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Testing for micro-structure effects of international dual listings using intraday data

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Abstract

This paper examines the impact on the liquidity of NYSE/AMEX listed stocks when they were subsequently listed on the London or the Tokyo Stock Exchanges. It can be argued that the increased competition from foreign market makers will reduce the monopoly rents that specialists can earn, thereby improving their quotes. We find, however, that spreads do not decrease following a dual listing, though the depth of the quotes increases as predicted. The apparent increase in depth disappears once we account for changes in price, volume and return variance. We also find that the level of informed trading increases, which increases the cost to the specialist of providing liquidity, and explains why spreads do not decline in spite of increased competition. Consistent with an increase in informed trading, we also document an increase in trading activity.

JEL classification: G15

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1. Introduction

With the accelerating globalization of capital markets, investors look at foreign stocks to diversify their investment portfolio. In the last decade, trading in foreign

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stocks by U.S. investors increased more than thirteen-fold from $19 billion to $258 billion. [1] During the same period, foreign trades in U.S. stocks increased more than five-fold to over $400 billion per year. [2] This trend has been accompanied by a relaxation in the listing requirements for foreign corporations in many important stock exchanges. [3] Consequently, there is an increasing tendency for firms to list shares on foreign stock exchanges in addition to those in their home country.

The potential benefits associated with foreign listings are not clear. Howe and Kelm (1987) document a negative wealth impact on shareholders' wealth due to international listing, while Lee (1991) finds an insignificant effect. Also, Barclay et al. (1988) demonstrate that foreign listing of U.S. firms does not affect stock price volatility and Howe and Madura (1990) show that it does not impact covariance risk. On the other hand, Alexander et al. (1988) and Damodaran et al. (1992) show that expected returns decline after foreign listings and Howe et al. (1993) document significant increases in volatility associated with the international listing of U.S. firm's stocks. While these conflicting findings may have resulted because of different sampling frames, they do not offer much insight into why firms choose to list abroad.

Saudagaran (1988) and Mittoo (1992) have shown that corporate managers perceive access to additional capital sources and increased visibility (for marketing reasons) as the major factors motivating foreign listings. Another reason for international listing has been suggested by Merton (1987) in his model of capital market equilibrium with incomplete information. Merton (1987) relaxes the standard CAPM assumption of equal information across investors and shows that investors invest only in those securities of which they are aware. According to Merton's model, ceteris paribus, an increase in the size of a firm's investor base will lower expected returns and increase the market value of the firm's share. Merton suggests that one of the ways in which managers can increase the size of the firm's investor base is to have the firm's shares listed on a stock exchange. If listing is indeed accompanied by an increase in the size of the firm's investor base, it should reduce the expected returns and, consequently, the cost of capital for the firm.

While investor recognition from international listing may represent one source of reduction in the cost of capital, other potential sources have been suggested. Of these, the most prominent is superior liquidity services. The bid–ask spread is a

[1] U.S. Treasury Bulletin, February, 1992.

[2] New York Stock Exchange Fact Book, 1992.

[3] During the 1970s, when U.S. companies were first allowed entry into the Tokyo Exchange, they had to submit to an expensive and time-consuming double audit by both the Japanese and U.S. accountants and were required to disclose confidential information. Moreover, officials in Tokyo demanded quarterly dividend notices and year-end statements as soon as they were filed in the home country. Most of these requirements were eliminated in 1984.

direct cost of transacting and thus can be viewed as the cost per share of liquidity. Stoll (1978b) investigates the determinants of the bid–ask spread and concludes that the greater the competition among market makers the lower the spread. Since market makers abroad offer at least partial competition for specialists on the domestic exchanges, it can be argued that international listing should reduce spreads. However, as noted by Harris (1990) and Lee et al. (1993), the spread is only one dimension of market liquidity. A complete quote includes the best price available for both purchases (the ask) and sales (the bid), as well as the number of shares available at each price (the depth). Thus, specialists can increase their competitiveness by increasing the depth of their quotes.

