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The Behavior of Bid–Ask Spreads and Volume in Options Markets during the Competition for Listings in 1999

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ABSTRACT

In August 1999, U.S. exchanges began to compete directly for order flow in many options that had been exclusively listed on another exchange, shifting 37% of option volume to multiple-listing status by the end of September. Effective and quoted bid–ask spreads decrease significantly after multiple listings with spreads generally maintaining their initial lower levels 1 year later. These results hold for both time series and pooled regressions and are robust. We reject that economies of scale in market making cause the decrease in spreads and support the view that interexchange competition reduces option transaction costs.

IN AUGUST 1999, U.S. OPTIONS EXCHANGES began a campaign to target each other's exclusively listed stock options. The listings campaign started when the Chicago Board Options Exchange (CBOE) and American Stock Exchange (AMEX) made same-day announcements that they would list Dell Computer options (Exchanges, on one Dell swoop from CBOE . . . (1999)). Dell options were one of the highest volume option classes and previously had been listed exclusively on the Philadelphia Stock Exchange (PHLX). The PHLX responded by announcing that it would list CBOE-listed IBM, Coca-Cola, and Johnson and Johnson options and AMEX-listed Apple Computer options. Pacific Exchange (PCX) tech-oriented

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options soon became targets as well. By the end of September, listing announcements had shifted 37% of all equity option volume from single- to multiple-exchange trading. Prior to this effort, some active options were multiple listed (e.g., America Online, Yahoo, and Amazon), but the majority of options and option volume were from single-exchange listings. These events present a unique opportunity to examine how increased competition in the form of new exchange entrants affects market making in options markets.

The listings campaign and other past activities by options exchanges attracted the attention of regulators. The U.S. Justice Department filed suit against the exchanges to enjoin them from "maintaining, continuing or renewing an agreement to limit competition among themselves by not listing equity options that were previously listed on another exchange" (United States of America vs. American Stock Exchange . . . (2000) p. 2). In addition, the U.S. Securities and Exchange Commission (SEC) instituted administrative proceedings after it had "investigated significant issues relating to the competitiveness of the options market and the fulfillment by the options exchanges of their obligations as self-regulatory organizations" (U.S. Securities and Exchange Commission (2000) p. 2). The SEC release stated: "Bid–ask quotations made on respondents' markets have frequently been at the maximum allowable bid–ask spreads. The frequency of maximum spreads may indicate anticompetitive conduct" (p. 6). These actions are reminiscent of investigations of Nasdaq market makers that evolved from Christie and Schultz's (1994) research on bid–ask spreads. A basic question in their research was whether spreads were too high on many Nasdaq stocks.

This study examines whether bid–ask spreads were higher when option classes were singly listed. Consistent with equity market studies by Wahal (1997), Klock and McCormick (1999), and Boehmer and Boehmer (2002), we find that both effective and quoted bid–ask spreads decrease after trading begins on a competing exchange. For options, spreads decrease dramatically. The average decreases in effective spreads are 31.3% and 38.7% for calls and puts, respectively, across the 28 option classes investigated in this study. This decrease is immediate, reflecting a demonstrative change in market-making activity after these announcements. Furthermore, for most option classes, this change is permanent. One year later these option classes continue to trade on multiple exchanges with effective spreads still showing significant reductions from their premultiple-listing levels.

We investigate whether economies of scale have a role in reducing spreads with multiple listing. Multiple listing generated (at least temporarily) additional trading volume in the option markets. As Neal (1987, 1992) indicates, volume effects may confound the interpretation of multiple-listing effects. Option exchanges share common clearing facilities, so scale effects may arise because contracts purchased on one exchange may be sold on another exchange with minimal difficulty. In addition, with increased volume, there is an increased flow of price information across exchanges, and this may reduce information costs to market makers. If so, we might expect spreads to reflect these lower costs.

We examine whether increased volume explains the decrease in spreads after multiple listing. Total contract volume increases for many option classes after multiple listing even though volume on the original exchange often diminishes.

Consistent with Battalio, Hatch, and Jennings (2002), we find that the original exchange continues to attract the majority of order flow after entry in an option class. In time-series regressions on each option class, series volume shows no consistent effect on spreads. In pooled time-series and cross section regressions, there is a negative volume effect, but this effect does not generally diminish the effect of multiple listing. Confirming Neal (1987), the pooled results suggest that the decrease in spreads following multiple listing is larger for low volume series than for high volume series.

We also investigate whether reduced hedging costs in the primary market might be responsible for the drop in option spreads. We find that option deltas and the underlying effective spread are significantly related to the size of option spreads, suggesting that the cost of hedging plays a role in setting option spreads. However, option deltas and underlying spreads change little after multiple listing, so hedging cost reductions do not appear to be related to the decrease in option spreads following multiple listing.

This analysis builds on early studies of multiple listings in options markets. Lightfoot et al. (1986) compare 31 AMEX-listed classes that could not be multiply listed to 14 over-the-counter (OTC) stock options that were *eligible* for multiple-listing and at some point were actually multiply traded. They find quoted spreads are lower in multiply listed than singly listed options by 16.7% to 23.9% with similar results for relative effective spreads. Neal (1987) compares 27 singly listed options on the AMEX to 7 multiply listed options and 9 OTC options that are eligible for multiple listing. He finds that quoted spreads on high volume options *eligible* for multiple listing are about 20% lower, but this difference decreases with volume. He concludes that spread differences may not be due to multiple listing, but rather scale economies in market making.

More recently, Mayhew (2002) and Wang (1999) investigate multiple listing effects. Mayhew compares single- to multiple-listed options for 1986 to 1997 data and documents that multiply listed options exhibit lower spreads. He finds that quoted spreads decrease with trading volume, and that options traded by designated primary market makers have lower quoted spreads than options traded in open outcry systems. Interestingly, Mayhew shows that differences in quoted spreads between market structures do not generalize to effective spreads because open outcry systems offer greater price improvement opportunities. Wang examines similar data in selected months for CBOE-listed options, and finds quoted spreads on multiple listed option classes to be 14% lower than spreads on comparable single-listed options.

In related work, Battalio et al. (2002) find mixed evidence for integrated or national markets in exchange traded options. Using post-multiple listing data from 2000, they document that exchanges successfully compete for market share, but that quoted prices may differ significantly across exchanges. They document large numbers of trades outside the national best bid and offer (NBBO), and conclude that there could "be an advantage to linkage" of the options markets. Their results suggest that calculating effective spreads using the NBBO as a quote benchmark may not be consistent with the way the U.S. options markets actually operate. To address this concern, we use both the NBBO and same-exchange quotes in our multiple listing tests, and find substantially similar results. Thus, the lack of an integrated market does not bias our results.

The main difference between this study and these previous efforts is that we analyze the actual listing event by comparing before and after multiple listing data. This helps to minimize any omitted variable biases that may arise with earlier studies. We also investigate the longer-term change in spreads after multiple listing to determine if these changes were permanent. Furthermore, we show that hedging parameters are also determinants of option spreads, but cannot explain the decrease in spreads that follows multiple listing.

On the surface, these findings may not appear unusual because the number of exchanges listing an option class doubles, triples, or even quadruples in our sample. However, on each exchange, a large number of market makers appear to compete for order flow. For example, more than 50 PHLX market makers regularly traded Dell options before multiple listing (Some Dell option traders want to stay in the Big Apple (1998)). Despite this large number of market makers, the advent of multiple listing reduced effective spreads by an average of 33% and 44% on Dell call and put options, respectively. The magnitude of the spread reductions across all option classes provides evidence that *intra*-exchange competition is not a good substitute for *inter*-exchange competition, evidence that fragmented order flow across competing markets may offer important benefits to investors.

The remainder of this paper is organized as follows. The next section presents the circumstances leading up to the surge in multiple listings in August and September of 1999, and details the events in question. Section II discusses theories of bid–ask spreads in equity and option markets. Section III presents the data and filters used to form the sample. Section IV presents the empirical evidence for both short and long term changes in spreads and the effects of volume. Our conclusions are developed in Section V.

I. Multiple Listing History

Hill (1995) reviews how the options markets have evolved over time. Both changes in the regulatory environment and growth in the financial industry have caused these markets to innovate and adapt. The CBOE became the first SEC-approved options exchange and began trading in April 1973. Later that year, the AMEX and PHLX applied to trade stock options. The issue of multiple listings first arose with these new applications. Despite the debate at the time, the AMEX and PHLX were approved for trading with only a cursory SEC remark that each exchange ". . . did not intend initially to undertake the dual trading of options" (U.S. Securities and Exchange Commission, 1975, p. 13).

