Potential Competition and Actual Competition in Equity Options
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# Potential Competition And Actual Competition In Equity Options

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## I. Introduction

Trading in most individual stock options takes place on the exchange holding an exclusive franchise on that particular option. The process by which these rights are granted is known as the "allocation plan" and it is sanctioned by the SEC.

This study is an examination of the economic effects of this allocation plan. Specifically, the bid ask spread is compared for those options governed by the allocation plan—single listed options—with those that can be traded on more than one exchange—multiple listed options. These multiple listed options fall into two categories. The "old" multiple listed options have been traded on several exchanges since 1977. In the second category are options on OTC stocks. These options have been multiple listed since their introduction in June 1985.

There is a strong tendency for the trading of an option to become dominated by one exchange. It has therefore been considered an open question whether elimination of the allocation plan, and allowing the multiple listing of options, could yield benefits to investors. This issue is addressed by contrasting the following two points of view:

(i): the traditional viewpoint, which maintains that effective competition depends upon the number of actual competitors and their respective market shares; and
(ii): the recent "contestable markets" viewpoint which maintains that effective competition depends only upon the ease of entry and exit in the market, and not upon the number of actual competitors or their market shares.

To test for which of these two viewpoints is correct, a model of bid ask spreads is developed to examine the cost of transacting in options. The results show that options eligible for multiple listing have significantly lower spreads despite having virtually all their volume on a single exchange. This study provides evidence for the following conclusions:

(i): The multiple listing of options can produce significant investor benefits even when there is high concentration of trading volume on a single exchange.

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(ii): The theory of contestable markets is given strong general support.
(iii): The allocation plan imposes substantial costs upon investors. The estimated cost of the allocation plan exceeds 150 million dollars annually.

A survey of previous research in bid ask spreads is presented in Section II. Section III outlines a specification for bid ask spreads in options markets. Section IV describes the data and sampling procedures, and the results are presented in Section V. Section VI examines the implication of these results for the theory of contestable markets. Concluding comments are offered in Section VII.

## II. Previous Research in Bid Ask Spreads

The previous research on bid ask spreads has shown that spreads are negatively related to trading volume and competition, and positively related to security price. Theoretical models with these implications have been developed by Stoll (1978) and by Ho and Stoll (1981). Empirical support from the equity markets for these hypotheses comes from Demsetz (1968), Tinic (1972), Tinic and West (1972), Benstron and Hagerman (1974), and Branch and Freed (1978).

The models by Stoll and by Ho and Stoll predict that price volatility should increase spreads since specialists require compensation for bearing risk. The empirical evidence on this point is mixed. Studies by Benstron and Hagerman, and by Branch and Freed, find a positive relation between volatility and spreads, but studies by Tinic, and by Tinic and West obtain insignificant results.

A second class of models relates the bid ask spread to informational differences between specialists and traders. The models by Copeland and Galai (1983) and by Glosten and Milgrom (1985) formalize the logic set forth in Bagehot (1971). In these models, the dealer sets the bid ask spread to reflect a tradeoff between profits from liquidity traders and losses to informed traders. While this is a difficult empirical issue, an attempt to estimate these effects is contained in Harris and Milgrom (1986).

There are two empirical studies that examine the effect of competition in options markets. A recent study from the Directorate of Economic and Policy Analysis at the Securities and Exchange Commission, focuses on the effect of multiple listing in the recent OTC options. This study shows that spreads on the OTC options—after controlling for price, volatility, and volume—are 19.8 percent lower than single listed options.

The second study is the Special Study of Options Markets. Conducted by the SEC in 1978, this study examined options spreads both before and after the start of multiple listing in 1977. The SEC found a 28 percent reduction in mean spreads for six options where CBOE initiated trading in AMEX options. This effect, however, is exaggerated because the measurement ignores changes in options price, volatility, and trading volume. Assuming that price and volatility were not appreciably different in these two periods, then the increase in trading volume and short term below cost pricing accounted for roughly one half of the reduction in spreads. The pure effect of multiple listing was to decrease spreads by 10 to 20 percent.

Many of the previous empirical studies of transaction costs contain estimation problems which require their results to be interpreted with caution. Serial correlation and heteroskedasticity are seldom discussed. Most studies use volatility measures based on transaction prices. This induces a spurious positive correlation between volatility and spreads. Since transactions typically occur at the bid or the ask, a wider spread generates a greater computed volatility, independent of true security risk.

A more fundamental criticism of all these studies is their potential for selection bias: the reason some securities are competitively traded at several exchanges is precisely because these securities generate great interest. These popular securities may have lower spreads than single listed securities, even if they were not multiply listed. This selection bias can cause the benefits from increased competition to be overstated. The effects from multiple listing occur simultaneously with the benefits from a more active market.

In addition, existing studies pay insufficient attention to the interactions between volume and competition. For sufficiently high volume, spreads are reduced to the minimum bid ask spread, independent from the effect of multiple listing. Failure to recognize this interaction makes it difficult to separate the pure effect from multiple listing from the effects of volume.

To design a powerful test of the economic effects of multiple listing, special attention is given to the sample design. This analysis abstracts from the optimization process that determines the bid and ask prices. These processes are assumed to be the same for all options and that differences in spreads—conditional on holding price, volume, and volatility constant—are due to multiple listing.

## III. A Model of Bid Ask Spreads

*Theory of Contestable Markets*

This study develops a model of bid ask spreads that is based on the theory of contestable markets.[1] This theory emphasizes the competitive effect of potential, not actual, competition.

A market which is perfectly contestable requires one essential characteristic: both entry and exit from a market must be economically costless. Any investment costs incurred in the entry process can be recovered upon exit. This means a firm can enter and exit from an industry in a hit-and-run fashion. If a firm sees a profit opportunity, the firm can quickly enter the market, make a profit, and exit when conditions become unfavorable.

This characteristic produces an equilibrium where prices are reduced to marginal cost. Any price above marginal cost will induce another firm to enter the market and make a profit, while charging less than the current market price. In the limit, this pressure drives the price down to marginal cost.

In the case of a natural monopoly, potential competition forces a monopolist to set the price equal to the average cost. This is the minimum price that allows

[1] This theory is formally developed in Baumol, Panzar, and Willig (1982). Good overviews are presented in Spence (1983), Baumol (1982), and Baumol and Willig (1986). Earlier treatments of this theory are contained in Fama and Laffer (1972), Demsetz (1968), and Bain (1956).

the firm to recover its costs and it will be below the monopoly price. This difference between the average cost and the monopoly price is the effect of potential competition.

