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The Impact of Options Trading on the Market Quality of the Underlying Security: An Empirical Analysis

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ABSTRACT

We find that option listings are associated with a decrease in the variance of the pricing error, a decrease in the adverse selection component of the spread, and an increase in the relative weight placed by the specialist on public information in revising prices for the underlying stocks. We also find that there is a decrease in the spread and increases in quoted depth, trading volume, trading frequency, and transaction size after option listings. Overall, our results suggest that option listings improve the market quality of the underlying stocks.

THIS STUDY EMPIRICALLY examines the impact of stock option listings on several aspects of the market quality of the underlying stocks. The motivation for this examination is to provide new and comprehensive evidence on whether stock options, in particular, and derivative securities, in general, have a beneficial or a harmful effect on the market for the underlying securities.

We show that the previously documented decrease in the bid–ask spread following option listings is accompanied by an increase in the number of contracts the specialist is willing to trade at the quoted prices (quoted depth). Furthermore, the spread decreases and the depth increases even after controlling for changes in trading volume, volatility, and price. Lower spread and higher depth together provide unambiguous evidence of higher liquidity, and suggest that larger trades can be executed at lower transaction costs after option listings. Consistent with this, we find that the increase in trading volume after option listing is a combined effect of higher trading frequency and larger average transaction size.

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We find that the adverse selection component of the bid–ask spread decreases for the underlying stocks after option listings using the method developed in George, Kaul, and Nimalendran (1991).[1] Also, using the model developed by Madhavan and Smidt (1991), we find that the relative weight placed on public information by the specialist in the price revision process increases after option listings. These findings suggest that the level of information asymmetry and/or informed trading decreases for the underlying stocks following option listings. Finally, employing the method developed in Hasbrouck (1993), we find that the variance of the pricing error (defined as the difference between the efficient price and the observed price) decreases for the underlying security. This lower variance of the pricing error is evidence of greater pricing efficiency and improved market quality.

We repeat our tests for two subsamples based on the prelisting market capitalization of the underlying stock. We expect that the beneficial impact of option listings will be greater for lower market capitalization stocks because this sample is likely to have lower liquidity, lower trading volume, higher information asymmetry, and lower pricing efficiency prior to option listings. Consistent with this, we find that the impact of option listings is generally greater for lower market capitalization stocks.

Overall, the results of this paper suggest that option listings have a beneficial impact on the quality of the market for the underlying stocks in terms of higher liquidity, lower information asymmetry, and greater pricing efficiency. In the next section, we present the theoretical arguments for the impact of option listing on the underlying market, and discuss the existing evidence. Section II provides the description of the sample. In Section III, we present the empirical results. Section IV concludes.

I. Effect of Options on the Underlying Stocks

Option listings may have a beneficial impact on the quality of the underlying asset market for several reasons. First, as suggested by Ross (1976) and Hakansson (1982), options improve the efficiency of incomplete asset markets by expanding the opportunity set facing investors. This, in turn, suggests that options reduce the volatility of the underlying stock.

Second, option listings may cause informed traders to migrate to the options market. In a model developed by John, Koticha, and Subrahmanyam (1993) informed traders migrate to options markets on the listing of options because they view options as superior speculative vehicles. This superiority of options stems from their inherent leverage and their ability to avoid short

[1] The adverse information component of the spread arises in a market that consists of informed and liquidity (uninformed) traders. In this framework, the marketmaker expects to lose on trades with the informed traders, and sets the bid–ask spread to maximize the difference between the expected gain from transactions with liquidity traders and the expected loss from transactions with informed traders. See Bagehot (1971), Copeland and Galai (1983), and Glosten and Milgrom (1985) for more details.

sale restrictions on the stocks.[2] The reduction in the proportion of informed traders in the underlying market lowers the adverse selection costs of the marketmaker, thereby lowering the spread and improving liquidity.

Finally, options may improve the efficiency of the underlying market by increasing the level of public information in the market. Specifically, the marginal benefit of becoming informed after the introduction of options is greater given the superiority of options as a speculative vehicle. This increase in marginal benefit results in a greater information search by traders. In turn, this increase in public information lowers information asymmetry, lowers the spread, improves liquidity, and reduces the variance of the pricing error, thereby making the underlying market more efficient.

