THE EFFECT OF MULTIPLE LISTINGS ON THE BID–ASK SPREAD IN OPTION MARKETS: THE CASE OF MONTREAL EXCHANGE

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In this article, we examine the effect of multiple listings of options on their bid–ask spread, by comparing options contracts listed only on the Montreal Exchange with those interlisted on that exchange and on a U.S. exchange as well. Using a statistical procedure adapted to panel data and two models for the determination of the bid–ask spread, we find that the bid–ask spreads of Montreal options interlisted in U.S. markets are narrower than those of non-interlisted options. That advantage tends to disappear, however, with an increase in option price and to increase with its volatility, but is not affected by the volume of transactions in the option market. The analysis also shows that interlisting may result in time lags in the convergence of quotes between Montreal and the U.S. markets. Moreover, our evidence shows that with interlisting, volume shifts to the option market where trading in the underlying security is concentrated, irrespective of the location where the option was first introduced. © 2002 Wiley Periodicals, Inc. Jrl Fut Mark 22:939–957, 2002

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INTRODUCTION

In 1997, The Toronto stock exchange served notice to the Montreal exchange that it intended to interlist Montreal derivatives on its floor, thus reneging on their agreement to the effect that each exchange had the exclusive rights over the derivatives it listed. After several meetings, the four principal Canadian exchanges reached a new agreement in 1999, restructuring their markets along the lines of market specialization. Under this agreement, the Montreal Exchange became the sole market for derivative products in Canada, the Toronto Stock Exchange became the market for large cap equity, and a new stock exchange—the Canadian Venture Exchange—opened for trading in small cap equity. One of the main objectives of this restructuring is to "avoid market fragmentation by centralizing liquidity in one market."[1] By opting for market specialization, the exchanges clearly rejected interlisting of derivatives as an alternative course of action. This article attempts to shed light on the soundness of this new arrangement by analyzing the implications of order flow fragmentation of Montreal options interlisted on U.S. exchanges. To our knowledge, the literature devoted to the interlisting of options has not until now dealt with the simultaneous listing of the same option in Canadian and U.S. markets. The specific characteristics of this situation offer some unique features that make it worthy of particular attention.

Since its inception, the option market of the Montreal exchange was, and still is as of the time of writing, a monopoly-dealer (specialist) market. As of December 31, 1997, 88 classes of options were listed at the Montreal Exchange. Of this total, 26 classes were also interlisted on the Chicago Board of Option Exchange, the American Stock Exchange, the Pacific Stock Exchange, and the Philadelphia Stock Exchange. The options interlisted in these U.S. markets represent the most liquid segment of the Montreal option market; they typically account for around 60% of the total volume of transactions even though they represent roughly 30% of listed options.[2] Their underlying securities belong to some of the largest canadian corporations; they were interlisted in the United States before their options, and are among the most traded in Canada accounting for about 14% of the total volume of transactions even though they represent roughly 1.75% of listed stocks.[3]

It is commonly known that the listing of a security on several different exchanges leads to a competitive market structure in which market

[1]Montreal Exchange: Annual Report 1999, p. 4.

[2]This information was privately obtained from the Montreal Exchange.

[3]TSE Review, October 1997, and information privately obtained from the Montreal exchange.

makers must strive to attract order flows. Single listings, by contrast, concentrate order flows in one particular market. Opinions are divided as to the relative merits of multiple versus single listings. With respect to multiple listings, the advantage most often cited is the reduction of transaction costs for the investor (primarily via the reduction of the bid–ask spread) (Benston & Hagerman, 1974; Branch & Freed, 1977; Hamilton, 1979). However, multiple listings also fragment order flows among various rival markets, with the possible negative effects of liquidity reduction, poorer price discovery performance, nonunique prices for the same securities across markets, and transaction execution that may be slower or of lower quality (Cohen et al., 1985, 1986; Noronha et al. 1996).

Indeed, several studies have addressed the general question of the simultaneous trading of a security at two or more locations and the effect such multiple trading has on market microstructure. Chowdhry and Nanda (1991), for example, develop a multimarket trading model for interlisted securities that demonstrates that competition among market makers facilitates the transmission of information among these competing markets and deters insider trading in them. However, information lags between these markets is shown to produce short-term disparities in the prices of securities that trade simultaneously in them. Moreover, the authors also show that order flow in the case of multiple trading becomes concentrated in one dominant location, namely the one with the lowest trading costs. Foerster and Karolyi (1998) use transaction data for Toronto Stock Exchange (TSE) stocks that became interlisted on U.S. exchanges between January 1981 and December 1990, to examine the impact of interlisting on their "posted" and "effective" bid–ask spreads. Their results show that both spreads decreased for these stocks on the TSE market after interlisting. However, the decline was concentrated in those stocks whose trading volume diverted significantly to the United States after interlisting. This evidence can be seen as an extension of Chowdhry and Nanda's model. Mendelson (1987) studies the impact of consolidation versus fragmentation on several aspects of market performance under two alternative exchange regimes, namely a clearing house and a dealer market mechanism. He demonstrates that, in general, fragmentation has negative and positive effects on market performance. Röell (1990) also examines the impact of competition among multiple professional broker-dealers under the assumption that they can distinguish liquidity trading from insider trading among their customers. It is found that broker-dealer profits, insider profits as well as transaction costs to liquidity traders as a group are minimized under competition. Although the analysis in the above studies is not confined to multiple listings of options, the insights it provides will be helpful when discussing the empirical results of this article.