Shortly thereafter, in February 1976, the CBOE initiated the first multiple listing with PHLX-listed Boise Cascade Corp. options. In the next month, the PCX was approved for and began trading several existing options. By June 1977, 22 call option classes were multiple listed. These early listings proved challenging, however. Within 3 years, only 15 classes remained active on multiple exchanges. Classes were delisted as trading volume diminished. One explanation for the delistings is that scale economies in market making cause volume to gravitate to a single exchange.

In July 1977, the SEC asked for a moratorium on new option listings pending a study of the options markets. The *Special Study of the Options Markets* was completed in December 1978 (U.S. Securities and Exchange Commission (1978)), reporting that the multiple listing of options reduced bid–ask spreads. However, the SEC expressed concerns about fragmented markets arising from such listings and asked the exchanges to propose a plan to allocate new option classes across exchanges. The exchanges proposed a lottery system of exclusive trading rights, called the "Allocation Plan," which the SEC adopted in May 1980 (U.S. Securities and Exchange Commission (1980)).[1]

By 1985, all but 13 listed stock options had been allocated using the lottery system. Only OTC stock options (which began trading in June 1985 and were excluded from the Plan) were eligible for trading on multiple exchanges. Indeed, as interest in OTC options grew, several of these options became multiply listed. The majority of options, however, remained listed on a single exchange.

The listing environment changed 4 years later in May 1989 with Rule 19c-5 phasing out the Allocation Plan. Effective January 21, 1991, this rule prohibits exchanges from restricting the multiple listing of any option class. After various delays and phase-in rules, exchanges were free to list any option class by the end of 1994. However, Table I shows that in mid-August of 1999, trading volume in the nearly 2,900 option classes remained concentrated in singly listed options: 68% of equity options were traded on one exchange, accounting for 61% of total equity option trading volume.

The multiple listings campaign in 1999 changed the volume distribution of option market trading. By the end of September, 131 additional option classes were multiple listed, representing about 37% of the total trading volume in all options. This effect continued in the following year as the August 2000 results show. Clearly, exchanges sought higher volume option classes for multiple listing.

The listing campaign began suddenly. Once the CBOE announced the listing of Dell options on Wednesday morning, August 18, other exchanges followed suit. That same day, the AMEX made its own Dell-listing announcement. After the markets closed, the PHLX announced that it would list AMEX's Apple options, and the CBOE's Coca-Cola, Johnson & Johnson, and IBM options. The details and timing of these announcements are shown in Table II.

During the next week, the exchanges appeared to follow a tit-for-tat multiple-listing strategy. The PHLX announced 7 additional CBOE listings on August 26. The CBOE, AMEX, and PCX responded with 78 additional multiple-listing announcements the next day. The PHLX then announced 10 additional option listings on August 31, with 7 PCX options among the 10.

The business press noticed that the AMEX and CBOE had failed to list each other's options in late August (Battle for market share heats up . . . (1999)). There was speculation that, via multiple listing, these larger exchanges sought to trade

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[1] Also, U.S. Securities and Exchange Commission (1989) provides a review of the reasons for the moratorium on new option listings.

Table I

Class Count and Volume for Single- and Multiple-Listed Options

This table shows how the distribution of trading changed during the competition for multiple listings in 1999. The fraction of options listed on one, two, three, and four, or five exchange is shown for 2 days before the competition began in mid-August (8/17 and 8/18), for 2 days during the listing competition in late September (9/21 and 9/22), and for August 2000. The August 2000 data includes volume traded on the International Securities Exchange (ISE), which started operations in 2000. The listing count data in the top panel show little change due to the listings competition. However, the volume of trading data shown in the bottom panel indicate that total option volume migrated to options listed on multiple exchanges. Thus, the listings competition targeted the higher volume option classes.

	Number of Exchanges			
Period	One	Two	Three	Four or Five
Fraction of option classes listed on:				
Mid-August 1999	68%	16%	8%	4%
September 1999	64%	15%	9%	6%
August 2000	55%	23%	13%	9%
Fraction of option volume for listings on:				
Mid-August 1999	61%	15%	17%	7%
September 1999	24%	13%	28%	35%
August 2000	15%	9%	13%	63%

option classes they were not able to obtain via mergers, which had been cancelled earlier that year.[2] On September 10, soon after this press speculation, the CBOE and AMEX both made sizable, competitive listings announcements. The CBOE announced 43 new listings (36 AMEX-listed) and the AMEX announced 35 new listings (all CBOE-listed). These announcements continued, resulting in 131 new multiply listed option classes by the end of September 1999.

The exchanges listed many of the same option classes. The CBOE and AMEX both chose to list 9 of the same PHLX options and 13 PCX options. The AMEX and CBOE dual listed 71 option classes between each other. In contrast, the PCX and PHLX had dual listed only 14 option classes between each other and dual listed 91 other option classes previously listed on the AMEX and CBOE. On balance, the smaller exchanges (PCX and the PHLX) primarily sought AMEX and CBOE listings, while the AMEX and the CBOE sought options from all other exchanges.

II. Determinants of Option Spreads

Madhavan (2000) and Coughenour and Shastri (1999) review models of market making, which generally stress either inventory or asymmetric information costs as the main determinants of spreads. Stoll (1978), Amihud and Mendelson (1980),

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[2] The CBOE and PCX canceled merger plans in January 1999 citing delays caused by the Justice department inquiry; the AMEX and PHLX canceled merger plans in April 1999. See "Chicago Board Options Exchange cancels merger . . ." (1999).

Table II

Option Listing Announcements and the Affected Exchanges

The number of option classes affected by a new listing announcement are reported for the American Stock Exchange (AMEX), Chicago Board Options Exchange (CBOE), Pacific Exchange (PCX), and the Philadelphia Exchange (PHLX) on the announcement date. The distribution of these new listings across exchanges that already trade the option class is shown for each announcement. The dates of each announcement are taken from exchange news releases and business news services. Listing announcements in September are for options that were traded on more than one exchange, so the individual exchange counts may sum to more than the listing total.

		Number Previously Traded on			
Date	Announcement	AMEX	CBOE	PCX	PHLX
August 18	CBOE: Dell				1
	AMEX: Dell				1
	PHLX: Apple, Coke, IBM, and J&J	1	3		
August 26	PHLX: 7 listings		7		
August 27	CBOE: 29 listings			16	13
	AMEX: 25 listings			15	10
	PCX: 24 listings	6	16		2
August 31	PHLX: 10 listings		3	7	
September 9	PCX: 30 listings	13	18		2
September 10	CBOE: 43 listings	36		8	1
	AMEX: 35 listings		35	3	3
September 13	PCX: 25 listings	16	10		2
September 14	PHLX: 11 listings	4	7	1	

and Ho and Stoll (1981, 1983) develop models of bid–ask spreads based on inventory costs and adjustments. These models predict that bid–ask spreads decrease with trading volume and increase with price (an opportunity cost of inventory) and the volatility of the security.

Copeland and Galai (1983), Kyle (1985), Glosten and Milgrom (1985), Easley and O'Hara (1987), Admati and Pfleiderer (1992), Madhavan (1992), and Foster and Viswanathan (1994), among others develop asymmetric information models of bid–ask spreads. These models predict that, on average, market makers lose to informed traders, so spreads are sufficiently wide to offset these losses. The informativeness of the order flow therefore affects spreads.

There are relatively few models of market making in option markets. Back (1993) and Biais and Hillion (1994) develop asymmetric information models. Option spreads in these models depend on how aggressively insiders trade, which is not generally observable. John et al. (2000) focus on leverage effects and informed trading. They show that option spreads increase with more informed traders and vary inversely (directly) with margin requirements (leverage). In a similar setting, Easley, O'Hara, and Srinivas (1998) derive pooling and separating equilibria for informed traders' choice of trading venue, and derive conditions under which informed traders will specialize in either derivative or underlying markets. In their model, sufficiently wide spreads in options may cause informed traders to concentrate their trades in underlying markets.

Cho and Engle (1999) and Kaul, Nimalendran, and Zhang (2001) offer "derivative hedge" theories to relate option and underlying spreads. In this approach, market makers in options transfer inventory or information risks to the underlying market by hedging. These hedges are restricted only by the liquidity of the underlying market. Because actively traded options are typically written on liquid stocks, market makers could readily implement this strategy. The derivative hedge theory implies that bid–ask spreads in options are related to the cost of market making in the underlying asset and the degree of hedging. Specifically, the underlying spread and hedging parameters, such as delta and gamma from an option-pricing model, are expected to affect option spreads. An increase in delta is expected to positively affect call option spreads, as a larger delta requires a larger size hedge and greater underlying hedging costs. This is reversed for put options, as the sign of the put delta is negative. An increase in gamma is expected to positively affect spreads for both calls and puts. This is because a larger gamma requires the hedge to be rebalanced more frequently, thus raising hedging costs.