On the other hand, it has been suggested that derivative markets have a destabilizing effect on the underlying market. The rationale behind this argument is that the existence of derivative securities allows institutional investors to take large positions in both the derivative and the underlying markets to take advantage of price discrepancies. This large volume of trading, in turn, creates price pressures in the underlying security and increases the volatility in the underlying market. There is also some concern that derivatives may exacerbate the volatility in the underlying market during periods of higher uncertainty such as the October 1987 crash.

Previous studies have found that the bid–ask spread and the volatility of returns decline, and the trading volume increases after the listing of options.[3] This is evidence that the existence of options improves the liquidity of the underlying market. Our study extends the results of previous studies in several ways. First, we examine quoted depth in addition to the spread. Second, we examine trading frequency and average transaction size in addition to trading volume. Finally, we examine the effect of option listings on pricing efficiency and the level of information asymmetry by analyzing its impact on the variance of the pricing error, the adverse selection component of the spread, and the revision in price resulting from a trade. Thus, this investigation provides comprehensive evidence on the impact of derivative securities on the underlying market.

II. Sample

The starting point of our sample is all stocks that have an option listed on either the American Stock Exchange (Amex), the Chicago Board Options Exchange (CBOE), the New York Stock Exchange (NYSE), the Pacific Stock

[2] It has also been argued that options are superior because they have lower transactions costs. However, the empirical evidence in Vijh (1990) is not consistent with this argument since bid–ask spreads on the CBOE and NYSE are nearly identical even though the extent of information-related trading on the CBOE is small.

[3] See, for example, Conrad (1989), Damodaran and Lim (1991), DeTemple and Jorion (1990), Fedenia and Grammatikos (1992), Schultz and Zaman (1991), and Skinner (1989). However, Harris (1989) shows that the S&P stock return volatilities are not economically different from a matched set of stocks after listing of index futures and index options.

Table I

Option Listing Dates for Sample Firms: 1983–1989

Yearly frequency distribution of listings of options traded on the American Stock Exchange (Amex), the Chicago Board Options Exchange (CBOE), the New York Stock Exchange (NYSE), the Pacific Stock Exchange (PSE), or the Philadelphia Stock Exchange (PHLX) in the period 1983 to 1989. The sample also meets the following criteria: (a) the underlying stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, (b) there is no stock split in the 250-day period around the listing, and (c) there are no other listed options on the stock at the time of the listing.

Year	Amex	CBOE	NYSE	PSE	PHLX	Total	Number of Independent Dates
1983	4	5	0	3	2	14	5
1984	3	2	0	4	1	10	9
1985	7	4	3	4	8	26	19
1986	3	3	1	7	7	21	17
1987	9	14	16	11	12	62	24
1988	12	7	6	4	4	33	18
1989	1	3	1	2	1	8	7
Total	39	38	27	35	35	174	99

Exchange (PSE), or the Philadelphia Stock Exchange (PHLX) from 1983 to 1989. From this group, we exclude all stocks that split in the 125-day period before and after the listing date to avoid distortions in our analysis arising from dual trading in both presplit and when-issued shares. We also exclude all stocks that already have options listed on another exchange at the time of listing on the new exchange. Finally, to enable us to obtain information on volume, transaction size, transactions frequency, price, bid–ask spread, and depth, we require the underlying securities to have data available on the Institute for the Study of Security Market (ISSM) transaction database for 250 trading days around the listing date. The final sample consists of 174 listings.

We provide the distribution through calendar time of our sample of option listings in Table I. Approximately 82 percent of the listings in our sample occur in the four years 1985 through 1988, with 1987 contributing 36 percent. Notice that the exchanges tend to list a number of options on the same day, so the 174 listing dates comprise only 99 calendar dates.

III. Results

A. Impact of Option Listings on Liquidity

If options have a beneficial impact on the market quality of the underlying asset, we should observe an improvement in the liquidity of the underlying stocks after option listings. Most previous studies use the bid–ask spread as a measure of liquidity without examining the depth (number of shares that the marketmaker is willing to trade) at the bid and the ask quotes. Lee, Mucklow, and Ready (1993) show that the bid–ask spread and depth are jointly determined with an increase in quoted depth, ceteris paribus, indicating an improvement in liquidity. They suggest that an observed change in either the spread or the quoted depth, without any associated information on the behavior of the other parameter, is an ambiguous signal for inferring changes in liquidity. Therefore, we examine the impact of option listings on the quoted depth in addition to the spread.