Thus, central to the comparison of the two regimes is an analysis of market quality, which is affected by many aspects of market microstructure. In this study we compare and contrast order flow fragmentation for options (via multiple listings) with concentration (via a single listing) mainly through their impact on bid–ask spreads. The empirical tests will focus on Montreal options interlisted on U.S. markets as opposed to those traded only on the Montreal exchange. Section I contains a review of previous studies, methodology, data, and the empirical evidence pertaining to this issue. Section II presents other empirical results relating to the quote adjustment delay between the United States and Canadian option markets and the relation between concentration of transactions in an option and concentration of transactions in the underlying security. Our concluding remarks are presented in the last section.

THE BID–ASK SPREAD OF OPTIONS

It is now a commonplace observation that the components of stocks bid–ask spreads are: order processing costs, inventory costs, and asymmetric information costs (Huang & Stoll, 1997; Khoury et al., 1991; Stoll, 1989). Early literature mostly lumped the first two components together (Benston & Hagerman, 1974; Demsetz, 1968; Stigler, 1964), but later studies emphasized inventory holding costs associated with the fluctuating level and lack of diversification of liquidity suppliers inventories (Amihud & Mendelson, 1980; Ho & Stoll, 1980; Stoll, 1978, 1989). Other researchers focused on the third component of the spread that arises when liquidity suppliers deal with informed traders (Copeland & Galai, 1983; Glosten & Milgrom, 1985). In this regard, a substantial increase in the volume of transactions denotes an increased activity on the part of informed traders that sends a signal to the liquidity supplier to widen his spread (Hasbrouck, 1988; Lee et al., 1993). In their empirical analysis Huang and Stoll (1997) identify and estimate all the components of the spread at which trades of 19 stocks in the Major Market Index occurred in 1992. Their results show that the average order-processing component of traded spread amounts to 61.8% the average inventory cost component 28.7% and the average adverse information component 9.6%. The authors also show that the spread components differ significantly according to trade size.

The article by Khoury, Yourougou, and Vigneau (1991) ("KYV") presents a complete decomposition of the bid–ask spread of Canadian options into its determinants. The study covers 35,780 transactions on 556 call options written on 33 different Toronto Stock Exchange listed stocks, together with 242,289 transactions on their underlying stocks, over the period from April to June 1988. The authors test the hypothesis that options bid–ask spreads are determined by the same variables that determine the underlying securities bid–ask spread in addition to the specific characteristics of option markets. The evidence reveals that the liquidity characteristics of the underlying security are transmitted to its call options. However, of all the factors affecting option bid–ask spread, the option price (representing the capital invested in the specialist's inventory), the continuity of the option market, and whether the option is in-the-money or not (reflecting the degree of transmission of the underlying security's liquidity characteristics to the option) appear to be the most important determinants of bid–ask spreads.

The option price alone accounts for 31.6% of spread variation, the continuity of the option market accounts for 3.8%, while the "moneyness" of the option accounts for 4.1%. The entire model explains 46.3% of option spread variation. The results also reveal that the standard deviation of the option and that of its underlying security are positively correlated. The nonsystematic risk of the option is, however, overshadowed by that of its underlying security, particularly when the potion is in the money. On the other hand, both the volume of transactions and the continuity of the market seem to characterize the level of activity of the option market. This is reflected in the result that the higher the option's volume of transaction the more pronounced the negative effect of the continuity of the option market on the option spread. More notably, neither the volume of transactions of the underlying security nor the proportion of this volume accounted for by block trading do have any bearing on the option spread. We will return to the findings of this study when formulating our bid–ask model.

Empirical analysis of the bid–ask spread of U.S. options was carried out in two articles by Neal (1987, 1992). The first study compares the bid–ask spread of AMEX options interlisted on a second exchange, to the bid–ask spread of options traded only on AMEX. The sample used in the study is made up of 16 interlisted options and 27 options listed only on AMEX, and covers 3 different trading weeks. To minimize the incidence of price and maturity, the author limited the sample to at-par options with 1 week to maturity at the end of the sampling period. His model specifies that option spread is function of its daily transactions volume, its price calculated as the average between the bid and the ask prices, the implicit volatility of its underlying security, whether the option is interlisted or not, and whether its price is higher than 0.50$ or not. The results of the study show that interlisting of options indeed reduces their bid–ask spread.[4] However, as the volume of transaction increases, the reduction in the spread grows smaller until it becomes negligible.[5]

In the second study, Neal makes a comparative analysis of the bid–ask spread of options listed on AMEX with those listed on CBOE, using essentially the same model of his previous study. His purpose is to compare the impact on the spread of a market structured around the specialist to one structured around competition between market makers. The sample used in this study is made up of 26 Amex options and 16 CBOE options. The data covers two different trading weeks, and all options are at par with 1 week to maturity at the end of the sampling period. The results show that options with a low volume of transactions exhibit a narrower bid–ask spread when traded on an exchange structured around a specialist. By contrast, options with a relatively high volume of transactions exhibit a narrower bid–ask spread when traded on a market structured around competitive market makers. These findings are consistent with the theoretical results of the model by Grossman and Miller (1988).