We compute the option deltas and gammas using the Black–Scholes formula at each trade price (Hull (2002)). As suggested by Cho and Engle (1999) and Kaul et al. (2001), an option market maker that is fully hedged with the underlying security will bear the spread cost in the underlying market. We measure the relative cost of executing the underlying hedge with the daily average of the effective underlying stock spread.

To isolate the effects of multiple listing, we also control for other factors that may affect spreads. In addition to the theoretical literature cited above, the empirical literature also suggests that option spreads are a function of the option price, volume, and volatility (e.g., Harris (1994) and Bessembinder and Kaufman (1997)). We create option series volume by summing trade volume across all trades in a given option series (i.e., given strike and expiration month) on each trading day. We measure volatility with the simple daily average implied standard deviation (ISD) for the option class.[3]

III. Data

We use option data from the Options Price Reporting Authority (OPRA), which disseminates real-time option prices to commercial vendors. For underlying equity data, we use the NYSE's Trade and Quote (TAQ) data. The OPRA data are similar to the TAQ data, except that there is no depth information for option quotes. We examine two samples in this study. The short-term sample compares

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[3] The ISD data are from the Bloomberg Professional database and are computed daily using either Black–Scholes option formula or the binomial formula depending on whether the underlying equity pays a dividend. The calculation is an average of the at-the-money strike, one strike above, and one strike below for series with more than 20 days to expiration. Alternatively, the standard deviation of underling stock prices using a 10-day moving average yields qualitatively similar results.

the pre-multiple-listing period in August 1999 (8/2/99 to 8/20/99) with the immediate post-multiple-listing period running through the end of September 1999. The long-term sample compares the pre-multiple-listing period in August 1999 with the period exactly 1 year later (7/31/00 to 8/15/00).

Our sample includes 28 of the first 31 option classes multiply listed during August 1999.[4] Further multiple listing announcements followed in September 1999 and beyond, but our sample captures 61% of the volume shifting from single listing to multiple listing. We also highlight the five options that started the listings competition: Apple, Coca-Cola, Dell, IBM, and Johnson & Johnson. Because these announcements were the least likely to be anticipated, they represent a clean break between single listing and multiple listing regimes. However, our findings extend to the other classes that were not part of these initial announcements.

We match each option trade to the best prevailing quote or NBBO across exchanges. Because the options exchanges may not be effectively integrated into a national market system and there is no officially disseminated NBBO for options, the NBBO may not reflect the quotes actually faced by investors (see Battalio et al. (2002) and Hansch and Hatheway (2001)). As a robustness check, we also match each trade on an exchange to the same exchange's prevailing quote, which is used to compute the "OWN" effective spread. Although we compute both effective and quoted spreads, our focus is on effective spreads because these are a better measure of trading costs actually paid by investors.[5]

A series of standard filters are applied to these data. We eliminate all records with time stamps outside of the range 9:30 a.m. to 4:10 p.m. Canceled trades and quotes posted during trading halts are also deleted. We delete all quotes with a zero ask. We also exclude trades with an effective spread exceeding five dollars. We exclude trades that do not take place within 5 minutes of a quote, considering the quote to be stale. Lastly, we exclude longer-term and near-expiration options from the sample by selecting options that expire within the next 90, but not within the next 7, calendar days. Long-term options are thinly traded, making inferences difficult. Trades in very near-term options are likely motivated to avoid delivering stock on in-the-money options, adding noise to our analysis. Our days-to-expiration filter generally reduces our sample to the most actively traded series.[6]

To construct our sample, we average across all trades in given series on a given day. This approach reduces the effects of intraday patterns.[7] Table III provides

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[4] We drop three option classes from our sample. Chase Manhattan Bank and Monsanto were subsequently involved in mergers and not available for long-term analysis. Homestake Mining lacked sufficient long-term trading volume and short-term put volume.

[5] The effective spread is twice the difference between the trade price and the quote midpoint. This measure will overstate true effective spreads when buyer-initiated trades are below and seller-initiated trades are above the midpoint.

[6] Stephan and Whaley (1990) find that approximately two-thirds of options transactions occur in options with fewer than 90 days to expiration.

[7] We also analyze these data on a trade-by-trade basis with very similar results. There is more noise in this approach, but the effect of multiple listing on spreads is always significantly negative.

Table III

Average Behavior of Option Spreads and Volume—Before and after Multiple Listing in 1999 and 2000 Samples

This table shows averages for effective and quoted bid-ask spreads, underlying effective spreads, and option volume. The averages are reported by class for call options with sample averages reported for put options. Effective spreads are shown for the original listing exchange and the best bid/ask across all exchanges after multiple listing. All option data are computed at an option trade and averaged over the day. The mean of the daily averages for each option class in the sample is reported for call options. The underlying spreads are also computed at each trade using the prevailing best quote to compute effective spreads. Option volume is measured in contracts (one contract equals 100 shares of the underlying stock) and summed over all exchanges trading the option series to compute the daily average. These averages are reported for the periods before and after multiple listing (ML) in 1999 and for the August 2000 sample, separately. All spreads are reported in cents.

	Effective Spread					Quoted Spread All Exchanges			Underlying Effective Spread			Option Volume		
	Original Exchange			All Exchanges										
Call Option Class	Before ML	After ML	August 2000	After ML	August 2000	Before ML	After ML	August 2000	Before ML	After ML	August 2000	Before ML	After ML	August 2000
Amgen	12.2	10.7	10.6	10.0	8.7	29.4	21.6	18.9	8.8	8.7	6.6	208	300	239
Apple Computer	9.5	8.2	7.0	7.7	5.2	24.1	13.8	12.2	7.5	7.8	6.3	224	408	200
AT&T Corp.	7.0	4.6	5.1	4.6	4.8	21.7	6.4	11.6	5.7	5.7	4.4	713	795	845
Boeing	8.4	3.6	6.1	3.5	5.3	25.4	8.0	11.9	6.0	5.7	6.2	183	225	140
Coca-Cola Co.	6.6	5.1	6.6	5.2	6.8	23.1	10.4	15.7	6.6	6.6	7.7	293	323	333
Compaq Computer	5.5	4.1	5.3	3.6	4.9	13.6	7.3	11.2	5.6	5.6	6.1	391	948	1031
Dell Computer	7.8	5.3	5.4	5.2	5.2	21.3	10.3	10.9	6.4	6.4	5.4	2296	2269	1227
Eastman Kodak	9.3	6.3	6.6	6.3	6.5	25.6	10.6	15.3	7.0	7.4	8.0	164	281	415
EMC Corp.	11.7	8.1	17.5	7.6	17.0	32.4	12.9	33.0	7.7	7.8	10.5	227	484	66
Exxon	9.9	6.6	6.7	6.6	6.7	28.2	10.0	14.8	6.4	6.4	7.3	179	284	363
General Electric	10.6	8.4	7.4	7.7	6.6	30.3	10.8	13.6	7.2	7.5	5.7	325	439	540

Hewlett Packard	13.7	9.0	9.9	8.9	8.4	33.0	10.6	19.7	10.8	10.2	9.7	319	253	235
Home Depot	9.0	6.3	8.4	6.5	7.2	26.8	10.2	16.0	7.4	6.8	7.8	368	220	338
IBM	14.4	9.5	9.3	9.0	8.3	38.6	15.0	19.3	10.3	9.8	9.4	445	848	492
Intel	11.7	8.9	9.2	8.2	7.8	33.4	18.0	16.3	6.8	7.2	5.9	1218	1442	1029
Johnson & Johnson	8.8	6.7	7.4	6.9	6.4	29.9	13.3	15.3	7.1	7.2	7.3	200	342	174
Merck	8.1	5.3	7.0	5.2	6.1	25.4	10.2	14.8	6.6	6.6	7.7	318	320	272
Microsoft Corp.	9.5	6.8	7.4	6.4	7.2	22.8	10.2	15.8	7.0	7.0	5.2	1112	1444	1602
Motorola	10.4	7.8	6.3	7.4	5.5	27.6	14.1	14.0	10.2	9.6	5.9	299	485	520
Newmont Mining	6.4	5.5	6.1	5.3	4.8	24.5	10.4	11.9	6.0	6.1	5.2	312	523	238
Nextel Communications	12.4	9.8	13.7	9.4	12.1	29.9	16.9	25.0	7.8	8.4	8.3	182	161	336
Oracle Corp.	7.9	6.2	10.2	6.3	9.1	22.3	12.7	19.0	6.8	6.8	6.1	336	735	858
Pfizer Corp.	7.1	4.9	6.3	4.7	5.3	20.1	9.9	10.9	6.5	6.5	6.4	754	431	483
Phillip Morris Companies	4.2	4.0	6.1	3.5	5.4	13.4	6.8	12.2	6.2	6.3	5.3	579	1421	1046
Schwab (Charles) Corp.	9.2	5.4	6.9	5.1	6.7	26.4	8.5	15.8	8.5	7.2	7.9	277	366	272
Southwest Airlines	5.8	4.6	5.7	4.5	6.5	18.4	11.5	21.0	6.3	6.1	6.0	66	105	65
Texas Instruments	17.6	10.7	10.5	9.7	9.1	27.9	9.6	18.7	10.1	8.5	10.9	237	293	282
Wal-Mart Stores	8.1	5.4	6.6	5.5	6.5	24.0	11.6	16.1	6.6	6.3	6.9	284	331	355
Average (Call Options)	9.4	6.7	7.9	6.4	7.1	25.7	11.5	16.1	7.4	7.2	7.0	447	588	500
Average (Put Options)	9.5	6.0	7.7	5.8	6.7	26.5	10.4	14.6	7.4	7.2	7.0	278	399	393