We examine the impact of option listing on the underlying stock's bid–ask spread and quoted depth using a method similar to that used for the examination of the volatility impact of these events in Skinner (1989).[4] Specifically, we obtain all quoted bid–ask spreads and depths, and the amount of time each quote is valid in the 100-day prelisting (day −125 to day −26 relative to the listing date) and the 100-day postlisting (day +26 to day +125 relative to the listing date) periods for each underlying stock in our sample. Then, for each day, we estimate the daily relative bid–ask spread as the weighted average of all relative spreads in a day, where the weight is the amount of time the quote is valid. The relative bid–ask spread is the difference in the ask and the bid prices divided by the average of the bid and ask prices. The bid–ask spread ratio for a particular stock is defined as the ratio of the median daily relative bid–ask spread in the postperiod divided by the median daily relative bid–ask spread in the preperiod. A ratio greater than one implies an increase in the bid–ask spread. The depth ratio is calculated in an identical manner using an average of quoted depths at the bid and the ask.

We report the bid–ask spread and the depth ratios for the underlying stocks around the listing of options in Table II. The second column contains the results for the spread, and the third column presents the corresponding figures for depth. We find that the bid–ask spread decreases by a median value of 9.9 percent. This decline in the spread is significant at the 0.1 percent level in a Wilcoxon signed-rank test. Additionally, the quoted depth increases by a median value of 4.8 percent, which is also significant at the 0.1 percent level. Taken together, the decrease in the spread and the increase in depth provide unambiguous evidence of an improvement in liquidity in the underlying stock market.

B. Impact of Option Listings on Order Flow

Lower spread and greater quoted depth associated with option listings should be accompanied by higher trading volume. Specifically, a lower transaction cost (spread) should encourage trading activity and higher depth would allow traders to trade in larger blocks. Thus, trading volume should increase as a result of greater trading frequency and a higher average transaction size. Therefore, we examine changes in order flow using three variables: standardized trading volume, trading frequency, and average transaction size.

[4] Although the focus of this paper is on microstructure impacts of listings, we also analyze the behavior of volatility around these events to ensure that our sample is similar to those used in previous studies. We find, consistent with previous studies, that volatility decreases significantly after listings. Specifically, the median change in volatility for our sample is −12.4 percent.

Table II

Impact of Option Listing on the Liquidity of the Underlying Stock

Relative bid–ask spreads and depth ratios for a sample of 174 underlying stocks that have an option listed in the period 1983 to 1989. The sample also meets the following criteria: (a) the underlying stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, (b) there is no stock split in the 250-day period around the listing, and (c) there are no other listed options on the stock at the time of the listing. The relative bid–ask spread on a stock is defined as the ratio of the difference between the ask and bid price to the average of the ask and bid price. Depth is the average of the number of shares the marketmaker is willing to trade at the bid and the ask. The bid–ask spread ratio is the median value of the weighted average of all bid–ask spreads (depth) quoted on each day in the period starting 26 days and ending 125 days after listing divided by the median value of the weighted average of all bid–ask spreads (depth) quoted on each day in the period starting 125 days and ending 26 days before listing. The weight used is the amount of time the quote is valid. The average daily relative spread in the prelisting period is 0.90 percent. The average daily depth in the prelisting period is 7,767 shares.

	Bid–Ask Spread Ratio	Depth Ratio
Mean	0.948	1.165
Median	0.901	1.048
Proportion of stocks with increases in the postlisting period	0.35	0.57
One-tailed signed rank probability for change in the postlisting period	0.00	0.01

Standardized trading volume is the daily trading volume on the stock under consideration divided by the average trading volume on all stocks listed on the Center for Research in Security Prices (CRSP) Daily Master File for the day. Trading frequency is the average number of trades per day, and transaction size is the average number of shares sold/purchased in a transaction. The method for estimating the postlisting to prelisting ratios is identical to that used in the previous section.