Methodology

To examine the effect of multiple listings of options on their bid–ask spreads, we compare the options contracts listed only on the Montreal Exchange with those interlisted on that exchange and on a U.S. exchange as well. To neutralize the effects of maturity and in-the-money characteristics on the bid–ask spread as revealed in the KYV study cited above, only at-the-money options expiring within 1 month are analyzed. This reduced sample better represents overall option transaction activity than would a set of more varied expiration dates and strike prices, and also leads to better estimates of option price volatilities.

The focus of our analysis is to examine the implications of options interlisting on their bid–ask spread. Thus, following KYV (1991) and Neal (1987, 1992) we retain only those variables that were found to be potential explanations of the effect of interlisting on the bid–ask spread. Consequently, we posit that the relationship between the listing of an

[4]By projecting the volume of transactions to zero, the author estimated the maximum reduction of the bid–ask spread at around 20% or 4$ per contract.

[5]The volatility of the volume of transactions makes it impossible to estimate with any reasonable precision the level of transactions after which interlisting has no impact on the bid–ask spread. Nevertheless, the author suggested that 1500 options per day is the threshold after which competition no longer reduces the bid-ask spread.

option contract on more than one exchange and the bid–ask spread is related to the following variables:

1. the option price, calculated as the average between the bid and ask quotes
2. the number of daily transactions
3. the daily standard deviation of the option price calculated from the middle point of posted quotes, or alternatively, the implied daily volatility of the underlying security estimated using also the middle point of posted quotes.

As KYV have shown, the option price is the most important determinant of its bid–ask spread, explaining 31.6% of spread variation (compared to a total of 46.33% for the entire model). Indeed, the option price represents the capital invested in option inventories needed to maintain immediate liquidity in the market. Thus, higher option prices imply greater investment in inventories, and consequently, larger bid–ask spreads. We expect, therefore, to find a positive relationship between option prices and bid–ask spreads.

We employ the daily number of transactions instead of the average daily volume of transactions to measure option market activity, to avoid the distorting effects of extreme values associated with the latter statistic. According to the asymmetric information approach to the spread, more active options are likely to be associated with increased activity on the part of informed traders. Liquidity suppliers are, therefore, induced to widen their spread in the face of increased market activity as a buffer against adverse selection costs. This observation is consistent with the notion that option markets serve as testing ground for new information related to their underlying stocks (Gendron et al., 1994). We expect, therefore, a positive relationship between this activity variable and the bid–ask spread.

As KYV have argued, the market maker's portfolio is not usually sufficiently diversified to offset exposure to market fluctuations, and in fact, a complete diversification would be inconsistent with the efficiency required by market-making activities. Consequently, total rather than systematic risk of the option is the most appropriate risk measure from the point of view of the market maker. The daily standard deviation of the option price can thus be used as a proxy for the risk of market movements to which the market maker is exposed. Alternatively, one might consider that the use of the daily implied volatility of the underlying security would provide a more consistent measure of this risk. This alternative variable will also be tested. These two measures of risk are, of course, alternative proxies of option volatility. We, therefore, expect that with either proxy the relationship between option volatility and the bid–ask spread would be positive, given the risk aversion of the market maker. It should also be noted that by using the middle point of posted quotes to calculate the daily standard deviation of option prices as well as the daily implied volatility of the underlying securities, we avoid the problems of market thinness and multicolliniarity mentioned by Neal (1987), which arise when prices at which true transactions occur are used. This is because market participants typically hit either the market maker's bid or offer price in real time. Our model is specified to eliminate this problem, which reinforces the conclusions that will be reached.

The above three variables identify inventory holding and adverse selection components of the option spread. The remaining portion associated with order processing costs is reflected in the intercept of models (1) and (2) below.

Neal (1987) observed that the effects of multiple listings on the bid–ask spread could be analyzed using the theory of contestable markets. Recall that this theory takes into account potential competition rather than existing competition, and requires only that potential competitors enter and exit the market at a negligible cost. The resulting competitive pricing is then expected to reduce the equilibrium price to the level of marginal cost. In this study, market contestability has been incorporated by allowing the coefficients of each independent variable in the model to vary according to whether an option is considered to be traded in a contestable market (if interlisted) or in an uncontestable market (if listed on a single market). As such, we should be able to detect if the bid–ask spread is narrower for interlisted options than for options with a single listing, and if the specification of the bid–ask spread differs between these two types of markets.