The market for equity options is an excellent area to apply the theory of contestable markets. Options data is plentiful and highly accurate. Options investors have a well defined objective function: they maximize the risk-adjusted rate of return. An option traded on one exchange is a perfect substitute for the same option traded on another exchange.

Options exchanges incur minimal costs to list or delist an option. Exchanges are changing the scale of their operations, not investing in a new business line. The major cost for some exchanges is the opportunity cost of floor space. Insufficient room forces them to allocate their space to the most attractive securities. However, after the space has been allocated, the marginal costs are low. In contrast, other exchanges do not have this space constraint. In either case, there are low economic costs of entry and exit from trading options.

To capture the effects of multiple listing, the theory of contestable markets is used to develop an alternative specification of bid ask spreads. This model incorporates the effects of discrete prices and relates the option bid ask spread to the option trading volume, price, price volatility, and competition.

Discrete prices have important implications for this model. When transactions occur only at discrete intervals, the "true" bid ask spread will be less than or equal to the quoted spread. This truncation also creates a lower bound for the option. It cannot be less than the minimum spread of one-sixteenth, or 6.25 cents.

Spreads for options with a sufficiently low price or high volume approach this lower bound. This is important because some options that are competitively traded are high volume options. This high volume drives the spread toward the lower bound and masks any competitive effect from multiple listing.

The volume of trading is negatively related to bid ask spreads for two reasons. If the bid ask spread, as suggested by Demsetz, is viewed as the premium paid for immediate transactions, then greater volume increases the frequency of transactions and reduces the time a specialist will hold a position. Second, limit orders are positively correlated with volume. They directly enter the Specialist's Book and act as a substitute for his commitments.

Thus, an increase in volume will lower the spread by reducing the specialist's costs, and simultaneously attracting floor brokers. The additional competitive pressure from these brokers allows the lower costs to be reflected in lower spreads.

The effects of volume and the lower bound for spreads are illustrated by the simple model in equations (1) through (3). Let the monopolist (single listed) bid ask spread have $m$ subscript, and the competitive (multiple listed) spread have a $c$ subscript. Let $V^*$ be the volume sufficient to make the spread equal to the minimum spread. For convenience, this specification focuses on trading volume and ignores the effects of price and volatility. The spread, as a linear function of volume is

$$S_m = a_m - B_m V \qquad \text{if} \quad V < V^* \quad \text{where} \quad a_m > 0, B_m > 0 \tag{1a}$$

$$S_m = \text{minimum spread} \quad \text{if} \quad V \geqq V^* \tag{1b}$$

$$S_c = a_c - B_c V \quad \text{if} \quad V < V^* \quad \text{where} \quad a_c > 0, B_c > 0 \tag{2a}$$

$$S_c = \text{minimum spread} \quad \text{if} \quad V \geqq V^* \tag{2b}$$

Taking the difference between monopolist and competitive spreads yields:

$$(S_m - S_c) = (a_m - a_c) + (B_c - B_m)V \quad \text{if} \quad V < V^* \tag{3a}$$

$$(S_m - S_c) = \text{zero} \quad \text{if} \quad V \geqq V^* \tag{3b}$$

This simple model is quite suggestive about ways to test for competive effects in securities markets. Above $V^*$, there should be no effect of volume on spreads. Below $V^*$ there should be an effect, but this effect is a decreasing function of $V$. Since the old multiple listed options have much higher volume than the new OTC options, this model suggests the pure effects of multiple listing should be greater in the OTC options.

The level of volume where the effect of multiple listing is zero can be calculated. Setting (3a) to zero and solving yields $V^* = (a_m - a_c)/(B_m - B_c)$. This model also implies the effects from multiple listing are a decreasing function of trading volume. When $V = 0$ the difference in spreads is $(a_m - a_c)$ and the difference falls to zero when $V = V^*$.

The empirical implication of this model is the effects of multiple listing will be reflected in both intercept changes and interaction variables. The intercept shift will measure the difference between $a_m$ and $a_c$, and a volume interaction variable the difference between $B_c$ and $B_m$. Intuitively, these results come from the lower bound for both competitive and monopoly spreads. There should be no effect of multiple listing on spreads for high volume options, and a large effect for low volume options.

While this simple model allows multiple listing to increase or decrease spreads, the theory of contestable markets predicts lower spreads for the market with potential competition. This is illustrated graphically in Figure 1, which relates the bid ask spread to volume. The slope of spread against volume is flatter for the multiple listed options and the reduction in spreads from multiple listing are measured by the vertical difference between the monopolist and competitive slopes. The reduction in spreads diminish as volume rises and reach zero at $V^*$, the volume sufficient to drive spreads to their minimum value.

This model reflects a substitution effect between competitive pressures. At low volume, the dominant effect occurs from listing the option on a competing exchange. As volume rises, it becomes worthwhile for floor brokers to compete with the specialist, and competition on the floor dominates the exchange effect.

A similar truncation of the spread occurs in very low price options. Below a certain price, $P^*$, the bid ask spreads approach their lower bound. Modeling this effect as a simple linear function of price yields:

$$S = \text{minimum spread} \quad \text{if} \quad P \leqq P^* \tag{6a}$$

$$S = \text{minimum spread} + B_1 P \quad \text{if} \quad P > P^* \tag{6b}$$

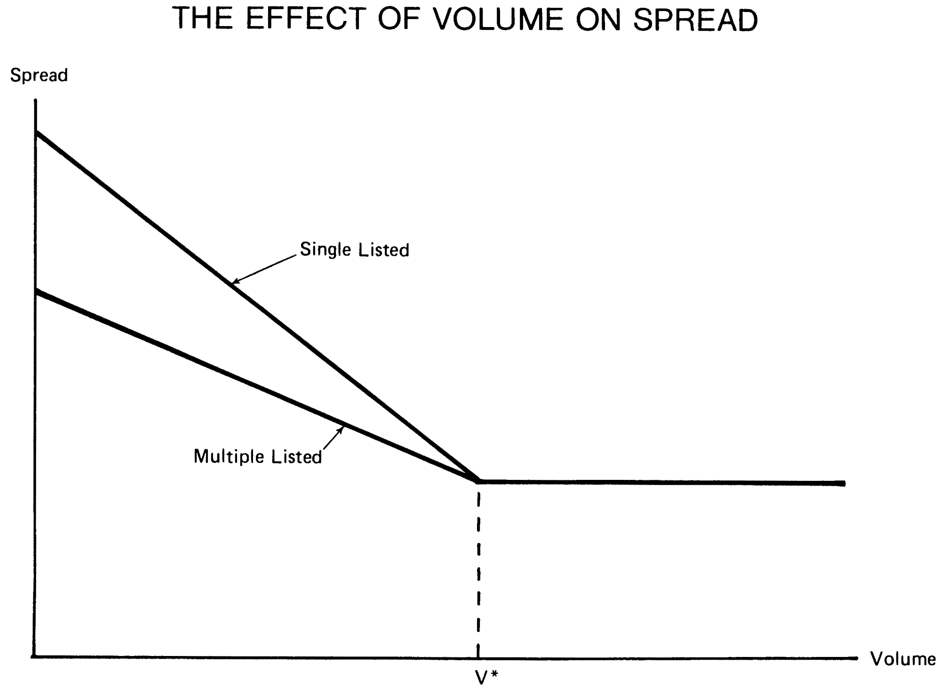


**Figure 1**

Ignoring the discreteness, the price of the option is positively correlated with the spread. This occurs because the spread is similar to the transactions fee; as the price rises, so will the fee. The empirical implication is shown in Figure 2.