We provide statistics on the ratios of these three variables around option listings in Table III. We find that standardized trading volume increases significantly by a median value of 2.0 percent around option listings (p-value of 0.01).[5] In addition, trading frequency increases by a median value of 6.7 percent and average transaction size increases by a median value of 3.9 percent. Overall, the results of this section show that the increase in trading volume associated with option listings is a combined result of higher trading frequency and higher average transaction size. These results provide further confirmation of the hypothesis that the option listings have a beneficial impact on the liquidity of the underlying market.

[5] The mean and median values of standardized trading volume ratio differ considerably because of two stocks in our sample that have extremely low prelisting trading volume. The mean value excluding these two stocks is 1.26.

Table III

Impact of Option Listing on the Order Flow in the Underlying Stock

Standardized trading volume, trading frequency and transaction size ratios for a sample of 174 underlying stocks that have an option listed in the period 1983 to 1989. The sample also meets the following criteria: (a) the underlying stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, (b) there is no stock split in the 250-day period around the listing, and (c) there are no other listed options on the stock at the time of the listing. Standardized trading volume is defined as the trading volume divided by the average trading volume on the same day for all stocks listed on the CRSP Daily Master File. Trading frequency is the number of trades per day. Transaction size is defined as the number of shares purchased/sold in a transaction. The ratio is the median value of the measure of order flow under consideration in the period starting 26 days and ending 125 days after listing divided by the median value of the same variable in the period starting 125 days and ending 26 days before listing. The mean prelisting values for standardized trading volume, trading frequency, and transaction size are 0.135 percent, 71 trades per day and 1,400 shares, respectively.

	Standardized Trading Volume Ratio	Trading Frequency Ratio	Transaction Size Ratio
Mean	5.168	1.867	1.226
Median	1.020	1.067	1.039
Proportion of stocks with increases in the postlisting period	0.54	0.60	0.52
One-tailed signed rank probability for change in the postlisting period	0.01	0.00	0.02

C. Cross-Sectional Analysis of the Change in Liquidity

Existing literature suggests that changes in spread and depth may be a result of changes in trading volume, volatility of returns, and price levels. In particular, several studies show that spread decreases with increases in trading volume, decreases in volatility, and increases in the price level, but that depth is positively related to trading volume and negatively related to price and volatility.[6] Many factors besides option listing may cause these determinants of spread and depth to change. To account for that, we estimate regressions with the changes in spread and quoted depth as dependent variables, and changes in volume, price, and volatility as independent variables. The results of these regressions tell us whether the changes can be completely explained by changes in price, volume, and volatility. More important, these regressions correct for any biases in the univariate results caused by events unrelated to listing, and strengthen the power of tests by accounting for idiosyncratic changes in covariates. The regressions are estimated using the Seemingly Unrelated Regression (SUR) framework because the

[6] See, for example, Choi and Shastri (1989), Copeland and Galai (1983), Glosten and Milgrom (1985), Harris (1994), and Stoll (1978).

error terms for the two equations are likely to be negatively related (see Lee et al. (1993)). The two equations are:

$$\log SpreadRat_j = \beta_{S0} + \beta_{S1} \log VolumeRat_j + \beta_{S2} \log PriceRat_j + \beta_{S3} \log VarianceRat_j + \epsilon_{Sj} \tag{1}$$

and

$$\log DepthRat_j = \beta_{D0} + \beta_{D1} \log VolumeRat_j + \beta_{D2} \log PriceRat_j + \beta_{D3} \log VarianceRat_j + \epsilon_{Dj}, \tag{2}$$

where $\log SpreadRat_j$ is the natural logarithm of the postlisting to prelisting spread ratio for stock j, and $\log VolumeRat_j$, $\log PriceRat_j$, $\log VarianceRat_j$, and $\log DepthRat_j$ are the corresponding natural logarithms of the postlisting to prelisting volume, price, variance, and depth ratios.[7] Based on previous work, we would expect β_{S1} and β_{S2} to be negative and β_{S3} to be positive. Similarly, we would expect β_{D1} to be positive and β_{D2} and β_{D3} to be negative.

The results of the estimation of equations (1) and (2) are presented in Table IV. All coefficients have the anticipated sign and are statistically significant. Additionally, the intercept in the spread equation is negative and significant, and in the depth equation it is significant and positive. This suggests that the bid–ask spread decreases and quoted depth increases even after controlling for changes in volume, volatility, and price.