summary statistics for the sample with call options featured and averages for put options reported across classes. Table III reports averages for the effective spreads using quotes on the original listing exchange, effective spreads using the NBBO, quoted spreads, underlying effective spreads, and option volume.

Table III shows that average effective and quoted spreads decreased after multiple listing for all option classes. The effective spread decreases are dramatic for both the NBBO and original exchange calculations. The latter result suggests even an investor who was not willing (or able) to "shop around" for the best price could benefit from multiple listing.[8]

Without controls for other factors, the average effective spreads fell by 3.0 cents and 3.7 cents for calls and puts, respectively, using the all exchange calculation. Across option classes, these changes average 31.3% and 38.7% for calls and puts, respectively. Quoted spreads fell by more than 50% or by more than 14 cents for calls and 16 cents for puts immediately after multiple listing. This provides the first empirical evidence that the multiple-listing competition resulted in lower option spreads. Notably, in the long-term sample, these spread averages show a slight rebound, but the change appears to be mostly permanent.

Following multiple listing, trading in an option became cheaper relative to trading the underlying stock. Table III reports that the underlying effective spread decreases by about 0.2 cents from before to after multiple listing, far less than the decline in option spreads. The spread ratio offers another perspective. Before multiple listing, the average underlying effective spread is about 80% of the average option effective spread. Immediately after multiple listing and through to August 2000, this ratio exceeds 100%. Although the average underlying spread decreases over this period, multiple listing has had an effect on options that exceeds the decrease in hedging costs in the underlying security.[9]

Average series volume increases from the pre- to post-multiple-listing period. One year later, put volume remains elevated but call volume reverts slightly. Notably, average trade size (not shown) shows little change for calls, but steadily increases across these periods for puts. A mean of 447 call contracts trade each day before multiple listing, increasing to 588 contracts per day after multiple listing. This gain of 141 contracts per day suggests that volume or scale effects may play a role in the spread changes observed after multiple listing. For put volume, the increase averages 121 contracts per day. However, average spreads increase somewhat between September 1999 and August 2000 for both calls and puts, but only call volume shows a decrease from 588 to 500 contracts per day. Thus, without conditioning on other factors, volume appears to have an ambiguous or asymmetric role in the observed changes in spreads.

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[8] This also shows that our results are not dependent on how we handle crossed markets, that is, those in which the ask price on one market may be less than the bid price on another market.

[9] The post-multiple-listing relation between underlying and option spreads is consistent with that observed during 1985 by Vijh (1990). He finds that "stock and option bid–ask spreads are nearly equal" (p. 1159). Vijh's result is most likely due to use of quoted spreads and the higher tick sizes ($1/8 versus $1/16) for underlying securities that were present in his sample.

IV. Empirical Evidence

Although the univariate results show a consistent, dramatic reduction in option spreads with the onset of multiple listing, the source of these declines is still uncertain. If multiple listing creates increased trading volume, then economies of scale across exchanges may drive the decrease in spreads. If multiple listing facilitates hedging opportunities for option market makers, this cost saving may be passed along in the form of smaller spreads. On the other hand, the introduction of interexchange competition may drive down spreads. To sort out these effects, we control for volume and factors known to influence hedging costs in the regressions presented below.

We estimate pooled and separate time-series regressions. One reason for pooling these data is that the effects of important variables (such as volume) may be distorted in a pure time-series analysis. Specifically, suppose that volume reached a new, higher level after multiple listing. There would be a high correlation between volume and the multiple-listing dummy variable. In the time-series regression, this correlation implies that estimates of the volume and multiple-listing effects may be confounded. In the pooled regression, however, the additional cross-sectional variation in volume will enhance the model's ability to capture the true effect of volume on trading costs.

Although our regressions focus on effective and not quoted spreads, we use appropriate controls for the bounds that each exchange sets on quoted option spreads.[10] These bounds vary with the option price and have the effect of censoring the quoted spread data. For instance, the bound is \$1/4 for options with a bid price less than \$2, and relaxes to \$3/8 for prices between \$2 and \$5. A set of dummy variables is used to capture these differences, with the \$2–\$5 range absorbed in the intercept.

We also create a multiple listing dummy variable, which equals zero before an option class begins trading on multiple exchanges and one afterwards. The coefficient on the multiple-listing dummy measures the incremental effect of multiple listing on effective spreads after controlling for economies of scale, hedging effects, and other option characteristics.

A. First Five Multiple Listed Options

Table IV presents time-series regressions on effective spreads for the five option classes involved in the first announcements. The standard errors of the estimated coefficients in these (and all) regressions are corrected for heteroskedasticity using White's (1980) method. We estimate models for calls and puts separately. In addition, all independent variables have been standardized to have zero mean, so that the intercept measures the average effective spread before multiple listing.

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[10] Our basic findings are not sensitive to whether we use effective, quoted, or relative spreads. The results for quoted and relative spreads, reported in a previous draft of this paper, are available on request.

Table IV

Determinants of Effective Bid–Ask Spreads for Five Option Classes in the First Announcements

This table shows estimates from regressing effective bid–ask spreads on a *multiple listing* dummy, *option price, underlying effective spread, option delta, option gamma, volatility, series volume, and series∗multiple listing* interaction term. These estimates are corrected for heteroskedasticity using White's (1980) method. The *effective spread* equals 2∗ABS [trade price – quote midpoint]. A trade is excluded if the quote is older than 5 minutes. The *delta* and *gamma* are computed using Black–Scholes formulaes. The implied standard deviation (ISD) from Black–Scholes or the binomial model if dividends are paid (measured in percent) is used for *volatility.* Option *volume* is summed across all trades in the series. All variables are daily averages except series *volume*, which is summed over the day. The multiple listing dummy equals zero before another exchange began to list the option. Independent variables are standardized to zero mean, so the intercept represents the average effective spread before multiple listing. A dash indicates insufficient observations on this variable. A double and single asterisk implies 99% and 95% levels of significance, respectively.

	Call Options by Class					Put Options by Class				
Variable	Apple	Coca-Cola	Dell	IBM	J&J	Apple	Coca-Cola	Dell	IBM	J&J
Panel A: August to September 1999 Sample										
Intercept	0.107**	0.079**	0.090**	0.146**	0.097**	0.093**	0.080**	0.092**	0.123**	0.088**
Multiple listing	– 0.030**	– 0.028**	– 0.041**	– 0.081**	– 0.032**	– 0.026**	– 0.017*	– 0.041**	– 0.055**	– 0.032**
Option price	0.000	0.009	0.000	0.004**	– 0.001	0.007*	0.011**	0.006*	0.006**	0.028**
Dummy (bid < \$2)	– 0.017**	– 0.007	– 0.008*	– 0.026*	– 0.019*	– 0.008*	0.012	– 0.001	– 0.034**	0.010
Dummy (\$5 < bid < \$10)	0.004	0.013	0.004	0.019*	0.013	– 0.015*	– 0.033*	– 0.011	0.027**	– 0.025
Dummy (\$10 < bid < \$20)	– 0.007	0.145**	0.007	0.052**	0.043	– 0.045**	– 0.094**	– 0.017	0.082**	—
Dummy (\$20 < bid)	0.010	—	—	0.086**	0.074	—	0.000*	—	0.002	—
Underlying effective spread	0.131	0.964*	0.321	0.183	0.548	0.558	0.836	1.571*	0.238*	0.438
Option delta	0.058**	0.005	0.064**	0.002	0.080*	– 0.028	– 0.048	– 0.050**	0.050**	0.097
Option gamma	– 0.223	0.029	– 0.192**	0.278	– 0.124	0.063	– 0.151	– 0.220*	0.330*	0.710
Volatility	– 0.022	– 0.082	0.008	0.350**	0.108	– 0.149*	– 0.103	0.048	– 0.002*	– 0.155
Series volume (1,000s)	– 0.016*	– 0.013	– 0.003**	– 0.032**	– 0.005	– 0.073*	0.002	– 0.003	– 0.028**	0.006
Series volume∗mult. listing	0.016	0.022*	0.003**	0.035**	0.017	0.073*	– 0.009	0.003	0.031**	– 0.001
Sample size	317	189	485	609	202	152	186	332	463	133
Adj. R-squared	53.8%	48.1%	65.6%	60.7%	45.8%	53.4%	33.8%	68.2%	66.3%	29.8%