In this study, we examine the impact on the spread and depth of quotes of 126 NYSE/AMEX listed stocks that were subsequently listed on the London or the Tokyo stock exchanges. Contrary to the expectation that increased competition from dual listings would decrease bid–ask spreads, we find no significant change in the post-listing bid–ask spreads for our overall sample and our London Stock Exchange (LSE) sub-sample. Bid–ask spreads actually increased for the Tokyo Stock Exchange (TSE) sub-sample. However, we do find an increase in the depth of quotes for our overall sample and both our sub-samples. One possible explanation is that even though increased competition reduces the profit margins specialists can maintain, their cost of providing liquidity increases because of an increased probability of trading with investors with superior information.

To examine this possibility, we estimate the change in the degree of asymmetric information after international listings. We use three different tests developed by Hasbrouck (1991), Madhavan and Smidt (1991), and George et al. (1991), which are elegant and successfully use the richness of intraday data. We find that the level of informed trading increases for both our complete sample and the sample of listings on the LSE. This is consistent with Freedman's (1992) finding that dual listing attracts informed traders because it increases their opportunity to trade on their inside information. However, similar results are obtained for Tokyo listings using only Hasbrouck's (1991) Vector Autoregression approach.

In the final part of our analysis, we investigate whether the increase in informed trading also corresponds to an increase in trading activity. The increase in informed trading may drive liquidity traders out of the market and also, as suggested by Freedman (1992) and Chowdhry and Nanda (1991), there may be some diversion of trading activity to the foreign exchange, leading to a decline in trading in the domestic exchange. However, if the costs of trading stocks differ across markets, foreign listings should result in an increase in volume occurring in the market with the lower trading costs. This happens because of increased trading by 'liquidity' traders whose incentives drive them to concentrate their activity in markets where the transactions costs are the lowest, and by 'information' traders for whom the profitability of trading on their information is maximized in the most liquid market, in which they are most likely to conceal their trades. Since transaction costs are typically lower in the U.S. than in other markets (Securities

Table 1
Dual listing dates for sample firms: 1983-1989

Year	LSE	TSE	All listings
1983	4	0	4
1984	33	1	34
1985	3	6	9
1986	10	16	26
1987	9	25	34
1988	3	5	8
1989	6	5	11
Total	68	58	126

Yearly frequency distribution of firms listed on a U.S. Exchange which were subsequently listed on either the London Stock Exchange (LSE) or the Tokyo Stock Exchange (TSE) between 1983 and 1989. The sample also met the following criteria: (a) the stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date and (b) there was no stock split in the 250-day period around the listing.

and Exchange Commission, 1987; Breeden, 1994), we expect that dual listing of U.S. stocks should increase the domestic trading volume. We find that there is an increase in trading volume after listing for both our overall sample and the sub-sample listing on the London Stock Exchange. [4] The increase in trading volume is not statistically significant for the sub-sample listed on the Tokyo Stock Exchange.

The rest of the paper is organized as follows: Section 2 describes the sample and the data sources. Section 3, Section 4 and Section 5 study the impact of dual listing on spread and depth of quotes, level of informed trading, and order flow, respectively. Section 6 concludes the paper.

2. Sample description

Our sample begins with 159 stocks listed on a U.S. exchange of which 91 were subsequently listed on the London and 68 on the Tokyo exchange between 1983 and 1989. The names of the companies and the dates these companies were admitted on the London Stock Exchange and the Tokyo Stock Exchange (i.e., the date when trading in the company's stock began on the foreign exchange) were taken from the London Stock Exchange Quarterly (1992) and the Tokyo Stock Exchange Fact Book (1992), respectively. We exclude 12 stocks which split in the 125 day period before and after the listing date. [5] Also, to enable us to obtain the

[4] These findings are similar to those of Damodaran et al. (1992).

[5] This avoids distortions in our analysis arising from dual trading in both pre-split and when shares are issued.

intraday transaction and quote data, we require the securities to have data available on the *Institute for the Study of Security Markets* (ISSM) transaction data base for 125 trading days before and after the listing date. This reduces our sample further by 21 firms, leaving the final sample with 68 listings on the London Stock Exchange (LSE) and 58 listings on the Tokyo Stock Exchange (TSE).