To check for the robustness of our results, we also construct the depth-to-spread ratio (*DepSpr*) for each stock. This measure encompasses both aspects of the quote. We then estimate an ordinary least squares regression, where the dependent variable is the natural logarithm of the postlisting to prelisting ratio of *DepSpr* and the independent variables are the same as in equations (1) and (2). The estimated equation is:

$$\begin{aligned} \log DepSpr = {} & \underset{(0.03)}{0.07} + \underset{(0.00)}{0.50} \log VolumeRat \\ & + \underset{(0.01)}{0.40} \log PriceRat - \underset{(0.00)}{0.31} \log VarianceRat \end{aligned} \tag{3}$$

The adjusted R^2 for this equation is 0.45, and the p-values are in parentheses.

Again the intercept term is significantly positive and suggests that the liquidity in the underlying stock improves because of a fundamental change in the characteristics of the underlying security induced by the introduction of the options.

[7] The variance ratio is the ratio of postlisting to prelisting variance of returns estimated using the midpoint of bid and ask quotes instead of transaction prices. The variance of returns using the quote midpoint does not contain a bid–ask bounce component.

Table IV

The Relationship between Changes in Liquidity, Order Flow, Price, and Volatility

Seemingly Unrelated Regression (SUR) estimates from cross-sectional regressions of the following form:

$$\log SpreadRat_j = \beta_{S0} + \beta_{S1} \log VolumeRat_j + \beta_{S2} \log PriceRat_j + \beta_{S3} \log VarianceRat_j + \epsilon_{Sj}$$

and

$$\log DepthRat_j = \beta_{D0} + \beta_{D1} \log VolumeRat_j + \beta_{D2} \log PriceRat_j + \beta_{D3} \log VarianceRat_j + \epsilon_{Dj},$$

where log *SpreadRat* is the natural logarithm of the ratio of the relative bid–ask spread in the period starting 26 days and ending 125 days after listing to the period starting 125 days and ending 26 days before the listing. log *VolumeRat*, log *PriceRat*, log *VarianceRat*, and log *DepthRat* are the corresponding natural logarithms of the postlisting to prelisting ratios for daily trading volume divided by average daily trading volume for all stocks listed on the CRSP Daily Returns File, price per share, volatility of returns based on the average of the bid and ask prices, and depth, respectively. The sample includes 174 underlying stocks that have an option listed in the period 1983 to 1989 and also meets the following criteria: (a) the underlying stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, (b) there is no stock split in the 250-day period around the listing, and (c) there are no other listed options on the stock at the time of the listing. The p-value for one-tailed test of the null hypothesis that the coefficient is zero is in parentheses.

	Dependent Variables		
Independent Variables	log *SpreadRat*		log *DepthRat*
Intercept	−0.031		0.040
	(0.00)		(0.09)
log *VolumeRat*	−0.103		0.397
	(0.00)		(0.00)
log *PriceRat*	−0.767		−0.359
	(0.00)		(0.00)
log *VarianceRat*	0.110		−0.199
	(0.00)		(0.00)
System weighted R^2		0.799	
Cross-equation correlation		−0.624	
		(0.00)	

D. Impact of Option Listings on the Adverse Selection Component of Bid–Ask Spreads

The introduction of options can reduce the level of information asymmetry and/or the level of informed trading in the underlying stock, allowing marketmakers to reduce the adverse selection component of the spread (as a fraction of the total spread). To test this hypothesis, we estimate the adverse selection component of the spread, using the method developed by George et al. (1991) (hereafter, GKN (1991)). In the GKN method, the components of the spread are estimated using a two-step procedure. In the first step, the effective spread is estimated as $EstSpread = 2\sqrt{-\text{Cov}}$, where Cov is the serial covariance of the difference between returns based on transaction prices and returns based on the bid price quoted subsequent to the time of this transaction price. In the second step, the order-processing component of the spread is estimated as the slope coefficient of a regression of the effective spread on the quoted spread. The estimate of the adverse selection component of spread is one minus the slope coefficient of this regression.