Panel B: August 1999 (pre-multiple listing) to August 2000 Sample

Intercept	0.098**	0.090**	0.074**	0.150**	0.104**	0.060**	0.065**	0.106**	0.114**	0.080**
Multiple listing	– 0.028	– 0.024**	– 0.013*	– 0.078**	– 0.044**	– 0.015	0.006	– 0.038**	– 0.039**	– 0.018
Option price	0.007**	0.013	0.007*	0.009**	0.007	0.014	0.014	0.010**	0.007**	0.041**
Dummy (bid < \$2)	– 0.016**	0.006	– 0.006	– 0.023**	– 0.018	0.026*	– 0.007	– 0.007	– 0.027**	0.032
Dummy (\$5 < bid < \$10)	– 0.005	– 0.034	– 0.005	0.007	0.016	—	0.061*	– 0.015	0.017	– 0.045
Dummy (\$10 < bid < \$20)	– 0.053**	– 0.130*	– 0.068**	0.015	0.013	—	0.090	– 0.038*	0.095**	—
Dummy (\$20 < bid)	—	—	—	0.022	—	—	—	—	—	—
Underlying effective spread	0.135	– 0.537	1.346**	0.144	1.137*	1.163	– 0.522	– 0.110	0.158	– 0.803
Option delta	0.012*	0.055	0.033	– 0.011	– 0.013	– 0.136*	0.034	– 0.018	0.039	0.077
Option gamma	– 0.019	– 0.071	– 0.001	0.386	0.260	– 0.368	0.239	– 0.026	0.529	0.211
Volatility	– 0.040	0.102	0.049	– 0.013	0.292	0.016	– 0.015	0.139	– 0.090	– 0.260
Series volume (1,000s)	– 0.017*	– 0.005	– 0.003**	– 0.024**	– 0.026	– 0.039	– 0.006	– 0.002	– 0.031**	0.004
Series Volume * mult. listing	0.014	0.009	0.003**	0.031**	0.024	0.038	– 0.019	0.004	0.029**	– 0.010
Sample size	136	81	251	412	130	44	70	197	271	57
Adj. R-squared	72.9%	56.3%	79.7%	69.3%	49.9%	62.4%	53.2%	69.9%	70.2%	53.7%

The results from August to September 1999 are presented in Panel A of Table IV. They show the short-term effects of multiple listing. The coefficient estimates on the multiple-listing variable strongly support the hypothesis that multiple listing had an immediate and significantly negative effect on spreads. The impact on effective spreads ranges from − 1.7 cents for Coca-Cola puts to − 8.1 cents for IBM calls. In percentage terms, the spread reductions range from 22% for Coca-Cola puts to 55% for IBM calls.

The long-term results in Panel B are for the August 1999 to August 2000 sample. These regressions also show negative effects for the multiple-listing variable, but they are not as strong as the short-term results. Only six of these coefficients are statistically significant and their magnitude is generally reduced from the corresponding coefficient in Panel A. Although the longer-term effects show lower effective spreads due to multiple listing, there is evidence that spreads revert somewhat in several of these option classes.

Among our control variables, option price alone is usually positively related to effective spreads. This relationship changes somewhat depending on the significance of the price range dummies. These dummies are used to capture the effects that spread limits may have on the size of quoted and hence calculated effective spreads. Combining the option price coefficient with the range dummies shows a generally positive (stepwise) relation between option price and effective spreads for most option classes.

The underlying effective spread, option delta, and gamma variables are designed to capture the costs of hedging on effective spreads. The underlying spread is often positively related to effective spreads, but it is significant in only 5 of the 20 regressions. The results for the option delta are only slightly stonger, with significance in 7 of the 20 regressions, but with the wrong sign for IBM puts. One reason for these poor results may be that delta is closely related to price, which implies a potential multicollinearity problem. In pooled regressions, we explore this issue further. The option gamma results are significant in only 3 regressions, with 2 of these generating the wrong sign. Thus, these time-series findings offer very weak support to the hedging theory of option spreads.

The results for option volatility (ISD) are even less consistent with the theory. Higher volatility is expected to increase effective spreads. Eleven of the 20 coefficients are negative and most are insignificant. This suggests that underlying volatility plays a relatively minor role in setting option effective spreads.

The volume measure is particularly important because we wish to isolate any scale effects during these periods. Total daily volume in the option series across all exchanges is expected to vary inversely with effective spreads.[11] In addition, it is possible that the effect of volume on spreads changed after multiple listing (see Mayhew (2002) and Neal (1987, 1992)). To capture this possibility, we include an interaction term between volume and the multiple-listing dummy variable. Most

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[11] We also used other definitions of volume in these regressions, including series volume on an exchange, class volume on an exchange (defined across all strikes and expirations months), and class volume across all exchanges. These measures provide results similar to the time-series and pooled regressions presented here.

of the volume coefficients are negative but only nine are significant. In addition, the interaction term is nearly always positive, which acts to offset the volume effect. Thus, the volume results are somewhat mixed for these regressions.

We also explore other aspects of the scale economies argument for these five option classes. In results not reported, we estimate the regressions in Table IV using an own-exchange measure of volume to determine if scale economies occur only within a given exchange. The multiple-listing and volume results are similar to those reported here. However, the distribution of volume across exchanges does not support within-exchange scale economies. The original exchange retains the largest market share after multiple listing, while each new entrant typically accounts for only a small fraction of total volume. If scale economies occur only within an exchange, one would expect trading costs on the new exchanges to exceed those on the original exchange. After multiple listing however, effective spreads are nearly identical across exchanges for a given option class. Thus, there appears to be little within-exchange scale effect for the observed volume changes.

In general, the R-squared values are fairly high in these regressions, providing additional support for our specification and inferences about multiple-listing effects. In the short-term sample, the adjusted R-squared is near or above 50% for all equations except Coca-Cola put options. In the long-term sample, the adjusted R-squared is even higher, with Dell calls showing a fit of 79.7%, for example.

The models estimated in Table IV use a linear specification. Mayhew (2002) provides evidence that spreads may be nonlinearly related to several of the control variables used in these regressions, notably volume and price. To address this concern, we also estimate the regressions in Table IV (and Tables V and VI) using a log–log specification. A negative and significant multiple-listing effect was consistently present in these regressions, too. The adjusted R-squared values were similar to those in the corresponding linear regressions.[12]

B. Pooled Cross Section and Time-Series Analysis

Volume changes between pre- and post-multiple listing may be highly correlated with the multiple-listing variable, which may confound the effects of volume and multiple listing. To reduce this correlation, we add variation to the volume series by pooling the cross section and time-series data. These pooled regressions also help to identify the effects of hedging variables as these costs vary across option classes. Table V presents the pooled regression estimates of our basic model. The two panels in Table V show estimates for the short- and long-term samples, respectively. In these regressions, the intercept is allowed to vary by class, but the multiple-listing effect is not, so that a single multiple-listing estimate is available for reference. The table shows estimates based on four different specifications, plus an estimate based on an own-exchange (OWN) calculation of effective spreads. Models 1 and 2 show the sensitivity of the regression results to including the option delta, gamma, and volatility terms. These variables are related in a

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[12] The Davidson and MacKinnon (1981) test for linearity versus nonlinearity showed mixed results: Neither linear nor log–log models are clearly dominant. For ease of exposition, we present the results for the linear model, but the log–log results are available on request.

Table V

Pooled Estimates of Effective Bid-Ask Spreads

This table shows regression estimates from pooling all option classes in a given sample period, separating call and put options. The estimates are corrected for heteroskedasticity using White's (1980) method. The independent variables are the same as in Table IV and are also standardized to have zero mean. Each option class is allowed a separate intercept term (not shown), but the multiple-listing effect is combined across all classes to report an average impact. The "OWN" model uses the bid–ask spread prevailing on the listing exchange where the trade occurs. Spreads are averaged over each daily and daily averages are used in these regressions. A double asterisk implies a 99% level of significance and single asterisk implies a 95% level of significance.