The spread should be constant below $P^*$ and increase with price above $P^*$. A second interaction variable for observations below $P^*$ should have a coefficient of $-B_1$ to make the net effect equal to zero for the low price options.

The third factor to affect spreads is the standard deviation of the daily option return. If specialists are risk averse, they may require compensation for providing a liquidity service, and this will be contained in the spread. Since options market makers hold portfolios dominated by options and equity in their particular market, the standard deviation is more appropriate than measures of systematic risk.

Most empirical work has estimated the volatility from transactions prices. There are two problems with this approach. First, there are days when some options have little or no volume.

Second, volatility estimates from transaction prices will be biased. The observed sequence of transactions will oscillate around the "true" price because of the bid ask spread. Other things equal, an increase in the spread will increase the computed volatility. This induces a spurious positive correlation between the spread and volatility that is independent of security risk. With large shifts in the "true" price, this problem is diminished. However, it is a serious concern because the sample construction minimizes variation in the options price.

To obtain consistent estimates of option volatility, the Black-Scholes options pricing formula is used to compute the implied option volatility.

THE EFFECT OF PRICE ON SPREAD

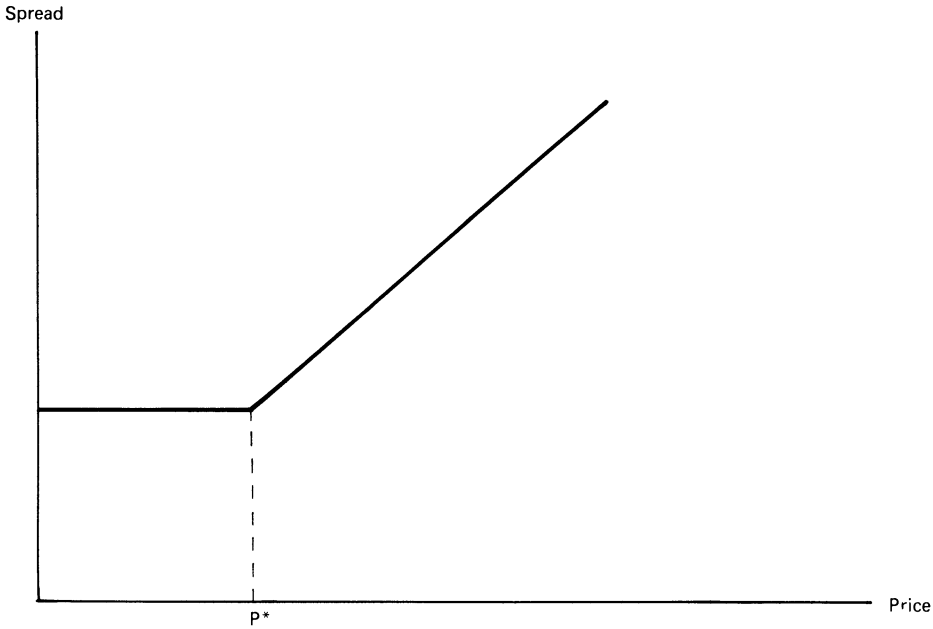


**Figure 2**

The fourth explanatory variable represents potential competition. A multiple listing dummy variable is constructed that is zero if the option is listed on a single exchange, and one if it may be listed on more than one exchange.

## IV. Data

To estimate the model, the data for the spread comes from the actual sequence of bid and ask quotes. Two important assumptions underlie the use of these quotes. First, all quotes are assumed to be good for one contract. This is the industry standard, but sometimes the quotes are implicitly good for greater volume.

The second assumption is that all quotes are valid until changed, and these quotes are "inside" quotes—the highest bid price and the lowest ask price. This assumption biases the results against finding an effect from multiple listing. An inside quote constructed from all exchanges must be less than or equal to inside quotes from any one exchange. Thus, the multiple listed spreads may be somewhat smaller than suggested by the data.

Four different functional forms are used to model the effect of volume: volume, the log of volume, the log of volume and the log of volume squared, and the square root of volume.[2] These alternative specifications allow a robust inference about the effects of multiple listing. The volume variable is the daily number of

[2] Since there are some days with zero volume, the constant 2 was added before the log transformations.

contracts traded and differs across days and across options. But, for a given day and a given option, the volume variable is identical for all quotes.

The interaction variable for volume is the volume variable times the multiple listing dummy variable. This dummy is one if the option is multiple listed and zero if single listed. This interaction variable allows—but does not require—a difference in the volume coefficients for a single listed and multiple listed options.

The price variable is the mean of the bid and ask quotes. The low-price interaction variable simply equals the price, if the price is below 50 cents, or zero if the price is above 50 cents.

The Black-Scholes options pricing model is used to compute the implied standard deviation of the option return for at the money calls. Under the joint hypothesis of efficient markets and validity of the Black-Scholes model, this method yields a consistent estimate of the standard deviation which avoids the spurious correlation between spread and volatility.

The following variables were used for inputs into the formula: the settlement price of the stock, the mean of the last bid and ask quote for the option price, and the 30 day commercial paper rate for the interest rate. With these variables the implied equity standard deviation and option delta were computed. The standard deviation of the option return was then calculated from the relation:

$$SD \text{ (option return)} = \text{stock price/call price} * \text{option delta} * \text{implied stock return standard deviation.}$$

*Sample Design*

There are two components of the research design to estimate the effects of multiple listing: model specification, and sample design. The sample is constructed to minimize the effects of price and time to maturity. This approach will cause the total explanatory power of the model to fall, but it will enhance the ability to discern a competitive effect.

The data minimizes the effects of maturity and price in two ways. First, the sample contains only near-term options that have one week until expiration. As expiration approaches, the near-term options become more active and the quality of these markets improves. This allows a more precise measure of the effects of multiple listing, especially in the low volume options where the competitive effect may be large.

