_i} may be correlated with current residuals, we obtained the unbiased t-statistics using Hansen's (1982) correction. Detailed estimates of equation (7) are presented in Panel A of Table V, but the $\hat{\beta}_1$ and $\hat{\beta}_2$ values are summarized below:

	$\hat{\beta}_1$ values	$\hat{\beta}_2$ values
Positive and significant at 5%	9	3
Positive but insignificant	8	11
Negative but insignificant	3	5
Negative and significant at 5%	0	1

The null hypothesis, $\beta_1 = 0$, can be rejected, but $\beta_2 = 0$ cannot be rejected. $\hat{\beta}_2$ is generally insignificant, although positive more often than negative, which can be explained by the positive correlation between V_{t_i} and N_{t_i}. An alternative specification of the information content of option trades as $[\beta_1 + \beta_2 \log v_j]$ leads to even less significant β_2 values (not reported). Combined with evidence from Section I, the null hypothesis of no correlation between trade size and adverse selection for CBOE options cannot be rejected.

Because β_2 is not significantly different from zero, V_{t_i} is dropped from equation (7). The following model results:

$$y_{t_i} = b_0 + b_1 N_{t_i} + e_{t_i}. \tag{8}$$

Panel B of Table V presents OLS estimates of equation (8). All values of $\hat{b}_1$ are now positive, and 13 out of 20 t-statistics are larger than 2.00. The average $\hat{b}_1$ value is \$0.0015, implying that 85 net trades, which are all bullish (bearish) on the stock, would increase (decrease) the option price by an eighth of a dollar. Because the change in option price equals delta times the change in stock price, nearly 40 trades would be required to change the underlying stock price by an eighth of a dollar. Forty average-sized option trades represent the right to buy or sell 320 round lots of stock. In comparison, Glosten and Harris (1988) found that the asymmetric information is proportional to trade size for NYSE stocks and that roughly 120 round lots of stock are required to create the price effect of an eighth. The asymmetric information in option trades appears to be quite small.

If stock prices respond very quickly to options activity, then b_1 understates the information in option trades. We infer the likely downward bias in b_1 as follows. First, we re-estimate equation (8) using alternate quotes instead of successive quotes, thereby doubling the time interval to an average of ten minutes. In 15 out of 20 cases, b_1 declines, suggesting that, over a period of ten minutes, some of the information in option trades does become a part of the stock price. Next, we estimate the same equation over the period from three days before to one day after an earnings announcement, when the information in trades is likely to be higher and, because of increased activity, the time interval between quotes is likely to be shorter. Panel C of Table V shows the results for the nine stocks which had an earnings announcement during this period. These results suggest that there is no further increase in b_1 values. The comparison was extended to another eleven stocks with similar results.

As b_1 does not increase with further shortening of the time interval, the downward bias in b_1 values estimated using successive option quotes should be small. Other important contingent claims, such as the S&P 500 futures contract, tend to be in disequilibrium with their underlying securities over longer periods of time, offering opportunities for program-trading activity.[12] Stock prices are unlikely to reflect information conveyed by option trades so fast that stocks and options are in equilibrium at all times.

The above results suggest that the CBOE options market is not dominated by information traders. Although the asymmetric information in option trades is statistically significant, it is small and uncorrelated with trade size. The adverse-selection half-spread averages 0.15 cents for twenty of the most active options. For this sample, the effective spread (transitory plus adverse-selection) was 14 cents. Apparently, asymmetric information cannot explain the large magnitude of option spreads. That asymmetric information is also independent of trade size is surprising, although it confirms our earlier finding that large trades are not motivated by superior information. Theoretical models by Kyle (1985) and Glosten (1987) suggest that informed investors will trade large blocks of securities before their information becomes public. At present, there is no satisfactory explanation for the observed independence of trade size and information.[13]

IV. Summary

This paper provides estimates of the CBOE options market liquidity. Comparing the liquidity of the CBOE options and the NYSE stocks shows that a tradeoff exists between the two major dimensions of liquidity: market depth and bid-ask spreads. On one hand, the CBOE options market is highly liquid, in the sense that large trades can be absorbed without a change in the prevailing prices. On the other hand, stock and option bid-ask spreads are nearly equal, even though an average option is equivalent to a levered position in less than half of a stock and costs one-tenth as much as the stock. This tradeoff between the two major dimensions of liquidity is explained by the CBOE's market mechanism. Multiplicity of dealers on the CBOE leads to greater market depth because prices do not change unless all dealers have skewed inventories. However, substantial costs are incurred by the CBOE dealers because multiplicity of dealers also leads to higher fixed costs (opportunity cost of dealers' time) and higher variable costs

[12] See Harris (1989) and Stoll and Whaley (1988) for evidence on relative pricing of the S&P 500 futures contract and the underlying stocks.

[13] However, a recent theoretical model of competitive market-making under asymmetric information by Chang (1989) may offer an explanation. Chang shows that the difference in informational impact of large and small trades decreases as the number of dealers increases. He points out that the dealers are required to post firm bid and ask quotations for minimum-size orders, but they usually negotiate the prices for large orders. The informed traders in his model want to trade large quantities but find it advantageous to first trade small quantities with dealers at their posted prices. Since the informed traders' ability to trade small orders at favorable prices increases with the number of dealers, the dealers correctly perceive that many small orders are motivated by the same quality of information as large orders.

(reduced ability to balance inventory). The heterogeneity of options compounds these costs. Furthermore, institutional arrangements on the CBOE prevent dealers from handling limit orders, which are a substantial source of revenue to the NYSE specialist. The large option bid-ask spreads reflect both the substantial costs of market-making on the CBOE and the limited sources of dealer revenue.

If only market depth and market spread were considered, the CBOE would appear to be better equipped than the NYSE to handle large trades. Since bid-ask spread is the major transaction cost facing small traders, they would appear to be better off under the NYSE specialist system. Other factors, such as the preferred investment horizon and the desired leverage, may of course affect the choice.

This paper also shows that information trading has only a small influence on the liquidity of the CBOE options and that the information content of option trades does not increase with trade size. That option dealers charge only a small premium to recover losses inflicted by informed traders suggests that the options market is not dominated by informed traders. What many option traders consider to be superior information may be just a different opinion.

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