	Call Options					Put Options				
Variable	Model 1	Model 2	Model 3	Model 4	OWN	Model 5	Model 6	Model 7	Model 8	OWN
Panel A: August to September 1999 Sample										
Multiple listing	–0.038**	–0.038**	–0.041**	–0.041**	–0.041**	–0.038**	–0.037**	–0.041**	–0.041**	–0.042**
Option price	0.005**	0.004**	0.004**	0.004**	0.004**	0.008**	0.007**	0.007**	0.007**	0.008**
Dummy (bid < $2)	–0.027**	–0.024**	–0.023**	–0.023**	–0.021**	–0.018**	–0.016**	–0.016**	–0.016**	–0.011**
Dummy ($5 < bid < $10)	0.015**	0.013**	0.013**	0.013**	0.010**	0.007*	0.008*	0.007*	0.007*	0.002
Dummy ($10 < bid < $20)	0.021**	0.020**	0.020**	0.020**	0.014**	0.015*	0.019*	0.019*	0.019*	0.006
Dummy ($120 < bid)	0.003	0.008	0.008	0.008	–0.002	–0.058	–0.045	–0.041	–0.042	–0.056*
Underlying effective spread	0.412**	0.426**	0.423**	0.407**	0.496**	0.487**	0.537**	0.526**	0.499**	0.540**
Option delta		0.014**	0.015**	0.015**	0.009*		–0.013**	–0.015**	–0.014**	–0.016**
Option gamma		–0.008	0.005	0.008	0.020		0.031	0.039	0.043	0.028
Volatility	0.020			0.026*	0.032*	0.049**			0.051**	0.040*
Series volume (1,000s)	–0.001**	–0.001**	–0.005**	–0.005**	–0.006**	–0.001	–0.001*	–0.008**	–0.008**	–0.009**
Series volume*mult. listing			0.005**	0.005**	0.006**			0.009**	0.009**	0.010**
Sample size	8181	8181	8181	8181	13009	5297	5297	5297	5297	8158
Adj. R-squared	59.3%	59.4%	59.8%	59.8%	36.9%	54.1%	54.1%	54.4%	54.8%	36.1%

Panel B: August 1999 (pre-multiple listing) to August 2000 Sample

Multiple listing	– 0.029**	– 0.029**	– 0.032**	– 0.032**	– 0.034**	– 0.030**	– 0.030**	– 0.034**	– 0.033**	– 0.037**
Option price	0.007**	0.006**	0.006**	0.006**	0.007**	0.007**	0.006**	0.006**	0.006**	0.007**
Dummy (bid < $2)	– 0.023**	– 0.020**	– 0.020**	– 0.020**	– 0.014**	– 0.024**	– 0.021**	– 0.021**	– 0.021**	– 0.016**
Dummy ($5 < bid < $10)	0.009*	0.008*	0.008**	0.008**	0.005*	0.018**	0.018**	0.017**	0.017**	0.007
Dummy ($10 < bid < $20)	0.014**	0.015**	0.015**	0.015**	0.003	0.036**	0.039**	0.039**	0.039**	0.015
Dummy ($20 < bid)	0.003	0.011	0.011	0.012	– 0.009	– 0.052	– 0.039	– 0.037	– 0.037	– 0.070*
Underlying effective spread	0.112*	0.135**	0.153**	0.148**	0.121**	0.130*	0.165*	0.179*	0.169*	0.185**
Option delta		0.015**	0.017**	0.017**	0.015**		– 0.020**	– 0.021**	– 0.021**	– 0.018*
Option gamma		0.004	0.001	– 0.001	– 0.010		0.009	0.011	0.009	– 0.013
Volatility (100s)	– 0.017			– 0.010	– 0.013	– 0.025			– 0.019	– 0.009
Series volume (1,000s)	– 0.002**	– 0.002**	– 0.005**	– 0.005**	– 0.006**	– 0.001	– 0.001*	– 0.007**	– 0.007**	– 0.009**
Series volume * mult. listing			0.005**	0.005**	0.006**			0.008**	0.008**	0.012**
Sample size	4800	4800	4800	4800	9330	2989	2989	2989	2989	5278
Adj. *R*-squared	65.7%	65.8%	66.1%	66.2%	48.6%	53.1%	53.2%	53.5%	53.5%	37.0%

Table VI

Short-term and Long-term Multiple-Listing Effects on Effective Spreads

This table shows regression estimates of multiple listing (ML) and series volume effects on effective spreads for the 28 option classes. These estimates are corrected for heteroskedasticity using White's (1980) method. These option classes became multiple listed during August to September 1999. The regressions are fitted for calls and puts and each option class separately. The table shows the coefficient of the multiple listing effect when each option class is estimated separately and the effect from a pooled regression. The series volume effect is from the separate regression models. The other control variables (not shown) are the same as in Table IV. Panel A shows results for the 1999 sample and Panel B shows results for the 2000 sample. A double asterisk implies a 99% level of significance and a single asterisk implies a 95% level of significance.

	Call Options			Put Option		
Option Class	Pooled ML Effect	Separate ML Effect	Series Volume Effect (1,000s)	Pooled ML Effect	Separate ML Effect	Series Volume Effect (1,000s)
Panel A: 1999 Sample Results—Short-term Effects						
Amgen	–0.023**	–0.026**	–0.014*	–0.022**	–0.010	0.012
Apple Computer	–0.040**	–0.030**	–0.016*	–0.031**	–0.026**	–0.073*
AT&T Corp.	–0.030**	–0.030**	–0.005**	–0.050**	–0.045**	–0.021*
Boeing	–0.032**	–0.030**	–0.011	–0.027*	–0.031*	–0.010
Coca-Cola Co.	–0.021**	–0.028**	–0.013	–0.024**	–0.017*	0.002
Compaq Computer	–0.024**	–0.020**	–0.005*	–0.034**	–0.038**	–0.014
Dell Computer	–0.051**	–0.041**	–0.003**	–0.044**	–0.041**	–0.003
Eastman Kodak	–0.027**	–0.020**	0.004	–0.045**	–0.031**	–0.079
EMC Corp.	–0.061**	–0.074**	–0.019*	–0.058**	–0.060**	–0.026*
Exxon	–0.027**	–0.030**	–0.051**	–0.042**	–0.054**	–0.013
General Electric	–0.044**	–0.046**	–0.018**	–0.047**	–0.045**	–0.013
Hewlett Packard	–0.035**	–0.033**	–0.005	–0.052**	–0.057**	–0.038*
Home Depot	–0.038**	–0.035**	–0.009	–0.024**	–0.021	–0.015
IBM	–0.064**	–0.081**	–0.032**	–0.046**	–0.055**	–0.028**
Intel	–0.046**	–0.046**	–0.004**	–0.029**	–0.023**	–0.003*
Johnson & Johnson	–0.026**	–0.032**	–0.005	–0.040**	–0.032**	0.006
Merck	–0.033**	–0.035**	–0.010	–0.043**	–0.042**	–0.008
Microsoft Corp.	–0.048**	–0.044**	–0.005**	–0.040**	-0.041**	–0.004*
Motorola	–0.043**	–0.042**	–0.020**	–0.034**	–0.033**	–0.014

Newmont Mining	– 0.022**	– 0.018**	– 0.007	– 0.011	– 0.008	– 0.002
Nextel Communications	– 0.049**	– 0.051**	– 0.017	– 0.037**	– 0.047**	– 0.026
Oracle Corp.	– 0.028**	– 0.031**	– 0.010	– 0.049**	– 0.067**	– 0.018
Pfizer Corp.	– 0.028**	– 0.026**	– 0.003	– 0.033**	– 0.029**	– 0.002
Phillip Morris Companies	– 0.017**	– 0.008*	– 0.001	– 0.019*	– 0.012**	0.007
Schwab (Charles) Corp.	– 0.038**	– 0.032**	– 0.015*	– 0.054**	– 0.057**	– 0.019*
Southwest Airlines	– 0.016	– 0.019	0.095	– 0.022	– 0.106**	– 2.067*
Texas Instruments	– 0.071**	– 0.072**	– 0.021**	– 0.057**	– 0.075**	– 0.050*
Wal-Mart Stores	– 0.026**	– 0.028**	– 0.011	– 0.034**	– 0.027**	– 0.015
Average	– 0.036	– 0.036	– 0.008	– 0.037	– 0.040	– 0.091
Percent of neg. coeff.	100%	100%	93%	100%	100%	86%
Percent sig. coeff. (5%)	96%	96%	50%	93%	89%	36%