The following constrained and unconstrained models will be used:

$$\text{Spread} = B_{10} + B_{11}INT + B_{12}P + B_{13}NBT + B_{14}VOL + \varepsilon_1 \qquad (1)$$

$$\begin{aligned}\text{Spread} = {} & B_{20} + B_{21}INT + B_{22}P + B_{23}P \times INT + B_{24}NBT \\ & + B_{25}NBT \times INT + B_{26}VOL + B_{27}VOL \times INT + \varepsilon_2 \qquad (2)\end{aligned}$$

where P is the option price calculated as the average between the bid and ask quotes, NBT is the number of daily transactions, VOL is the proxy of option volatility (either the daily standard deviation of the option price or alternatively the daily implied volatility of the underlying security), and INT is the dummy variables indicating interlisting.

As Neal (1987) demonstrated, the theory of contestable markets allows the prediction of a narrower bid–ask spread under the influence of potential competition. Consequently, we expect a smaller bid–ask spread for interlisted option contracts than for those with a single listing. This would result in an intercept that is smaller for the interlisted firms than for those listed in the Montreal Exchange only.

Model (1) has no interaction terms. This forces the regression to have the same slope for both the interlisted and noninterlisted options. On the other hand, Model (2) introduces interaction terms that allow the slope to be different in both regressions. Indeed, as underlined by Neal (1987), the effect of interlisting on the spread is related to potential rather than real competition. To detect if the determinants of the bid–ask spread of interlisted options are different from those of noninterlisted options, we compare the unconstrained Model (2) to the constrained Model (1) using a maximum likelihood ratio.

Data

The data used in this research was obtained from tapes provided by the Montreal Exchange. These tapes contain Canadian dollar (C$) prices, quote by quote and transaction by transaction on 68 classes of options registered at the Montreal Exchange, 26 of which are also registered in the United States. The observation period goes from November 18 to December 18, 1997 (21 days). Models (1) and (2) were estimated using a sample that covers 1428 observations of closing prices.

The description of the data presented above brings into evidence the fact that it follows a "panel" format. That is, we have 68 series of 21 middle points of closing bid–ask quotes, each serie corresponding to an option. The presence of panel data means that errors may not be homoskedastic, with the variation due either to the passage of time or the change in option.

Given the panel nature of the data, GARCH methodology is not applicable. However, to control for heteroskedasticity we use a random effect model of error correction.[6] We also apply "robust error" estimation techniques that follow White's (1980) technique to compute a consistent estimate of the covariance matrix allowing for heteroskedasticity and autocorrelation. Because the computed covariance matrix was positive definite, we had no need to apply the procedure of Newey and West (1987). Finally, we also use a weighted least-square (WLS) estimation technique to estimate Models (1) and (2). The justification for using

[6]See, for example, Davidson and MacKinnon (1993).

this technique is based on observations made by KYV. There it is noted that the volume of transactions produces a stratification of the sample. More concretely, KYV noted that the Mahalanobis distance allows them to identify four strata of concentration in the residuals of a bid–ask spread regression based on volume of transactions. We thus apply WLS with a function of our proxy of transaction volume used as the weights for the errors. Specifically, the weights take the form $p_t = 1/\sqrt{V_t}$, where V_t, is the volume of transaction (our NBT variable) of the option at time t. The advantage of this procedure over simple White (1980) consistent covariance technique is that it is based on a known source of heteroskedasticity.[7]

To control for autocorrelation we modify our WLS procedure to introduce an error specification as follows: $\varepsilon_\tau = \rho\varepsilon_{\tau-1} + \upsilon_\tau$. The parameters of the model thus modified were estimated using the Beach and MacKinnon (1978) maximum likelihood procedure.

Empirical Results

Maximum likelihood tests suggest that estimating the model by the weighted least-squares technique with first-order autocorrelation error correction and using maximum likelihood search is superior to estimating it using White (1980) correction of the covariance matrix for heteroskedasticity and autocorrelation, generating substantially lower sums of squared residuals. This lends further support to the finding of KYV that the samples are clustered around the volume of transactions. We also compared the constrained and unconstrained models (1) and (2) using a Wald test. With an $F(3, 1332)$ equal to 14.06 we reject the hypothesis of null interaction terms with a very high level of confidence. The results of this test suggest that the explanatory power of the unconstrained version of the model is greater than that of the constrained version. The results of the test for the constrained and unconstrained models are presented in Tables I and II where option risk is proxied by the variance of its quotes, and in Tables III and IV where it is proxied by the implied volatility of the underlying security. Details of the results of the Wald test are presented at the bottom of Tables II and IV.

Tables I and III exhibit the results of model (1) applied to the 68 option classes examined using WLS. As the tables show, the intercept of those Montreal Exchange listed options that are also listed on a U.S. exchange is lower than that of the noninterlisted options by about 1/20 of the spread of the noninterlisted options. Although the difference is

[7]See, for example, Pindyck and Rubinfeld (1981, Section 6.1).