Second, the sample contains only at-the-money calls. Since the effects of competition are small compared to the effects of price, selecting at the money options removes some of the variation in price, allows a better estimate of volatility, and a more precise examination of the effects of multiple listing.

To minimize any effects from differences between exchanges, the sample is restricted to options traded on AMEX. This stratification is suggested by the dominance of AMEX in both the old multiple listed options[3] and the new OTC options. The market shares for multiply traded options are presented below in Table 1.

[3] One explanation for the dominance of AMEX in the old multiple listed options is that AMEX was the dominant market before these options were multiple listed. After an exchange attains dominance, it is difficult for another exchange to attract trading volume.

**Table 1**

Market Share of AMEX Multiple Listed Options
Percent of Weekly Volume April 7–11, 1986

| Option | AMEX | CBOE | NYSE | PSE | PHLX | Weekly Volume |
|---|---|---|---|---|---|---|
| Apollo | 98.2 | 0.0 | 1.8 | 0.0 | 0.0 | 570 |
| Apple | 96.9 | 3.1 | 0.0 | 0.0 | 0.0 | 834 |
| Chi-Chi's | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1063 |
| DSC | 92.3 | 0.6 | 7.0 | 0.0 | 0.0 | 1567 |
| Intel | 93.5 | 4.4 | 0.0 | 2.1 | 0.0 | 1913 |
| Intergraph | 98.8 | 0.8 | 0.4 | 0.0 | 0.0 | 735 |
| Lotus | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 273 |
| Mylan Labs | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1555 |
| Tandem | 89.5 | 7.0 | 0.0 | 3.5 | 0.0 | 287 |
| DEC | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9150 |
| Disney | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6135 |
| Du Pont | 97.2 | 2.8 | 0.0 | 0.0 | 0.0 | 1997 |
| Merrill Lynch | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14682 |
| Amer Express | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2391 |
| Burroughs | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2785 |
| Tandy | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5834 |

Since the market for volume in options trading should not be fundamentally different from any other competitive market, the data suggests AMEX provides a superior "quality" of markets. Restricting the sample to AMEX options effectively controls for this effect.

Note the simplicity of the sample design. In this cross section of options, some are multiply listed and some are not. Both groups, however, have almost all of their trading volume on the same exchange. Holding the exchange constant, the objective is to determine whether AMEX options eligible for multiple listing have lower spreads than AMEX options that cannot trade on another exchange.

Selecting near-term, at-the-money quotes creates a sample relatively representative of the true population of options trading. Higher volume options have more quotes and thus receive a greater weight in the sample. While this is still not a random sample, it is superior to giving each option the same weight, regardless of their trading volume.

To increase the reliability of this analysis, three independent data sets are examined. The time periods cover September 9–13, 1985 with a September 21 expiration, January 9–14, 1986 with a January 18 expiration, and April 7–11, 1986 with an April 19 expiration.

The options in the sample are presented in Figure 3. There are minor differences in the options contained in the January and April samples due to ex-dividend dates.[4] The September data was on a different options expiration cycle

[4] The stock price will fall by the amount of the dividend on the ex-date. This violates an assumption of the Black-Scholes model and makes it difficult to compute the option return standard deviation. Since we possess an abundance of data, we exclude observations from firms with an ex-date prior to expiration.

*AMEX options*

| Single Listed | OTC Multiple Listed | Old Multiple Listed |
|---|---|---|
| Aetna | Apollo | DEC |
| E. F. Hutton | Apple | Disney |
| Lilly | Chi-Chi | Dupont |
| Manufacturers Hanover | DSC | Merrill Lynch |
| Motorola | Intel | Amer Express |
| Procter and Gamble | Intergraph | Burroughs |
| Ahmanson | Lotus | Tandy |
| Alaska Air | Mylan Labs | |
| American Cyanamid | Tandem | |
| Bausch-Lomb | | |
| Bell South | | |
| Chessbrough-Pond | | |
| Dart & Kraft | | |
| Goodyear | | |
| Gould | | |
| Greyhound | | |
| Phelps Dodge | | |
| Pitney Bowes | | |
| Rorer Communications | | |
| Sara Lee | | |
| Sonat | | |
| TRW | | |
| US Steel | | |
| US West | | |
| Walgreen | | |
| Warner-Lambert | | |
| Westinghouse | | |

**Figure 3**

and contains only the first six single listed and the first four multiple listed options from Figure 3.

The samples have been checked for outliers and filtered in three ways. First, about two percent of the quotes have a zero bid price and a positive ask price. This lower bound truncates the distribution and biases the spread towards zero. Consequently, observations with a zero bid price has been excluded. Second, all quotes with a spread in excess of $2.00 were excluded. It is unlikely that these are accurate quotes; they were probably generated by data entry errors. Third, firms with notable takeover or merger speculation were excluded to minimize adverse selection problems.

The data come from the Options Price and Reporting Authority, a producer of consolidated trade and quote information for the Securities Industries Automation Corporation.

## V. Empirical Results

The empirical work proceeds in three steps. The first step is to estimate the effects of multiple listing on spreads. The model in Section III suggests the effect of multiple listing will be reflected in intercept shifts and interactions with trading volume. The second step is to constrain the volume of single listed options, and investigate how the effects of multiple listing vary with volume. The third step is to examine whether wider spreads have more transactions executed inside the quotes. If this occurs, then the bid ask spread becomes less meaningful as a measure of transactions costs.

To summarize the results, there is evidence of intercept shifts and interaction effects in the direction predicted by the model. Multiple listing reduces spreads, and this reduction gradually disappears as volume rises. Both single and multiple listed options receive similar execution quality, suggesting the effect of multiple listing in AMEX options is confined to the spread.

The effect of multiple listing is estimated using equation (8).

$$\text{Spread} = \text{intercept} + B_1 \text{ volume} + B_2 \text{ volume} * DML + B_3 \text{ price} + B_4 \text{ price} * DLP + B_5 \text{ volatility} + B_6\, DML \quad (8)$$

where the variables are the following:

Spread = ask price − bid price
Volume = alternative transformations of the daily trading volume
*DML* = zero if single listed and one if multiple listed
Price = mean of bid and ask prices
*DLP* = zero if option greater than 50 cents and one if less than 50 cents
Volatility = the implied standard deviation of the option return

The results from these specifications are presented in Tables 2a through 2d. The functional forms examined for trading volume are volume, log volume, log volume and log volume squared, and the square root of volume.