We first estimate the effective spread ($EstSpread_{jt}$) for each stock in both the prelisting and postlisting periods ($t = 1, 2$) using intraday data.[8] We then estimate the following regression:

$$\begin{aligned} EstSpread_{jt} = {} & \gamma_0 + \gamma_1 QuotedSpread_{jt} + \gamma_2 OptDum_{jt} \\ & + \gamma_3 (QuotedSpread_{jt} \times OptDum_{jt}) + \epsilon_{jt}, \end{aligned} \tag{4}$$

where $QuotedSpread_{jt}$ is the median of the last quoted bid–ask spread at 1:00 p.m. for stock j over the prelisting and postlisting periods, and $OptDum$ takes on a value of 0 before, and 1 after listing. In this estimation, there are only two observations per stock, one each for the prelisting and postlisting period. Our primary interest is in γ_3, the estimate of the postlisting change in the slope coefficient of the regression. A positive γ_3 implies an increase in the proportion of the bid–ask spread determined by order processing costs, which, in turn, suggests a decrease in the adverse selection component of spread.

We provide the estimates of the coefficients of equation (4) in Table V. The results indicate that listings are associated with a decrease in the adverse selection component although the change is only marginally significant with a p-value of 0.08.[9] The result is more significant for the sample of firms with market capitalization less than the median of the complete sample. Specifically, for this group of firms, the estimate of γ_3 has a value of 0.898 and is significant at the 1 percent level. Option listings are not only followed by a lower spread, but also with a smaller fraction of the lower spread being determined by adverse selection costs. These results suggest that the advent of options trading results in a lower level of information asymmetry and/or a lower level of informed trading in the underlying market.

[8] In the estimation of the effective spread, transaction price returns are based on the last transaction as of 1:00 p.m., and bid returns are based on the first bid quoted after this transaction price. The use of the 1:00 p.m. transaction price avoids any problems associated with end-of-day trading biases. However, the results are not qualitatively different when closing quotes and prices are used. The effective spread cannot be estimated if the serial covariance is positive. None of the estimated serial covariances were positive for our sample of stocks.

[9] The coefficient γ_1 can be interpreted only if it is less than or equal to one. The estimated value of γ_1 in Table V is significantly less than one.

Table V

Impact of Option Listing on the Adverse Selection Component of Bid–Ask Spread

Ordinary least squares (OLS) estimates of coefficients from cross-sectional regressions of the following form:

$$EstSpread_{jt} = \gamma_0 + \gamma_1 QuotedSpread_{jt} + \gamma_2 OptDum_{jt} + \gamma_3 (QuotedSpread_{jt} \times OptDum_{jt}) + \epsilon_{jt}$$

$$j = 1, \ldots, n \wedge t = 1, 2$$

where $EstSpread_{jt} = 2\sqrt{-\text{Cov}}$, where Cov is the serial covariance of the difference between the returns based on transaction prices and the return based on bid-to-bid prices, $QuotedSpread_{jt}$ is the median of the last quoted bid–ask spread at 1:00 p.m. for stock j in prelisting (t = 1) and postlisting (t = 2) period, and *OptDum* takes on a value 1 after listing and 0 otherwise. The sample includes 174 underlying stocks that have an option listed in the period 1983 to 1989 and also meets the following criteria: (a) the underlying stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, (b) there is no stock split in the 250-day period around the listing, and (c) there are no other listed options on the stock at the time of the listing. The p-value for one-tailed test of the null hypothesis that the coefficient is zero is in parentheses.

γ_0	γ_1	γ_2	γ_3	Adj. R^2
0.205	0.754	−0.139	0.242	0.254
(0.10)	(0.00)	(0.24)	(0.08)	

E. Impact of Option Listings on the Weight Placed on Public Information

An alternative technique for measuring the impact of option listings on information asymmetry in the underlying market is based on a model for intraday security price movements developed by Madhavan and Smidt (1991). In this model, marketmakers use Bayesian rules to update their beliefs about the expected value of the stock. The expected stock value is represented as a combination of the prior mean (based on public information) and a revision due to a noisy signal based on private information contained in the current order flow. The relative weight placed on prior beliefs (public information) is then inversely related to the degree of information asymmetry in the market. We estimate the following version of the reduced form model for the revision in transaction price using trade-by-trade data in both the prelisting and postlisting periods:

$$\Delta P_{jt} = \beta_{1j} q_{jt} + \beta_{2j} D_{jt} - \beta_{3j} D_{jt-1} + \epsilon_{jt} - Z_j \epsilon_{jt-1}, \tag{5}$$

where ΔP_{jt} is the revision in price at trade t, q_{jt} is the signed transaction size, D_{jt} equals +1 for a buy and −1 for a sell, and there is first-order auto-