TABLE I

Impact of Interlisting on the Option Bid–Ask Spread—Constrained Model (with Volatility Proxied by the Daily Standard Deviation of Options Mid Bid–Ask Quotes)

Variable	*Coefficient*	*t-Statistic*	*Significance*
Constant	0.222	46.18	0.000
INT	−0.010	−2.44	0.014
P	0.019	9.09	0.000
NBT	−0.001	−1.36	0.173
VOL	−0.001	−1.65	0.098
RHO	0.356	13.58	0.000

Note. This table presents the results of the following regression equation:

$$\text{Spread} = B_{10} + B_{11}INT + B_{12}P + B_{13}NBT + B_{14}VOL + \varepsilon_1$$

where P is the option price calculated as the average between the bid and ask quotes; NBT is the number of daily transactions; VOL is the proxy for option volatility; and INT is a dummy variable indicating interlisting. Estimation was performed by Maximum Likelihood Search, with 1407 observations. Adjusted R^2 is 0.21 and the Durbin-Watson Statistic, 2.038.

TABLE II

Impact of Interlisting on the Option Bid–Ask Spread—Unconstrained Model (with Volatility Proxied by the Daily Standard Deviation of Options Mid Bid–Ask Quotes)

Variable	*Coefficient*	*t-Statistic*	*Significance*
Constant	0.132	44.56	0.0000
INT	−0.016	−3.32	0.0009
P	0.014	4.77	0.0000
INT × P	0.014	3.21	0.0014
NBT	−0.001	−1.15	0.2504
INT × NBT	0.001	0.32	0.7512
VOL	0.007	5.32	0.0000
INT × VOL	−0.008	−5.63	0.0000
RHO	0.349	3.22	0.0000

Note. This table presents the results of the following regression equation:

$$\text{Spread} = B_{20} + B_{21}INT + B_{22}P + B_{23}P \times INT + B_{24}NBT + B_{25}NBT \times INT + B_{26}VOL + B_{27}VOL \times INT + \varepsilon_2$$

where symbols are as described in Table I. Estimation was performed by Maximum Likelihood Search with 1407 observations. Adjusted R^2 is 0.23 and the Durbin-Watson Statistic, 2.038. A **Wald Test** with Null Hypothesis that all interaction terms are zero yields $F(3, 1332) = 14.06017$ with Significance Level of 0.000.

small it is highly significant, with a t statistic of 2.44 in Table I and 2.41 in Table III. This result is consistent with our expectations and with the empirical results obtained by Neal (1987) for the United States. As mentioned earlier the intercept can be associated with the first component of the market's quality, namely the cost of executing orders. With this

TABLE III

Impact of Interlisting on the Option Bid–Ask Spread—Constrained Model (with Volatility Proxied by the Daily Implied Volatility of the Underlying Security)

Variable	*Coefficient*	*t-Statistic*	*Significance*
1. Constant	0.209	40.04	0.000
2. INT	−0.009	−2.41	0.016
3. P	0.019	9.02	0.000
4. NBT	−0.001	−1.55	0.121
5. IMPVOL	0.021	4.77	0.000
6. RHO	0.322	11.56	0.000

Note. This table presents the results of the following regression equation:

$$\text{Spread} = B_{10} + B_{11}INT + B_{12}P + B_{13}NBT + B_{14}VOL + \varepsilon_1$$

where symbols are as described in Table I. Estimation was performed by Maximum Likelihood Search with 1344 observations. Adjusted R^2 is 0.201 and the Durbin-Watson Statistic, 2.071.

TABLE IV

Impact of Interlisting on the Option Bid–Ask Spread—Unconstrained Model (with Volatility Proxied by the Daily Implied Volatility of the Underlying Security)

Variable	*Coefficient*	*t-Statistic*	*Significance*
1. Constant	0.113	36.68	0.0000
2. INT	0.000	0.03	0.9789
3. P	0.011	3.97	0.0001
4. INT × P	0.018	4.32	0.0000
5. NBT	−0.001	−1.00	0.3158
6. INT × NBT	−0.000	−0.23	0.8204
7. IMPVOL	0.043	7.73	0.0000
8. INT × IMPVOL	−0.054	−6.21	0.0000
9. RHO	0.305	10.89	0.0000

Note. This table presents the results of the following regression equation:

$$\text{Spread} = B_{20} + B_{21}INT + B_{22}P + B_{23}P \times INT + B_{24}NBT + B_{25}NBT \times INT + B_{26}VOL + B_{27}VOL \times INT + \varepsilon_2$$

where symbols are as described in Table I. Estimation was performed by Maximum Likelihood Search with 1344 observations. Adjusted R^2 is 0.233 and the Durbin-Watson Statistic = 2.061. A **Wald Test** with Null Hypothesis that all interaction terms are zero yields an $F(3, 1269) = 17.78691$ with Significance Level 0.000.

interpretation, one can conclude that interlisting results in lower order execution costs, thus increasing the quality of the market.

In addition, the coefficient of the price (P) variable has the hypothesized sign, and is highly significant with a t statistic of 9.09 in Table I and 9.02 in Table III. With respect to the number of transactions (NBT) the coefficient is negative but not significantly different from zero in both tables. The coefficient of the standard deviation of the option price (*VOL*) in Table I, which represents the risk to which the market maker is exposed, is negative, contrary to expectation, and significant at the 10% level.[8] However, in Table III, that coefficient is positive, as expected, and highly significant with a t value of 4.77.