*Discussion of Regression Results*

The results from these regressions are consistent with the model in Section III and previous empirical research. Demsetz (1968), Tinic (1972), Tinic and West (1972), Benstron and Hagerman (1974), and Branch and Freed (1977) have all found spreads to be negatively related to volume and measures of competition and positively related to price. In contrast, the evidence on price volatility is mixed. Some studies find significant results while others are inconclusive.

The volatility variable—the standard deviation of the option return—has an inconsistent sign and small $t$-statistics. One explanation for this result is that options specialists strive to make their portfolio delta zero. They purchase and write options in a way to immunize their portfolio from equity price movements. In contrast, equity specialists are more likely to be net long or short and make little use of options. Thus, security volatility may be more important to equity specialists than to options specialists.

**Table 2a**

The Effect of Multiple Listing Using Volume Levels

| | September | January | April | Combined |
|---|---|---|---|---|
| Intercept | .106952 | .177642 | .162529 | .167806 |
| | (4.92) | (21.89) | (15.02) | (30.61) |
| Volume | −.000052 | −.000050 | −.000056 | −.000050 |
| | (−2.05) | (−9.06) | (−7.35) | (−11.19) |
| Volume * DML | .000030 | .000044 | .000035 | .000044 |
| | (1.12) | (8.07) | (4.35) | (9.93) |
| Price | .077084 | .049938 | .052487 | .051969 |
| | (10.53) | (20.46) | (18.58) | (32.23) |
| Price * DLP | −.060394 | −.058924 | −.047246 | −.058581 |
| | (−2.70) | (−5.06) | (−4.68) | (−7.64) |
| Volatility | .005988 | −.001047 | .000297 | −.000003 |
| | (3.07) | (−2.70) | (0.34) | (−1.35) |
| DML | −.059304 | −.030006 | −.039425 | −.042204 |
| | (−3.74) | (−4.65) | (−6.50) | (−9.69) |
| Sample size | 1098 | 4678 | 4426 | 10203 |
| $R$-squared | .173 | .158 | .214 | .164 |

Note: The $t$-statistics are in parentheses.

**Table 2b**

The Effect of Multiple Listing Using Log of Volume

| | September | January | April | Combined |
|---|---|---|---|---|
| Intercept | .141537 | .247430 | .226512 | .228696 |
| | (6.66) | (18.27) | (13.54) | (26.01) |
| Log of Volume | −.011586 | −.013011 | −.016994 | −.016335 |
| | (−4.35) | (−9.57) | (−7.50) | (−12.28) |
| Log Volume * DML | −.002193 | .002031 | .004014 | .000796 |
| | (−0.56) | (1.12) | (1.30) | (0.43) |
| Price | .076465 | .053598 | .053495 | .052825 |
| | (11.62) | (23.12) | (19.10) | (34.79) |
| Price * DLP | −.064575 | −.051919 | −.050428 | −.055927 |
| | (−2.95) | (−4.51) | (−4.99) | (−7.44) |
| Volatility | .006227 | −.000825 | .000971 | −.000177 |
| | (3.53) | (−2.22) | (1.15) | (−0.56) |
| DML | −.034884 | −.015868 | −.049699 | −.016314 |
| | (−1.61) | (−0.97) | (−2.68) | (−1.44) |
| Sample size | 1098 | 4678 | 4426 | 10203 |
| $R$-squared | .226 | .186 | .214 | .192 |

Note: The $t$-statistics are in parentheses. Volume has been replaced by volume + 2.

The Price variable has a positive effect and is fully offset for the low priced options. The low price interaction variable, consistent with (6a) and (6b), has the same magnitude and opposite sign of the price coefficient. The net effect of both variables makes the correlation zero between price and spread for low priced options.

The volume of trading has a significant negative effect in all specifications. The interaction variable for multiple listed options and volume is consistent with the model in Section III. The interaction coefficients have a positive sign and predict the volume effect to be significantly less for the multiple listed options. The multiple listing dummy coefficient is always negative and significant in most specifications.

**Table 2c**

The Effect of Multiple Listing Using Log Volume and Log Volume Squared

| | September | January | April | Combined |
|---|---|---|---|---|
| Intercept | .144050 | .200287 | .158351 | .193377 |
| | (6.30) | (12.99) | (7.05) | (18.75) |
| Log volume | −.014023 | .004406 | .016326 | .002938 |
| | (−1.55) | (1.42) | (2.12) | (0.90) |
| Log Volume$^2$ | .000378 | −.001293 | −.003456 | −.002153 |
| | (0.30) | (−6.25) | (−4.54) | (−6.49) |
| Log Volume * DML | −.002614 | .006079 | .009152 | .005013 |
| | (−0.30) | (3.21) | (2.84) | (2.59) |
| Price | .077124 | .051907 | .051856 | .052459 |
| | (11.11) | (23.12) | (18.75) | (34.78) |
| Price * DLP | −.064417 | −.055538 | −.050053 | −.057893 |
| | (−2.95) | (−4.89) | (−4.98) | (−7.73) |
| Volatility | .006149 | −.000959 | .000453 | −.000207 |
| | (3.45) | (−2.61) | (0.54) | (−0.66) |
| DML | −.034162 | −.043528 | −.073504 | −.035705 |
| | (−1.57) | (−2.60) | (−3.88) | (−3.07) |
| Sample size | 1097 | 4677 | 4425 | 10202 |
| $R$-squared | .226 | .197 | .224 | .198 |

Note: The $t$-statistics are in parentheses. Volume has been replaced by volume + 2.

**Table 2d**

The Effect of Multiple Listing Using the Square Root of Volume

| | September | January | April | Combined |
|---|---|---|---|---|
| Intercept | .122029 | .202559 | .184788 | .187967 |
| | (5.88) | (22.34) | (15.54) | (31.07) |
| Root Volume | −.002943 | −.002642 | −.002497 | −.002508 |
| | (−3.53) | (−10.51) | (−8.11) | (−13.16) |
| Root Volume * DML | .000679 | .001788 | .001136 | .001580 |
| | (0.88) | (6.64) | (3.19) | (7.56) |
| Price | .074971 | .050672 | .051976 | .051977 |
| | (10.74) | (21.92) | (18.70) | (33.65) |
| Price · DLP | −.063267 | −.057012 | −.049377 | −.058580 |
| | (−2.86) | (−4.98) | (−4.92) | (−7.76) |
| Volatility | .006263 | −.001056 | .000339 | −.000313 |
| | (3.39) | (−2.81) | (0.40) | (−0.96) |
| DML | −.052526 | −.036166 | −.043908 | −.043542 |
| | (−3.07) | (−4.49) | (−5.11) | (−7.70) |
| Sample size | 1098 | 4678 | 4426 | 10203 |
| $R$-squared | .201 | .182 | .222 | .186 |

Note: The $t$-statistics are in parentheses.