Table VI

Impact of Option Listing on the Weight Placed on Public Information

The ratio of weight placed on public information (PRIOR) for a sample of 174 underlying stocks that have an option listed in the period 1983 to 1989. The sample also meets the following criteria: (a) the underlying stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, (b) there is no stock split in the 250-day period around the listing, and (c) there are no other listed options on the stock at the time of the listing. The weight placed on public information (PRIOR) is calculated using the Bayesian model for intraday price movements developed in Madhavan and Smidt (1991). The prelisting value for this variable is 0.774. The reported ratio is the value of PRIOR in the postlisting period starting 26 days and ending 125 days after listing divided by the value of PRIOR in the prelisting period starting 125 days and ending 26 days before listing.

Mean	1.041
Median	1.023
Proportion of stocks for which PRIOR increases	0.62
One-tailed signed rank probability for change in PRIOR in the postlisting period	0.01

correlation in the error term.[10] The relative weight placed by the market-maker on public information is estimated as $PRIOR_j = \beta_{3j}/\beta_{2j}$. Madhavan and Smidt (1991) show that $PRIOR_j$ is inversely related to the level of information asymmetry in the market. This follows from the fact that in a market with a lower level of information asymmetry, each trade conveys less new information to the specialist, and therefore has a lower impact on the price revision. This will result in a lower value of β_{2j} relative to β_{3j}, and therefore a higher value of $PRIOR_j$.

The above model is estimated in the prelisting and postlisting periods for each stock in the sample. We would expect the values of *PRIOR* to be higher in the postlisting period if the advent of options trading causes a decrease in the level of information asymmetry in the underlying stock market.

We provide the results on the ratio of the weight placed on public information (*PRIOR*) around option listings in Table VI. We find that *PRIOR* increases by a median of 2.3 percent after listings, suggesting that market-makers place relatively lower weight on the information contained in the most recent trade in determining the new price. The increase in *PRIOR* is significant at the 0.01 level and supports the hypothesis that the advent of options trading results in a lower level of information asymmetry in the underlying stock market.

[10] The classification of a buy or a sell follows that used in Lee and Ready (1991). The original model in Madhavan and Smidt (1991) also includes terms for the specialists' current and lagged inventory as two additional explanatory variables. However, they find that the coefficients on these variables are generally insignificant. The exclusion of these variables is unlikely to have any significant effect on our results.

F. Impact of Option Listings on the Variance of the Pricing Error

Hasbrouck (1993) suggests that an overall measure of market quality is the variance of the pricing error (defined as the difference between the observed price and the efficient price), with lower variance implying a market of higher quality. A decrease in the variance of the pricing error would be evidence of greater pricing efficiency.

The analysis of market quality is based on the vector autoregression (VAR) representation of the price revision and trade process suggested in Hasbrouck (1991). In this model, the transaction price, p_t, is defined as the sum of the true price, m_t, and a term that embodies microstructure imperfections, s_t. The efficient price is assumed to evolve as a random walk; i.e., $m_t = m_{t-1} + w_t$, where the innovations w_t reflect updates to the public information set and have the properties $Ew_t = O$, $Ew_t^2 = \sigma_w^2$, $Ew_t w_T = O$, *for* $t \neq T$. A measure of market quality is then defined as the variance of the pricing error $s_t(\sigma_s^2)$.

To measure σ_s^2, Hasbrouck uses a VAR model for revisions in transaction price, $r_t(p_t - p_{t-1})$, and trade attributes, x_t, (e.g., the signed square root of the volume of trade) defined as:

$$r_t = a_1 r_{t-1} + a_2 r_{t-2} + \cdots + b_1 x_{t-1} + \cdots \nu_{1,t} \tag{6}$$

$$x_t = c_1 r_{t-1} + c_2 r_{t-2} + \cdots + d_1 x_{t-1} + \cdots \nu_{2,t}, \tag{7}$$

where the error terms are mean zero and serially uncorrelated with $\mathrm{Var}(\nu_{1,t}) = \sigma_1^2$, $\mathrm{Var}(\nu_{2,t}) = \Omega$, and $E(\nu_{1,t}, \nu_{2,t}) = 0$. The vector moving average (VMA) representation corresponding to the VAR model is:

$$r_t = \nu_{1,t} + a_1^* \nu_{1,t-1} + \cdots + b_0^* \nu_{2,t} + b_1^* \nu_{2,t-1} + \cdots \tag{8}$$

$$x_t = c_0^* \nu_{1,t} + c_1^* \nu_{1,t-1} + \cdots + \nu_{2,t} + d_1^* \nu_{2,t-1} + \cdots. \tag{9}$$