Panel B: 2000 Sample Results—Long-term Effects

Amgen	– 0.016**	– 0.019	– 0.006	– 0.018	0.030	– 0.009
Apple Computer	– 0.026**	– 0.028	– 0.017*	– 0.018	– 0.015	– 0.039
AT&T Corp.	– 0.023**	– 0.029**	– 0.001	– 0.042**	– 0.024	0.002
Boeing	– 0.029**	– 0.034**	– 0.005	– 0.052**	– 0.053*	– 0.005
Coca-Cola Co.	– 0.028**	– 0.024**	– 0.005	– 0.012	0.006	– 0.006
Compaq Computer	– 0.025**	– 0.015**	– 0.001*	– 0.018*	– 0.016**	0.000
Dell Computer	– 0.032**	– 0.013*	– 0.003**	– 0.042**	– 0.038**	– 0.002
Eastman Kodak	– 0.036**	– 0.045**	0.003	Insufficient data for estimation		
EMC Corp.	– 0.053**	– 0.120**	– 0.009	– 0.048**	– 0.027	– 0.023
Exxon	– 0.024**	– 0.024**	– 0.005	– 0.037*	– 0.007	– 0.006
General Electric	– 0.032**	– 0.040**	– 0.005	– 0.035**	– 0.015	0.004
Hewlett Packard	– 0.040**	– 0.037**	– 0.005	– 0.072**	– 0.073**	– 0.005
Home Depot	– 0.022**	– 0.021**	– 0.010	– 0.036**	– 0.033**	– 0.018
IBM	– 0.064**	– 0.078**	– 0.024**	– 0.036**	– 0.027**	– 0.031**
Intel	– 0.024**	– 0.016**	– 0.001	– 0.020**	– 0.007	– 0.001
Johnson & Johnson	– 0.026**	– 0.044**	– 0.026	– 0.039**	– 0.020	0.004
Merck	– 0.025**	– 0.025**	– 0.006	– 0.029**	– 0.036**	– 0.002
Microsoft Corp.	– 0.020**	– 0.019*	– 0.002**	– 0.009	0.022	– 0.003
Motorola	– 0.031**	– 0.038**	– 0.004	– 0.037**	– 0.038**	– 0.001
Newmont Mining	– 0.008	0.001	– 0.017	– 0.019	– 0.053	0.042
Nextel Communications	– 0.010	– 0.070*	– 0.001	– 0.014	0.007	– 0.028

continued

Table VI
(*continued*)

Option Class	Call Options: Pooled ML Effect	Call Options: Separate ML Effect	Call Options: Series Volume Effect (1,000s)	Put Option: Pooled ML Effect	Put Option: Separate ML Effect	Put Option: Series Volume Effect (1,000s)
Oracle Corp.	– 0.007	– 0.012	0.002	– 0.025**	– 0.034	0.003
Pfizer Corp.	– 0.026**	– 0.023**	– 0.003	– 0.019	– 0.023**	– 0.022
Phillip Morris Companies	– 0.002	0.002	0.000	– 0.010	0.024	– 0.001
Schwab (Charles) Corp.	– 0.032**	– 0.037**	– 0.005	– 0.047**	– 0.058**	– 0.005
Southwest Airlines	– 0.008	– 0.019	0.077	Insufficient data for estimation		
Texas Instruments	– 0.063**	– 0.059**	– 0.008	– 0.077**	– 0.076**	– 0.018
Wal-Mart Stores	– 0.016**	– 0.020**	– 0.007	– 0.015	– 0.012	– 0.006
Average	– 0.027	– 0.032	– 0.003	– 0.030	– 0.022	– 0.007
Percent of neg. coeff.	100%	93%	89%	92%	73%	73%
Percent of sig. coeff. (5%)	82%	79%	18/o	65%	42%	4%

nonlinear manner to option price, which may create multicollinearity problems. Note that the size and significance of the coefficient on option price changes little across these specifications, which suggests that multicollinearity in not a major problem. Models 3 and 4 show the sensitivity of the results to volatility and the series volume interaction term.

As the results in Table V show, the multiple-listing coefficient is robust to changes in model specification and the alternative definition of the dependent variable based on own-exchange quotes. Without adjusting for volume, the short-term results imply spread decreases on average of 36% for call and 38% for put options. In the long-term sample spreads revert slightly, decreasing an average of 29% for calls and 30% for puts. Thus, these results confirm the previous findings of a significant reduction in spreads after multiple listing, with only a small reversal after 1 year.

Other studies of multiple listing effects find smaller spread changes than those reported here. Lightfoot et al. (1986), Neal (1987), and Wang (1999) each find spread decreases of 14% to 20%. Neal finds that the spread reductions are isolated to low-volume options. Wang reports that spreads narrow by about 14% for multiple-listed options. The differences in magnitude observed here are likely due to the size of the competitive response to the multiple-listing announcements. Furthermore, these previous studies attempt to control for differences across matched samples but cannot control for all stock-specific factors or competitive responses. It appears that these factors may lead to the larger measured multiple-listing effects in this study.

Neal (1987) and Mayhew (2002) suggest that volume diminishes the effect of multiple listing. Our results from Table V generally support this view, with the volume/multiple listing interaction term positive and highly significant. However, it takes relatively high levels of volume before there is a measurable effect on the spread decreases associated with multiple listing. For Model 4 of Table V, the point at which higher volume negates the multiple-listing effect is about 8,000 contracts. Although some option series may maintain higher volumes, 8,000 contracts is significantly beyond the daily averages for the vast majority of option classes. Even at the average daily series volume for our highest volume (Dell call) options, the short-term effects of multiple listing imply a spread decrease of nearly 29%, in line with our other estimates of the multiple-listing effect.

Another implication of our reported coefficients for the volume/multiple listing interaction term is that scale economies do not explain why spreads declined after multiple listing. To illustrate this point, suppose that two series have the same average daily volume before multiple listing, and that one series experiences a sharp increase in volume after multiple listing. Because the volume/multiple listing interaction effect almost exactly negates the volume effect, the spread decrease for these series is expected to be about the same. Thus, the increase in volume after multiple listing does not generate an additional decrease in spreads, as would be the case if there were economies of scale.

Finally, the pooled results show that option price, the underlying effective spread, and option delta are important determinants of option spreads. These variables are highly significant and have the expected signs, suggesting that the pure time series analysis did not provide enough variation to consistently capture the effects of these variables. In contrast to the time-series results, these findings support the view that higher hedging costs increase option spreads (see Cho and Engle (1999) and Kaul et al. (2001)). However, the only hedging variable to show a measurable change after multiple listing is the underlying spread, which falls by approximately 0.2 cents. Using the coefficient for this variable found in either Model 4 or Model 8 in Table V implies only a small spread effect of between 0.08 and 0.10 cents. This change is not sufficient to explain the 2.7 to 3.5 cent decrease in average daily effective spreads.

C. Multiple-Listing and Volume Effects

As a final check on the robustness of our results, we estimate separate multiple-listing effects for each option class. This modified pooled regression allows both the intercept and the multiple-listing effect to vary for each option class, but constrains the other variables across option classes. These regression results use the specification shown in Table V, Model 4, but for ease of presentation, the table includes only the coefficient estimates for the multiple-listing dummy and series volume. For completeness, we also report the multiple-listing and series-volume effects from separate time series regressions for each of the 28 options classes.

In Panel A of Table VI, the short-term results reveal that the multiple listing coefficients are significantly negative for all call option classes except Southwest Airlines. This holds in both pooled and separate regressions. Likewise, multiple listing significantly reduces effective spreads for most put options as well. Effective spreads across these option classes decreased from between 3.6 cents to 4.0 cents after multiple listing, controlling for the other variables that affect spreads. These findings are consistent with the ranges reported above for the first five options affected by the multiple-listing competition.

Panel B of Table VI shows the coefficient estimates for regressions on the long-term sample. On a class-by-class basis these results are not quite as strong as those observed in the short-term sample. Nearly all of the multiple-listing coefficients for calls are negative, but fewer (82% for pooled and 79% for separate) of these are significant. For put options, all of the pooled results are negative, but only 81% of the separate regressions show negative coefficients. Thus, the decline in effective spreads persists, but not as strongly 1 year after the listing event. Measured relative to pre-multiple-listing means, call effective spreads decreased by 38.3% (from 9.4 cents to 5.8 cents) in the short term and 34.0% in the long term. Put effective spreads fell by 42.1% in the short term, but by only 24.2% in the long term. A special study by staff from the SEC's Office of Compliance Inspections and Examinations and Office of Economic Analysis (2000) suggests that payment for order flow that began in October 1999 raised the cost of market making for some option classes. Such payments may have encouraged the reversion in spreads for certain option classes. Overall, our results imply that there is a large permanent reduction in effective spreads after the multiple listing, with some reversion for selected option classes.