Table 1 provides the distribution through calendar time and exchange of our sample listings. As can be seen from this table, approximately two-thirds of the LSE listings in our sample occur in 1984 and 1986. The sample of listings in the TSE are concentrated in 1986 and 1987, which years account for over two-thirds of the Tokyo sample. Also, during our sampling period, 1983–1989, seven firms listed on both the London and Tokyo stock exchanges.

3. Impact of dual listing on spread and depth of quotes

3.1. Changes in spreads

Stoll (1978b) investigates the determinants of the bid–ask spread and concludes that the spread is lower, the greater the competition among market makers. Neal (1987) finds that the spreads on multiple-listed options are significantly lower than those on single-listed options, even when there is a high concentration of trading volume on a single exchange. Since market makers on international markets offer at least partial competition for specialists on the NYSE/AMEX, one can argue that the dual listing should narrow spreads.

To evaluate the impact of dual listing on the stock's bid–ask spread, we first obtain the daily weighted average bid–ask spread as in McInish and Wood (1992). For each stock, the relative bid–ask spread, defined as the difference in the ask and bid prices divided by the average of the bid and ask prices, is calculated for every quote. The daily weighted average bid–ask spread is then calculated as the weighted average of the relative bid–ask spread, where the weight for each quote is the number of seconds the quote was outstanding divided by the number of seconds for which any quote was outstanding in the trading day. [6] Then for each stock in our sample, we estimate the median weighted average bid–ask spread in the pre- and post-listing period. [7] Panel A of Table 2 contains descriptive statistics on the median of the weighted average bid–ask spread ratio across all stocks in our sample. As can be seen, there is no change in the bid–ask spreads for either

[6] We discard all quotes before and after the close of the market.

[7] The post-listing period starts 26 days and ends 125 days after listing. Similarly, the pre-listing period starts 125 days and ends 26 days before listing. We are interested in examining the equilibrium effects of dual listing and exclude the 50 day period around the event to avoid capturing any transitory effects caused by the lag between the initial application date and the date on which trading starts on the foreign exchange.

Table 2
Impact of international dual listing on spread and depth of quotes

	All listings (126) [a]	LSE listings (68) [a]	TSE listings (58) [a]
Panel A: Spread [b,c]			
Pre-listing [d]	0.615	0.784	0.543
Post-listing [d]	0.679	0.769	0.552
Z-statistic	0.67	−0.62	1.96 *
Proportion for which relative spread increases	51.72	44.44	60.38
Panel B: Depth [e]			
Pre-listing [d]	69.65	54.74	81.05
Post-listing [d]	75.83	64.52	87.86
Z-statistic	3.56 ***	2.99 ***	2.22 ***
Proportion for which depth increases	55.70	57.14	53.77

Percentage bid–ask spread and depth of quotes for a sample of 126 firms listed on a U.S. Exchange which were subsequently listed on the London Stock Exchange (LSE) or the Tokyo Stock Exchange (TSE) between 1983 and 1989. The sample also met the following criteria: (a) the stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, and (b) there was no stock split in the 250-day period around the listing.
***, ** and * indicate significance at 0.01, 0.05 and 0.10 levels, respectively, in a two-tailed Wilcoxon test (z-statistic) or binomial test (proportion).
[a] Figure in parentheses is the sample size.
[b] Spread = [(ask price − bid price)/((ask price + bid price)/2)] * 100.
[c] Quote-by-quote data is used to obtain the daily weighted average spread where the weight for each quotation is the seconds for which that quotation is outstanding divided by the number of seconds in the trading day. For each stock we estimate the median of the daily weighted spread in the pre- or post-listing period and report the median of this number across all stocks in our sample. The same weighting scheme is used for the depth measure.
[d] The 100-day pre-listing period starts 125 days and ends 26 days before the listing date, while the 100-day post-listing period starts 26 days and ends 125 days after listing.
[e] Depth = (depth at ask price + depth at bid price)/2.

the entire sample or the sample of LSE listings. Moreover, the bid–ask spreads significantly increase for firms listing on the TSE. This contradicts the argument that increased competition reduces the bid–ask spreads.