Tables II and IV present the results of the estimation of model (2) using WLS and including interaction terms. As the tables show, the constant term remains largely unchanged. The impact of interlisting on the spread is still negative and significant in Table II but non significant in Table IV. However, the impact of interlisting comes out very strongly in the interaction terms involving the option price and its volatility in both tables. Indeed, the tables reveal that the coefficient of the interaction term with the option price is positive and significant at least at the 1% level. The sign of the coefficient of the interaction term suggests that the advantage in the bid–ask spread of interlisted options tends to disappear with an increase in the price of the option. Regarding the coefficient of option volatility, it is positive and highly significant as expected in both tables. On the other hand, the coefficient of the interaction term with option volatility is negative and highly significant, indicating that the sensitivity of the spread to volatility decreases for interlisted options. In other words, the advantage in the bid–ask spread of interlisted options tends to increase with volatility. Finally, both the coefficients of the number of transactions and its interaction terms are not different from zero in a statistical sense in both Tables II and IV. In both the constrained and unconstrained regressions the first-order autocorrelation terms are highly significant, justifying the use of an autoregressive model in the estimation.

It would also be interesting to evaluate the impact of interlisting on the bid–ask spread across interlisted options as function of the concentration of trading between the United States and Montreal. To this end, we created a dummy variable for interlisted options that took the value of 1 when trading volume in U.S. markets exceeded 50% of the combined United States and Montreal total volume and 0 otherwise. The results show that the narrowing of the spread is more pronounced for interlisted options whose volume of transactions was more heavily concentrated in the United States rather than in Montreal. Although interesting, the

[8]It is interesting to note that we have also estimated the variance using an alternative procedure consisting of the sum of the squared changes in price. Models (1) and (2) were estimated using that definition of the variance. The results show no difference with regard to interlisting, which is the focus of our analysis. However, the sign of the coefficient of the variance was negative, contrary to expectation.

results are not, however, statistically significant, probably because of the relatively limited number of observations of interlisted options.[9] Nevertheless, these findings are consistent with the evidence reported by Forester and Karolyi (1998) for Toronto Stock Exchange stocks interlisted on U.S. exchanges.

We can thus conclude from our theoretical analysis and empirical results that the interlisting of Canadian options in the United States leads to a decrease in bid–ask spreads on the interlisted options. This result is consistent with the evidence on interlisted options and interlisted stocks in the United States (Benston & Hagerman, 1974; Branch & Freed, 1977; Hamilton, 1979; Neal, 1987, 1992). However, the magnitude of this reduction is difficult to predict in advance, as it is a function of several variables related to inventory costs, execution costs, and the potential cost of adverse information to the market maker. In addition, as the KYV article has shown, liquidity in the option market depends not only on the characteristics of the options traded but also on those of their underlying securities. This makes the prediction of the reduction in the bid–ask spread even more complicated.

OTHER RESULTS

The data collected for this study also allows some insights into two other implications of the interlisting of Montreal options in the United States: the quote adjustment delay between the United States and the Canadian options market on the one hand, and the relationship between concentration of transactions in options and concentration of transactions in their underlying securities on the other.

Quote Adjustment Delay

Order flow fragmentation can result in different price quotes for the same security in various markets, because the price in each market does not then reflect all the available information about demand and supply curves for the security. This result is consistent with Chowdhry and Nanda's (1991) analysis. This problem is particularly present with respect to the opening prices of the same option classes quoted on different exchanges which begin trading more or less simultaneously in the morning.[10]

In this regard, the average length of time needed for quotes of the same option classes interlisted on the Montreal and U.S. Exchanges to adjust to each other can be quite revealing, particularly in view of the lack

[9]The number of observations for interlisted options is limited to a total of 540.
[10]See SEC, File # S7-25-87 and File # S7-15-89.

of complete integration of Canadian and U.S. markets. Indeed, differential taxation between the two countries as well as factors related to firm size such as information incompleteness contribute to the partial segmentation of these markets (Bellemare, 1997). To estimate the synchronicity of these quote adjustments, we first identified on the Montreal Exchange over the December 1 to 5, 1997 period the bid–ask quotes of at-the-money options expiring in December 1997 that were listed on both the Montreal and a U.S. Exchange. These options were among the most active over this period. We then selected on the U.S. market the corresponding options expiring in December 1997 with a comparable strike price after adjusting for the exchange rate. The options thus retained for analysis are those option pairs in which the Montreal Exchange series of quotes represent a monotonic transformation of those listed on a U.S. Exchange (or vice versa), given the imperfections associated with the lack of complete integration of U.S. and Canadian financial markets. The final sample is thus limited to eight interlisted option pairs with quotes that move almost in perfect lockstep. To measure the relative quote adjustment delay, the average between the bid and ask quotes were successively recalculated on both the Montreal and the relevant U.S. Exchange, and listed in chronological order. The approach used then consists in estimating the length of time needed for the differences between successive quote variations in the two countries to fall back within a bound of ±5c.