*Econometric Issues*

Each of these models are corrected for a third order autoregressive process to obtain consistent estimates of the standard errors. The estimated autocorrelation and partial autocorrelation coefficients are less than .1 after a third lag and the residuals from these regressions are slightly heteroskedastic with respect to the option price.[5]

The large sample size necessitates a cautious interpretation of the $t$-statistics. On one hand, the large sample drives the standard error of the estimates towards zero and produces large $t$-statistics. This creates a problem if we have no prior for the coefficients and judge the significance of a variable by its $t$-statistic. In this case, a large sample is more likely to generate a spurious "significant" result.

On the other hand, the results are strengthened by similar estimates from independent data sets. The probability of type I errors—falsely rejecting the null hypothesis of no effect—is the product of the probabilities for each data set. This probability is a very small number for independent data sets.

The resolution of this issue is to double the $t$-statistic required for a "significant" effect[6] or use other data to form a prior for parameter estimates. Since these results are strongly consistent with previous empirical work, it is reasonable to retain the use of conventional levels of significance.

To analyze the effects of multiple listing requires both the multiple listing dummy and the interaction variable. This is illustrated in Figure 1. When volume is zero, the multiple listing dummy measures the vertical difference between the single and multiple listed spreads. The positive interaction coefficient forces the differences in spreads to narrow as volume rises.

Although the estimates vary with the specification, both implications are strongly supported by the data. The estimated reductions in spreads from multiple listing that would occur if volume were constrained to equal zero are presented in Table 3. These estimates suggest about a 20 percent[7] reduction in spreads and their approximate $t$-statistics[8] are highly significant.

In economic terms, the average low volume spread is about three and one half ticks, where a tick is one-sixteenth of a dollar. The effect of multiple listing is to reduce these spreads by about two-thirds of a tick, or about $4.00 per contract.

[5] Tests for heteroskedasticity were conducted by squaring the residuals and regressing them against the independent variables. For a summary of these tests see Judge et al. (1981). There was slight evidence that higher priced options have larger variances, but the $R$-squared from these regressions is only about .01.

[6] This can be formalized by a posterior odds ratio test. Following Zellner (1984), the large sample posterior odds ratio, as a function of the sample size and $t$-statistic, can be approximated by $K_{12} = (3.1416 * v/2)^{1/2} * \exp(-t^2/2)$. In this notation, $v$ is the degrees of freedom and $t$ is the $t$-statistic. For sample sizes equivalent to January and April, a $t$-statistic of 3.86 is needed to generate a posterior odds ratio of 20:1. In simple terms, this means we should double the $t$-statistic required for a statistically significant result.

[7] These values are computed from the ratio of the multiple listing dummy coefficient to the mean spread when volume is constrained to equal zero. The denominator of this ratio is the intercept from the regression of the spread onto volume.

[8] The statistically correct test uses the standard errors of the ratio of the coefficients. Since the $t$-statistic for the denominators is relatively large, the significance of the ratio is approximated by the significance of the numerator.

In principle, the intercept and interaction coefficients allow an estimate of $V^*$, the level of volume where the multiple listing effect disappears. These estimates are presented in Table 4. Although the median estimate is 1493 contracts per day, these estimates are very imprecise and the standard errors are huge. Accurate estimates of $V^*$ are impossible to obtain without the correct functional form for volume, and this is beyond the scope of this simple model.

The second step in the empirical analysis is to examine how the effects of multiple listing are a function of volume. These effects are illustrated by estimating equation (9).

$$\text{Spread} = \{a + B_1 \text{Logvol} + B_2 DOML + B_3 DOTC + B_4 \text{ Price} + B_5 \text{ Price} * DLP + B_6 \text{ Volatility}\} \mid SL \text{ Volume} < V_i \quad (9)$$

This differs from the previous specification in three ways. First, the multiple listing dummy is divided into two dummy variables, *DOML* for the old multiple listed options, and *DOTC* for the new OTC options. Second, the volume interaction variable is removed. Third, the model is estimated for several levels of single listed volume. The single listed volume, $V_i$, is successively truncated at 200 unit intervals.

The model in Section III predicts two effects. First, in reference to Figure 1, as the single listed volume approaches $V^*$, the effect of multiple listing should decrease and the dummy coefficients approach zero. In addition, the reduction for the low volume OTC options should exceed the high volume old multiple listed options, and the reduction for April should exceed high volume January data.

**Table 3**

Estimated reduction in spreads at zero volume

| Model | September | January | April | Combined |
|---|---|---|---|---|
| Volume | 25.8 | 14.7 | 18.5 | 21.2 |
| | (−3.74) | (−4.65) | (−6.50) | (−9.69) |
| Log Volume | 15.2 | 7.8 | 23.3 | 8.2 |
| | (−1.61) | (−0.97) | (−2.68) | (−1.44) |
| Log Volume and | 14.9 | 21.3 | 34.4 | 17.9 |
| Log Volume$^2$ | (−1.57) | (−2.60) | (−3.88) | (−3.07) |
| Root Volume | 22.8 | 17.7 | 20.6 | 21.8 |
| | (−3.07) | (−4.49) | (−5.11) | (−7.70) |

Note: The approximate $t$-statistics are in parentheses.

**Table 4**

Estimated volume for zero multiple listing effect

| Model | September | January | April | Combined |
|---|---|---|---|---|
| Volume | 1976 | 681 | 1126 | 959 |
| Log Volume | * | 2472 | 283330 | $8.1 \times 10^7$ |
| Root Volume | 5981 | 409 | 1493 | 759 |

Note: * indicates not possible to compute due to negative coefficient on the interaction variable.