Several studies, e.g., Barclay and Smith (1988), Benston and Hagerman (1974), Choi and Subrahmanyam (1993), and Stoll (1978b) have shown that price, return volatility, and volume explain a significant portion of the cross-sectional variation in bid–ask spreads. Demsetz (1968) and Stoll (1978a) discuss the reason why these variables should affect spreads. Demsetz (1968) argues that, in equilibrium, raw spreads should be higher for higher priced stocks to equate the costs of transacting per dollar traded. Stoll (1978a) argues that a larger volatility level implies greater inventory risk as well as greater potential profits for informed traders and hence implies higher spreads. Further, a higher trading volume facilitates the offsetting of inventory imbalances and hence should result in a lower spread. It is possible that changes in these variables have an offsetting effect on the spreads. To examine these arguments we use the following log-linear regression model, which is similar to the specification in Stoll (1978b) and Jegadeesh and Subrahmanyam (1993):

$$\begin{aligned}\mathrm{LNSPRD}_{it} &= \beta_1 + \beta_1 \mathrm{LNPRC}_{it} + \beta_2 \mathrm{LNVOL}_{it} + \beta_3 \mathrm{LNVAR}_{it} + \alpha\,\mathrm{DLIST}_{it} + \epsilon_{it},\\ i &= 1,\ldots,N \text{ and } t = 1,2. \end{aligned} \tag{1}$$

In the above specification, LNSPRD_{it} is the natural logarithm of the median relative spread and LNPRC_{it}, LNVOL_{it}, and LNVAR_{it} are the natural logarithms of the median prices, trading volume and daily return variance, respectively, for security i in period t. The number of stocks in the regression is denoted as N, and $t = 1$ or 2 denotes the pre- or post-listing period. The indicator variable DLIST_{it} is assigned a value of one in the post-listing period and zero in the pre-listing period. Our primary interest in the above regression is in the coefficient α, which indicates how spreads change after accounting for changes in other spread determinants.

The estimates of the parameters in Eq. (1) are presented in model (1) of Table 3. The estimates of the slope coefficients on the price, volume, and return variance are all significant, and their signs are consistent with the results obtained earlier. The estimate of the slope coefficient on the post-listing period is insignificant for our complete sample and both the U.K. and Japan sub-samples.

To provide some insight into how the market making process changes after dual listing, we interact each of the independent variables in Eq. (1) with the listing dummy and estimate the following regression.

$$\begin{aligned}\mathrm{LNSPRD}_{it} = \beta_0 &+ \beta_1 \mathrm{LNPRC}_{it} + \beta_2 \mathrm{LNVOL}_{it} + \beta_3 \mathrm{LNVAR}_{it} + \beta_4 \mathrm{DLIST}_{it}\\ &* \mathrm{LNPRC}_{it} + \beta_5 \mathrm{DLIST}_{it} * \mathrm{LNVOL}_{it} + \beta_6 \mathrm{DLIST}_{it}\\ &* \mathrm{LNVAR}_{it} + \epsilon_{it}, \quad i = 1,\ldots,N \text{ and } t = 1,2.\end{aligned} \tag{2}$$

The estimates of the parameters of Eq. (2) are reported in model (2) of Table 3. We find the spread is less sensitive to price after dual listing and more sensitive to volume for our complete sample and the sample of firms listed on the London Stock Exchange.

3.2. Changes in depth

As has been argued by Lee et al. (1993), the spread is only one dimension of market liquidity. A second measure that also impacts liquidity is the number of shares a market maker is willing to purchase or sell at the quoted bid and ask prices. Moreover, Lee et al. (1993) suggest that the bid-ask spread and the market depth are jointly determined with an increased depth, ceteris paribus, indicating an improvement in liquidity. Specialists can thus increase their competitiveness by

Table 3
Cross-sectional regressions relating spread to price, volume and volatility