Table V shows the time needed to converge to a difference between Montreal and U.S. quotes of a maximum of 5 cents per option. The adjustment is the most rapid upon market opening, with an average time to convergence of 7 min for call options and 3.30 min for put options. This is significant given that the first half-hour of trading represents about 10% of all daily transactions in interlisted at-the-money options on the Montreal Exchange. The average time to convergence expands as the day goes on, and is 16 min for call options and 10 min for put options when measured over the entire trading day. Without perfect integration of U.S. and Canadian financial markets, this noninstantaneous convergence of quotes allows for the potential problem of trade through, in which investors' orders are filled at disadvantageous prices.[11] This result is all the more significant because 62% of the volume of transactions in

[11]It is important not to underestimate the preoccupation of market participants concerning trade throughs. The following citation taken from the 1997 Toronto Stock Exchange document *Summary of Responses to the Blueprint (1997)* sheds some light on these concerns: "However, there was almost universal agreement among those in favour that the Exchange's trading system must automatically either route orders to the best market or guarantee a fill at the best price in order to prevent trade throughs. No one believed that multiple listing would be acceptable without some form of trade through protection for the broker."

TABLE V
Adjustment Delay for the 8 At-the-Money Option Pairs Interlisted on the Montreal and U.S. Exchanges

	All Options	*Calls*	*Puts*
Entire Day			
Less than 15 s	11.08%	12.75%	9.51%
Less than 1 min	32.44%	33.66%	31.29%
Less than 5 min	61.71%	59.15%	64.11%
Less than 15 min	79.27%	75.81%	82.52%
More than 15 min	20.73%	24.18%	17.48%
Average daily	0:13:21	0:16:19	0:10:34
Before 10 h			
Less than 15 s	15.39%	14.52%	17.65%
Less than 1 min	39.23%	38.71%	41.18%
Less than 5 min	70.00%	67.74%	72.06%
Less than 15 min	93.85%	91.94%	95.59%
More than 15 min	6.15%	8.06%	4.41%
Average daily	0:05:16	0:07:03	0:03:39

Note. This table shows the time needed to converge to a difference between Montreal and U.S. quotes of a maximum of 5 cents per option.

interlisted options on the Montreal exchange during the period under study compared to 61% for noninterlisted options came from large orders of 50 options or more.

Concentration of Transactions

It is also interesting to verify if the concentration of transactions in options follows the concentration of transactions in their underlying securities. To this end we analyze information privately obtained on the trading of all Canadian options (then listed on both Montreal and Toronto exchanges) interlisted in the United States and on their underlying securities for the period January to October 1997. The data thus comprises the total population of the 45 interlisted Canadian options and their underlying securities.[12]

The data reveals that 56% of these options have at least 70% of their transactions concentrated on a single exchange. Moreover, the concentration of transactions in an option seems to follow the concentration of transactions in the underlying security irrespective of the location

[12]Data for these calculations was privately supplied by the Montreal Stock Exchange. Although the main focus of this study is on Montreal options, information on all Canadian options interlisted in the United States reinforces the conclusions reached in this regard.

where the option originated from. Indeed, by regressing the share of the Canadian market in the volume of transactions in these options against its share in the volume of transactions in their underlying securities, we obtain a slope coefficient of 0.93 with an R^2 of 0.49.

CONCLUSIONS

The purpose of this article is to shed light on the soundness of the decision of the Canadian exchanges to concentrate trading of derivative products on the Montreal exchange, by examining the effects of order flow fragmentation of Montreal options interlisted in the United States on their bid–ask spread. The article also provides an empirical investigation of two further implications of the simultaneous listing of the same option in Canadian and U.S. markets. The unique features of this interlisting, and the fact that it has not been dealt with before, make it worthy of particular attention.

Using a statistical procedure adapted to panel data, we tested two models of the determination of bid–ask spreads, one with an interaction term and the other without, and controled for heteroskedasticity by using random effects models estimated with a WLS procedure. The risk variable for the option was also measured in two alternative ways: as the daily standard deviation of the option quote, and as the implied daily volatility of the underlying security. In all cases, our findings show that the bid–ask spread of Montreal options interlisted in U.S. markets are narrower than those of noninterlisted options. The narrower spread for interlisted options results from a decrease in the execution costs that are uncompensated by any increase in the other components of the spread. The findings also show that the advantage (in terms of narrowing of the bid–ask spread) of options interlisted in U.S. markets tends to disappear with an increase in the option price and to increase with its volatility; however, it is not affected by the volume of transactions in the option market.

However, the analysis shows that interlisting may result in time lags in the convergence of quotes between Montreal and the U.S. markets. This situation can give rise to a potential problem of trade through, that preoccupies market participants to a degree that should not be overlooked. Moreover, our evidence shows that with interlisting, volume shifts to the option market where trading in the underlying security is concentrated, irrespective of the location where the option was first introduced. One may surmise that this could have become a source of conflict among Canadian exchanges had they opted for dual listing of options.

It is tempting to think that interlisting of options within Canada, had it been approved by the exchanges, would have resulted in increased potential competition and narrower bid–ask spreads as predicted by the theory of contestable markets. However, the particular institutional setup in Canada, which is rooted in the traditional political and cultural divisions in the country, is not usually conducive to such an increased competition. In the circumstances, it is unlikely that interlisting would have had an impact on competition; and the decision of Canadian exchanges to restructure along the lines of market specialization had at least the merit of avoiding all the negative effects of interlisting mentioned above.