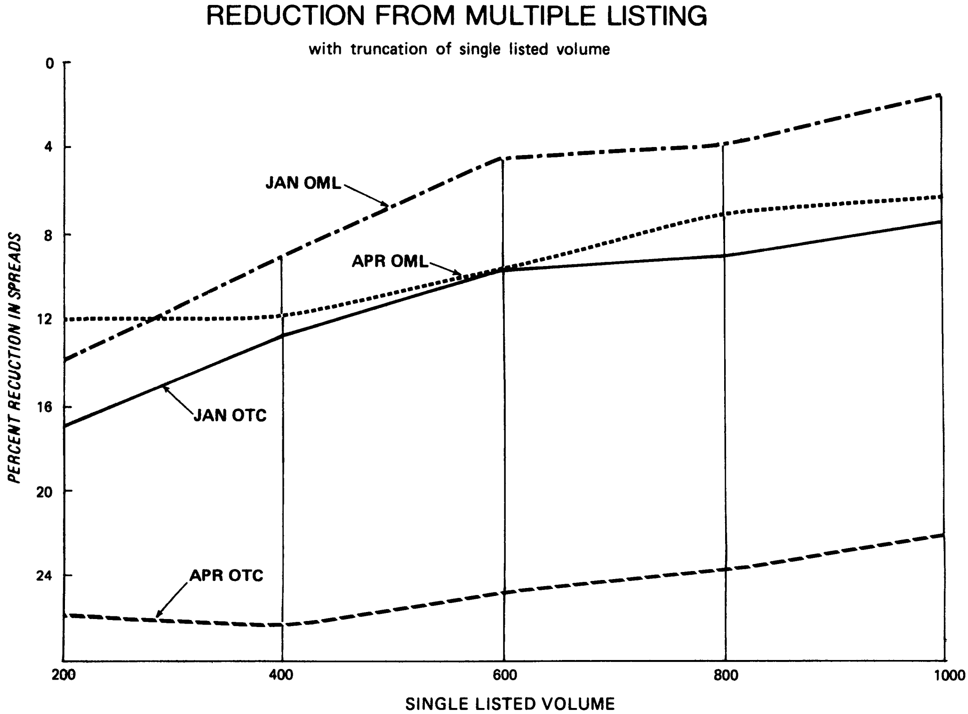


**Figure 4**

Both these implications are clear from Figure 4, which plots the reduction in spreads as a function of single listed volume. The truncation points for the single listed volume are on the horizontal axis and the estimated percentage reduction in spreads[9] are on the verical axis.

Consistent with the model in Section III, a rise in volume reduces the effect of multiple listing. The high volume January data shows a smaller effect than the lower volume April data; the high volume old multiple listed options have a lower effect than the low volume OTC options.

The third step in the analysis is to examine the relation between the quoted bid ask spread and the true cost of transacting. This is necessary for several reasons. First, since some trades occur inside the quotes, the quoted spread exceeds the bid ask spread. Second, if wider spreads have more transactions inside the quotes, then the significance of the regression results are reduced. Third, this allows an examination of non-price competition. We can determine whether the effect of multiple listing is reflected solely in the quotes, or whether the multiple listed options receive superior execution quality.

To examine this issue, a measure of execution quality is defined by

$$Z = 2 * [\text{Transaction price} - (\text{bid} + \text{ask})/2]/(\text{ask} - \text{bid}).$$

This variable is constructed from the bid and ask prices preceding each transaction. It is symmetric around zero and has a value of +1 if the transaction occurs at the ask price, and −1 if at the bid.

[9] These are computed by taking the ratio of the dummy coefficients to the mean spread.

To determine if multiple listed options have superior execution quality, both the absolute value of $Z$ and $Z^2$ were regressed onto the variables of price, low price dummy, trade size, spread, and multiple listed dummies. A second regression also included the daily trading volume and the volume times multiple listing dummy interaction variable. The results from these regressions for the combined January and April data are presented in Table 5.

The estimated coefficients from these regressions make intuitive sense. The negative coefficient on the spread reflects a greater potential for transactions inside the spread as the spread widens. The positive coefficient for price indicates that, conditioning on the size of the spread, a higher price implies a lower spread as a percentage of the price. Hence, a greater tendency for trades to be executed at the bid or the ask. Consistent with the results in Table 2, the low price interaction variable has the same magnitude an opposite sign as the price variable. While the size of the trade is negatively correlated with transaction efficiency, there was no effect from the volume of trading.

These results suggest the competitive effect from multiple listing is confined to the spread itself. The coefficients for the multiple listing dummies are either negative or positive, depending on the specification but in neither case are they significant. The data is consistent with the hypothesis that all AMEX options receive similar execution quality.

### *Selection Bias*

An important issue is whether the data contain a sample selection bias. While estimates of the effect of multiple listing are conditional on volume, some additional selection criteria might be related to volume. For example, some of

**Table 5**

Transactions Efficiency of Multiple Listed Options
Dependent Variable

| | Absolute Value of $Z$ | | $Z$ Squared | |
|---|---|---|---|---|
| Intercept | .97793 | .99624 | 1.05572 | 1.01629 |
| | (77.97) | (67.04) | (47.79) | (40.11) |
| Price | .10980 | .10891 | .17258 | .16972 |
| | (17.85) | (17.34) | (15.93) | (15.37) |
| Price * DLP | −.12139 | −.10206 | −.14445 | −.07745 |
| | (−3.65) | (−3.02) | (−2.47) | (−1.30) |
| DML | .00022 | −.01267 | .00229 | −.02325 |
| | (0.02) | (−1.10) | (1.36) | (−1.15) |
| Trade size | −.00038 | −.00040 | −.00020 | −.00028 |
| | (−4.30) | (−4.53) | (−1.32) | (−1.81) |
| Spread | −2.6516 | −2.5956 | −3.5671 | −3.3754 |
| | (−39.35) | (−36.19) | (−30.05) | (−26.77) |
| Volume | — | .000001 | — | .000010 |
| | | (0.50) | | (0.87) |
| Volume * DML | — | .000003 | — | .000005 |
| | | (0.79) | | (1.70) |
| Sample size | 9702 | 9702 | 9702 | 9702 |
| $R$-squared | .145 | .146 | .089 | .093 |

Note: The $t$-statistics are in parentheses.

the old multiple listed options are among the most active options. These options might have lower spreads than single listed options even if they were not multiply listed. The multiple listing dummy would then contain two effects: the reduction from multiple listing, and from the superior "quality" of option.

One approach to this issue is to examine the equity market for the multiple listed options. The equity value, and dollar volume of equity trading for the multiple listed options are presented in Table 6. If there is a selection bias, the criteria that induced the exchanges to select these options are likely to be related to these measures.

Table 6, however, suggests the absence of a selection bias. Although the equity value and dollar volume of trading for the old multiple listed options are greater than the single listed options, the single listed options are, in turn, greater than the OTC options.[10] Since the effects of multiple listing are concentrated in the low volume options, these criteria suggest the results are unlikely to be driven by a selection bias.

A second result that suggests the absence of selection bias is obtained from the Special Options Study. In 1978 the SEC examined the bid ask spread of six options three months before, and three months after the initiation of multiple listing. In each of these options, AMEX was the dominant market and CBOE attempted to gain trading volume from AMEX. Since the same group of options were examined both before and after multiple listing, there was no selection bias. The only effect is the additional competitive pressure from multiple listing.