V. Conclusions

There are significant reductions in effective and quoted spreads after another exchange lists an exclusively listed option class. Effective spreads drop significantly—on the order of 30% to 40%—following multiple listing. We document that these decreases are relatively permanent with little reversion after 1 year. We control for volume effects, hedging parameters, market making costs, and the uniqueness of an option class, and find little evidence that these spread reductions result from scale economies. In pooled results, we find hedging parameters to be important determinants of option spreads, but the changing cost of hedging in the underlying market cannot explain the drop in spreads following multiple listing.

The magnitude of the spread reductions and the lack of measurable scale economies or hedging effects suggest that intraexchange competition is not a perfect substitute for interexchange competition. Although an individual exchange may contain more than 50 market makers competing for order flow in an active option class, competition from another exchange helps to narrow spreads further. These results suggest that a market fragmented at the exchange level provides competitive pressures that do not naturally evolve on a single trading floor. Fragmentation of this type may help to reduce transaction costs for investors.

REFERENCES

Admati, Anat, and Paul Pfleiderer, 1992, A theory of intraday patterns: Volume and price variability, *Review of Financial Studies* 1, 3–40.

Amihud, Yakov, and Haim Mendelson, 1980, Dealership market: Market-making with inventory, *Journal of Financial Economics* 8, 31–53.

Back, Kerry, 1993, Asymmetric information and options, *Review of Financial Studies* 6, 435–472.

Battalio, Robert, Brian Hatch, and Robert Jennings, 2002, Does a national market system exist for U.S. exchange-listed equity options? An analysis of multiple-traded equity options, Working paper, University of Notre Dame.

Battle for market share heats up as CBOE plans to list 29 Philadelphia exchange options, 1999, *Wall Street Journal*, August 30 CI.

Bessembinder, Hendrik, and Herbert Kaufman, 1997, A comparison of trade execution costs for NYSE and Nasdaq-listed stocks, *Journal of Financial and Quantitative Analysis* 32, 287–310.

Biais, Bruno, and Pierre Hillion, 1994, Insider and liquidity trading in stock and option markets, *The Review of Financial Studies* 7, 743–780.

Boehmer, Beatrice, and Ekkehart Boehmer, 2002, Trading your neighbor's ETFs: Competition or fragmentation, Working paper, New York Stock Exchange.

Chicago Board Options Exchange cancels merger due to tight time schedule, 1999, *Chicago Tribune*, January 8.

Cho, Young-Hye, and Robert F. Engle, 1999, Modeling the impacts of market activity on bid–ask spreads in the option market, Working paper No. 7331, National Bureau of Economic Research, Cambridge, MA.

Christie, William G., and Paul H. Schultz, 1994, Why do Nasdaq market makers avoid odd-eighth quotes? *Journal of Finance* 49, 1813–1840.

Copeland, Thomas E., and Dan Galai, 1983, Information effects on the bid–ask spread, *Journal of Finance* 38, 1457–1469.

Coughenour, Jay, and Kuldeep Shastri, 1999, Symposium of market microstructure: A review of the empirical research, *The Financial Review* 34, 1–28.

Davidson, Russell, and James G. MacKinnon, 1981, Several tests for model specification in the presence of multiple alternatives, *Econometrica* 49, 781–794.

Easley, David, and Maureen O'Hara, 1987, Prices, trade size, and information in security markets, *Journal of Financial Economics* 19, 69–90.

Easley, David, Maureen O'Hara, and P. S. Srinivas, 1998, Option volume and stock prices: Evidence on where informed traders trade, *Journal of Finance* 53, 431–465.

Exchanges, on one Dell swoop from CBOE, cast aside their custom of exclusive listings, 1999, *The Wall Street Journal*, August 19, C15.

Foster, F. Douglas, and S. Viswanathan, 1994, Strategic trading with asymmetrically informed traders and long-lived information, *Journal of Financial and Quantitative Analysis* 29, 499–518.

Glosten, Lawrence, and Robert Milgrom, 1985, Bid, ask, and transaction prices in a specialist market with heterogeneously informed traders, *Journal of Financial Economics* 14, 71–100.

Hansch, Oliver, and Frank M. Hatheway, 2001, Measuring execution quality in the listed option market, Working paper, Smeal College of Business, Pennsylvania State University.

Harris, Lawrence, 1994, Minimum price variation, discrete bid–ask spreads, and quotation sizes, *Review of Financial Studies* 7, 149–178.

Hill, Joanne M., 1995, The history of equity derivatives, in Jack Clark Francis, William W. Toy, J.Gregg Whittaker, eds.: *The Handbook of Equity Derivatives* (Irwin Professional Publishing, Boston, MA).

Ho, Thomas, and Hans Stoll, 1981, Optimal dealer pricing under transactions and return uncertainty, *Journal of Financial Economics* 9, 47–73.

Ho, Thomas, and Hans Stoll, 1983, The dynamics of dealer markets under competition, *Journal of Finance* 38, 1053–1074.

Hull, John C., 2002, *Options, Futures, and Other Derivatives*, 5th ed. (Prentice-Hall, Inc., Upper Saddle River, NJ).

John, Kose, Ranga Narayanan, Apoorva Koticha, and Marti G. Subrahmanyam, 2000, Margins, informed trading in derivatives, and price dynamics, Working paper, New York University.

Kaul, Gautam, M. Nimalendran, and Donghang Zhang, 2001, Informed trading and option spreads, Working paper, University of Florida.

Klock, Mark, and D. Timothy McCormick, 1999, The impact of market-maker competition on Nasdaq spreads, *The Financial Review* 34, 55–73.

Kyle, Albert S., 1985, Continuous auctions and insider trading, *Econometrica* 53, 1315–1335.

Lightfoot, Lois, Peter Martin, William Atkinson, and Jeffry Davis, 1986, The effect of multiple trading on the market for OTC options, Staff Studies, Directorate of Economic and Policy Analysis, U.S. Securities and Exchange Commission.

Madhavan, Ananth, 1992, Trading mechanisms in security markets, *Journal of Finance* 47, 607–641.

Madhavan, Ananth, 2000, Market microstructure: A survey, *The Journal of Financial Markets* 3, 205–258.

Mayhew, Stewart, 2002, Competition, market structure and bid–ask spreads in stock option markets, *Journal of Finance* 57, 931–958.

Neal, Robert, 1987, Potential competition and actual competition in equity options, *Journal of Finance* 42, 511–537.

Neal, Robert, 1992, A comparison of transaction costs between competitive market maker and specialist market structures, *Journal of Business* 65, 317–334.

Some Dell option traders want to stay in the Big Apple, 1998, *Investment Dealers Digest*, September 7.

Stephan, Jens, and Robert Whaley, 1990, Intraday price change and trading volume relations in stock and stock option markets, *Journal of Finance* 45, 191–220.

Stoll, Hans, 1978, The supply of dealer services in securities markets, *Journal of Finance* 33, 1133–1151.

United States of America vs. American Stock Exchange, LLC; Chicago Board Options Exchange, Inc.; Pacific Exchange, Inc.; and Philadelphia Stock Exchange, Inc., USDC in the District of Columbia, September 11, 2000 (text of complaint available at http://www.usdoj.gov/atr/cases/f6400/6468.htm).

U.S. Securities and Exchange Commission, 1974, Release No. 11144.

U.S. Securities and Exchange Commission, 1975, Release No. 11423.

U.S. Securities and Exchange Commission, 1978, Special study of the options markets.

U.S. Securities and Exchange Commission, 1980, Release No. 16863.

U.S. Securities and Exchange Commission, 1989, Governing the Multiple Listing of Options on National Exchanges, Securities Exchange Act Release No. 26870, May 26.

U.S. Securities and Exchange Commission, 1989, Release No. 26871.

U.S. Securities and Exchange Commission, 2000, In the Matter of Certain Activities of Options Exchanges, Release No. 43268.

U.S. Securities and Exchange Commission, Office of Compliance Inspections and Examinations and Office of Economic Analysis, 2000, Payment for order flow and internalization in the options markets.

Vijh, Anand M., 1990, Liquidity of the CBOE equity options, *Journal of Finance* 45, 1157–1179.

Wahal, Sunil, 1997, Entry, exit, market makers and the bid–ask spread, *Review of Financial Studies* 10, 871–901.

Wang, Elizabeth Xiao-Ru, 1999, Competition among exchanges: Does multiple listing affect trading costs on options markets? Working paper, University of Chicago.

White, Halbert, 1980, A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity, *Econometrica* 48, 817–838.