BIBLIOGRAPHY

Amihud, Y., & Mendelson, H. (1980). Dealership market: Market-making with inventory. Journal of Financial Economics, 8, 31–53.

Beach, C., & MacKinnon, J. (1978). A maximum likelihood procedure for regression with autocorrelated errors. Econometrica, 46, 51–58.

Bellemare, G. (1997). Capital market segmentation: The case of Canada and the US. Unpublished Ph.D. dissertation, Faculty of Management, University of Toronto.

Benston, G. J., & Hagerman, R. L. (1974). Determinants of the bid-ask spreads in the over-the-counter market. Journal of Financial Economics, 1, 353–364.

Branch, B., & Freed, W. (1977). Bid-asked spreads on the Amex and the big board. The Journal of Finance, 32, 159–163.

Chowdhry, B., & Nanda, V. (1991). Multimarket trading and market liquidity. Review of Financial Studies, 4(3), 483–511.

Cohen, K. J., Conroy, R. M., & Maier, S. F. (1985). Order flow and the quality of the market, marketmaking and the changing structure of the securities industry. Amihud, Ho, & Schwartz (Eds.). Lexington Books.

Cohen, K. J., Maier, S. F., Schwartz, R. A., & Whitcomb, D. K. (1986). The microstructure of securities markets. Englewood Cliffs, NJ: Prentice-Hall.

Copeland, T. E., & Galai, D. (1983). Information effects on the bid-ask spread. Journal of Finance, 38, 1457–1469.

Davidson, R., & MacKinnon, J. G. (1993). Estimation and inference in econometrics. New York: Oxford University Press.

Demsetz, H. (1968). The cost of transacting. Quarterly Journal of Economics, 82, 33–53.

Foerster, S. R., & Karolyi, G. A. (1998). Multimarket trading and liquidity: A transaction data analysis of Canada–US interlistings. Journal of International Financial Markets, Institutions and Money, 8, 393–412.

Gendron, M., Khoury, N., & Yourougou, P. (1994). Probability of price reversal and relative noise in stock and option markets. Journal of Financial Research, XVII(2), 147–159.

Glosten, L. R., & Milgrom, P. R. (1985). Bid-ask and transaction prices in a specialist market with heterogeneously informed traders. Journal of Financial Economics, 14, 71–100.
Grossman, S. J., & Miller, M. H. (1988). Liquidity and market structure. Journal of Finance, 43(3), 617–637.
Hamilton, J. L. (1979). Marketplace fragmentation, competition, and the efficiency of the stock exchange. The Journal of Finance, 34, 171–184.
Hasbrouck, J. (1988). Trades, quotes, inventories, and information. Journal of Financial Economics, 22, 229–252.
Ho, T., & Stoll, H. (1980). On dealer markets under competition. Journal of Finance, 35, 259–267.
Huang, R. D., & Stoll, H. R. (1997). The components of the bid-ask spread: A general approach. The Review of Financial Studies, 10(4), 995–1034.
Khoury, N., Yourougou, P., & Vigneau, G. (1991). Les déterminants du coût de la liquidité immédiate sur le marché canadien des options. L'actualité Economique, 67(4), 499–516.
Lee, C. G., Mucklow, B., & Ready, M. (1993). Spreads, depths, and the impact of earnings information: An intraday analysis. Review of Financial Studies, 6, 345–374.
Mendelson, H. (1987). Consolidation, fragmentation, and market performance. Journal of Financial and Quantitative Analysis, 22(2), 189–207.
Neal, R. (1987). Potential competition and actual competition in equity option. Journal of Finance, 42(3), 511–531.
Neal, R. (1992). A comparison of transaction cost between competitive market and specialist market structures. Journal of Business, 65(3), 317–334.
Newey, W., & West, K. (1987). A simple positive-definite heteroskedasticity and autocorrelation consistent covariance matrix. Econometrica, 55, 703–708.
Noronha, G. M., Sarin, A., & Saudagaran, M. (1996). Testing for microstructure effects of international listing using intraday data. Journal of Banking and Finance, 20(6), 965–983.
Pindyck, R., & Rubinfeld, D. (1981). Econometric models and economic forecasts (2nd ed.). New York: McGraw-Hill.
Röell, A. (1990). Dual-capacity trading and the quality of the market. Journal of Financial Intermediation, 1, 105–124.
SEC, File #S7-15-89, May 26, 1989, and File #S-25-87, May 26, 1989.
Stigler, G. J. (1964). Public regulation of the securities markets. Journal of Political Economy, 37(2).
Stoll, H. (1978). The pricing of security dealer services: An empirical study of NASDAQ stocks. Journal of Finance, 33, 1153–1172.
Stoll, H. R. (1989). Inferring the components of the bid-ask spread: Theory and empirical tests. Journal of Finance, 44, 115–134.
TSE. (1997). Summary of responses to the blueprint.
White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and direct test for hereroskedasticity. Econometrica, 48, 817–838.