The difficulty with the 1978 SEC analysis is the focus on mean spreads. They find a 28 percent reduction in spreads, but do not allow for changes in volume, volatility, and option price. Using the data contained in the Special Study in conjunction with the estimated coefficients from Table 2, the increase in volume accounts for about one fourth of this reduction in spreads. In addition, it appears that spreads were artificially low for a short period around the initiation of multiple listing. Incorporating both these effects lowers the reduction in spreads to the 10 percent to 20 percent range. The similarity of results between the Special Study and this study suggest the effect of multiple listing is not driven by a selection bias.

*Estimating the Cost of the Allocation Plan*

The annual cost of the Allocation Plan to investors is estimated to be at least 150 million dollars annually. This cost, based on conservative estimates, is computed by

$$\text{Cost} = (\text{reduction in spreads}) * (\text{fraction of single listed volume}) * (\text{effective spread}) * (\text{mean spread})/2 * (\text{dollar volume of options trading})$$

The reduction in spreads from multiple listing is computed by assuming there is a 20 percent reduction at zero volume, and this reduction diminishes linearly until volume reaches 1500 contracts per day. Above this level there is no effect. Using the trading volume for *all* single listed options for the week of April 7–11,

[10] The most relevant measure is the dollar volume of equity trading, which should be invariant to the share price.

**Table 6**

Equity Characteristics of Listed Options

| | Single Listed | Multiple Listed | |
|---|---|---|---|
| | | *OTC* | *Old* |
| 1985 Mean Equity Value (Billions of dollars) | 4.16 | 1.04 | 8.57 |
| 1985 Mean Dollar Volume of Equity Trading (Billions of dollars) | 2.51 | 2.43 | 7.21 |

1986, the estimated reduction from multiple listing is 11.6 percent,[11] and single listed trades comprise 87 percent of total volume.

The estimated effective spread is .667. This is computed from the mean absolute value of $Z$ and indicates that options investors only pay two thirds of the quoted spread.[12] In addition, the mean spread is assumed to be 15 percent of the price of the option. This estimate is likely to be too small. In this study, the mean spread is 21 percent of the option price. And finally, the dollar value of options trading (both calls and puts) in 1985 was 30 billion dollars.[13]

This approach, however, seriously underestimates the true cost of the allocation plan because it ignores competitive effects across exchanges. If one exchange is more efficient, then options specialists and market makers face competition, not just from another market, but from the lowest cost market. This is important because the initial estimates suggest that AMEX spreads are lower than CBOE.[14] Since CBOE has 50 percent of the market in equity options, the dollar amount of this effect can be large.

## VI. Potential Competition vs. Actual Competition

An important policy issue is the distinction between actual and potential competition. Elimination of the allocation plan is likely to impose significant costs on some industry participants. This may be difficult to justify if the benefits are temporary, and the outcome is invariant to the allocation plan. Alternatively, if there is a continual effect from potential competition, the costs are identical but the benefits from elimination of the allocation plan are much greater.

While there are likely to be temporary effects from active competition, signifi-

[11] It can be argued that this reduction is too high or too low. This may underestimate the reduction in spreads because the estimate is computed from the ratio (dummy coefficient)/(mean spread | volume = 0). The estimated effect is greater because the denominator in this ratio falls as volume increases from zero. Alternatively, it may overestimate the effect because this sample contains some low volume in the money and out of the money options. These options may have lower spreads than predicted by this analysis if the at the money option is very active.

[12] The realized effective spread may be sightly lower due to inventory adjustment by the specialist and trades executed without the participation of the specialist.

[13] This data is from the February 1986 SEC Monthly Statistical Review. It should be noted this data includes both calls and puts. Although our analysis is based on calls, we see no difficulty in applying our results to put options.

[14] These results will be explored in future study by the Office of the Chief Economist.

**Table 7**
The Effect of Multiple Listing by Volume

| | September | January | April |
|---|---|---|---|
| Intercept | .104414 | .277874 | .401270 |
| | (4.75) | (13.71) | (12.01) |
| Log of Volume | −.014239 | −.025497 | −.036680 |
| | (−5.59) | (−10.18) | (−9.59) |
| Price | .100203 | .051533 | .033204 |
| | (13.17) | (17.26) | (6.08) |
| Price * DLP | −.095607 | .009958 | −.037887 |
| | (−2.87) | (0.51) | (−2.02) |
| Volatility | −.009587 | −.000745 | −.002666 |
| | (4.59) | (−1.38) | (−1.60) |
| DML | −.039569 | .016484 | .007955 |
| | (−3.70) | (1.62) | (0.81) |
| Sample size | 1077 | 1697 | 1677 |
| $R$-squared | .247 | .294 | .229 |
| Mean volume | 529 | 3840 | 1340 |

Note: The $t$-statistics are in parentheses.

cant support for the continual effects from potential competition comes from two sources. First, the study by the Directorate of Economic and Policy Analysis found the market share of the dominant exchange in the OTC options rose from about 75 percent to 95 percent from June 1985 to March 1986. Despite the decline in market share of competitors, the effect of multiple listing was to reduce spreads by about 20 percent in each period.

Additional support for the effect of potential competition is obtained by examining the old multiple listed options for several different volume levels. According to the actual competition hypothesis, there should be no effect from multiple listing because the dominant market receives virtually all the trading volume. Alternatively, the potential competition hypothesis predicts there will be no effect at high volume and a large effect at low volume. These results are presented in Table 7.

For the ten options contained in the September data,[15] the mean volume level is 3840 for January, 1340 for April, and 529 for September. Using a specification without an interaction term, multiple listing has an effect only for low volume options. These estimates show positive and insignificant coefficients for the high volume January and April data, and a significant negative effect for the low volume September data.

## VII. Summary

The objective for this study is to make an economic assessment of the options allocation plan. This plan gives an options exchange an exclusive franchise for trading a particular option. Uisng the bid ask spread as a measure of transactions cost, AMEX options eligible for listing on multiple exchanges have significantly

[15] The multiple listed options are DEC, Disney, Du Pont, and Merrill Lynch. The single listed options are Aetna, E. F. Hutton, Lilly, Manufacturers Hanover, Motorola, and Procter and Gamble.

lower transaction costs than AMEX single listed options. The competitive effect of multiple listing is confined to the size of the spread and is concentrated in low volume options. As volume rises, the bid ask spread approaches the minimum spread and makes it difficult to discern an effect from multiple listing.

This study emphasizes the theory of potential, not actual competition and provides empirical support for the theory of contestable markets. The effect of multiple listing persists long after the introduction of a competitor and despite the heavy concentration of trading volume in a single market.

Allowing options to be multiply listed reduces the bid ask spread by about 20 percent for low volume options and this competitive effect disappears when volume rises to roughly 1500 contracts per day. The estimated cost to investors of the allocation plan to exceeds 150 million dollars annually.

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