In this framework, market quality is defined as

$$\sigma_s^2 = \sum_{j=0}^{\infty} [\alpha_j^2 \sigma_1^2 + \beta_j \Omega \beta_j'], \tag{10}$$

where

$$\alpha_j = -\sum_{k=j+1}^{\infty} a_k^* \quad \text{and} \quad \beta_j = -\sum_{k=j+1}^{\infty} b_k^*.$$

In the implementation of this technique, we use one trade attribute defined as $+(\text{trade volume})^{1/2}$ or $-(\text{trade volume})^{1/2}$ if the trade is above or below

Table VII

Impact of Option Listing on the Variance of the Pricing Error

The ratio of the variance of the pricing error (σ_s^2) for a sample of 174 underlying stocks that have an option listed in the period 1983 to 1989. The sample also meets the following criteria: (a) the underlying stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, (b) there is no stock split in the 250-day period around the listing, and (c) there are no other listed options on the stock at the time of the listing. The variance of the pricing error (σ_s^2) is calculated using the VAR model developed in Hasbrouck (1993). The prelisting value for this variable is 0.008. The σ_s^2 ratio is the value of σ_s^2 in the postlisting period starting 26 days and ending 125 days after listing divided by the value of σ_s^2 in the prelisting period starting 125 days and ending 25 days before listing.

Mean	0.936
Median	0.833
Proportion of stocks for which σ_s^2 increases	0.39
One-tailed signed rank probability for change in σ_s^2 in the postlisting period	0.07

the quote midpoint, five lags in the VAR model, and ten lags in the VMA representation.[11] σ_s^2 is computed for each firm in the prelisting and postlisting periods. The hypothesis that option listings improve the pricing efficiency in the underlying market suggests that σ_s^2 decreases in the postlisting period. The significance of the changes in σ_s^2 is measured using the same technique employed previously in the analysis of changes in liquidity, order flow, and information asymmetry.

We provide the results on the ratio of σ_s^2 around option listings in Table VII. The value of σ_s^2 decreases by a median value of 16.7 percent after listings, suggesting that underlying stock prices become more efficient after the advent of options trading. However, the decrease in σ_s^2 is only marginally significant with a p-value of 0.07. For the sample of lower market capitalization stocks, σ_s^2 decreases by a median value of 25.5 percent, with the decrease being significant at the 1.5 percent level. This decrease in the variance of the pricing error is consistent with the notion that the trading of options increases the pricing efficiency in the underlying market.

IV. Conclusions

This paper examines the impact of option listings on the market quality for the underlying stock. We find that option listings are associated with a decrease in the bid–ask spread and with increases in depth, trading volume, transaction size, and trading frequency. Furthermore, the spread decreases and depth increases even after controlling for the changes in variance, vol-

[11] The sign assigned to the trade attribute variable follows the technique in Lee and Ready (1991). The choice of (trade volume)$^{1/2}$ as the trade attribute is based on the observation in Hasbrouck that price changes are nonlinear and concave in the trade attribute.

ume, and price. We interpret these results as consistent with the hypothesis that the advent of options trading improves the liquidity of the underlying stock.

We also find that option listings are associated with a decrease in the adverse selection component of the underlying stock's bid–ask spread, and an increase in the weight placed on public information in revising prices. These findings are consistent with the notion that option listings result in a lower level of information asymmetry and/or a lower level of informed trading. Finally, we find that option listings are associated with a decrease in the variance of the pricing error. This reduction in the variance of the pricing error is evidence of greater pricing efficiency and of higher market quality.

Overall, the results of this paper suggest that the option listings have a beneficial impact on the market quality for the underlying stocks in terms of higher liquidity, lower information asymmetry, and greater pricing efficiency.

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