Independent variables	All listings (126)		LSE listings (68)		TSE listings (58)	
	(1)	(2)	(1)	(2)	(1)	(2)
Intercept	−1.76 ***	−1.86 ***	−1.80 ***	−1.91 ***	−1.43 ***	−1.61 ***
	(−14.33)	(−11.33)	(−11.00)	(−9.03)	(−5.48)	(−3.89)
LNPRC	−0.52 ***	−0.44 ***	−0.50 ***	−0.42 ***	−0.59 ***	−0.50 ***
	(−17.93)	(−11.57)	(−12.28)	(−8.32)	(−12.27)	(−6.44)
LNVOL	−0.19 ***	−0.22 ***	−0.19 ***	−0.22 ***	−0.20 ***	−0.22 ***
	(−17.09)	(−16.06)	(−11.20)	(−10.90)	(−11.85)	(−9.24)
LNVAR	0.08 ***	0.08 ***	0.07 ***	0.07 ***	0.12 ***	0.11 *
	(3.93)	(3.13)	(2.64)	(2.38)	(3.36)	(1.79)
DLIST	−0.03	0.09	−0.06	0.14	0.01	0.27
	(−0.766)	(0.37)	(−0.96)	(0.47)	(0.11)	(0.52)
DLIST * LNPRC		−0.19 ***		−0.25 ***		−0.17 *
		(−3.36)		(−3.05)		(−1.71)
DLIST * LNVOL		0.08 ***		0.10 ***		0.04
		(3.56)		(2.91)		(1.34)
DLIST * LNVAR		0.01		−0.03		0.05
		(0.28)		(−0.50)		(0.69)
Adjusted-R^2	0.80	0.81	0.77	0.79	0.72	0.74

*** and * Indicate significance at the 0.01 and 0.10 level, respectively.
Estimates of cross-sectional regressions of the following form: (1) $\text{LNSPRD}_{it} = \beta_0 + \beta_1 \text{LNPRC}_{it} + \beta_2 \text{LNVOL}_{it} + \beta_3 \text{LNVAR}_{it} + \alpha\,\text{DLIST}_{it} + e_{it}$; (2) $\text{LNSPRD}_{it} = \beta_0 + \beta_1 \text{LNPRC}_{it} + \beta_2 \text{LNVOL}_{it} + \beta_3 \text{LNVAR}_{it} + \alpha\,\text{DLIST}_{it} + \beta_4 \alpha\,\text{DLIST}_{it} \text{LNPRC}_{it} + \beta_5 \alpha\,\text{DLIST}_{it} \text{LNVOL}_{it} + \beta_6 \alpha\,\text{DLIST}_{it} \text{LNVAR}_{it} + e_{it}$; $i = 1, \ldots, N$ and $t = 1,2$, where LNSPRD_{it} is the natural logarithm of the median of daily weighted relative spread in the pre- or post-period, and LNPRC_{it}, LNVOL_{it} and LNVAR_{it} are the corresponding price, volume and variance. The dummy variable DLIST_{it} is one in the post-change period and 0 otherwise. Our sample of 126 firms listed on a U.S. Exchange which were subsequently listed on the London Stock Exchange (LSE) or the Tokyo Stock Exchange (TSE) between 1983 and 1989 met the following criteria: (a) the stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, and (b) there was no stock split in the 250-day period around the listing.

increasing the depth of the quote. [8] Consistent with this argument, we see in panel B of Table 2 that the depth of quotes increases after dual listing on both the London and the Tokyo Stock Exchange. This increase is around 10% and is both statistically and economically significant. Another observation from Table 2 is that both the spread and depth of stocks which were subsequently listed on the Tokyo Stock Exchange are superior to those listed on the London Stock Exchange, i.e.

[8] Depth is defined as the average number of shares the specialist is willing to trade at a given price. That is depth = (depth at ask + depth at bid)/2. The daily weighted average depth is calculated similar to the weighted average spread i.e., weights are defined as the number of seconds for which each quoted depth was outstanding divided by the number of seconds in the trading day.

more liquid stocks were subsequently listed in Tokyo when compared to the stocks listed in London.

If the depth of the quotes is simultaneously determined with the spread, then the determinants of the spread should also be related to the depth. To examine whether the changes in depth documented in Table 2 are attributable to changes in volume, volatility and price, we estimate the following log–linear regression model:

$$\begin{aligned}\mathrm{LNDEPTH}_{it} = {} & \beta_0 + \beta_1 \mathrm{LNPRC}_{it} + \beta_2 \mathrm{LNVOL}_{it} + \beta_3 \mathrm{LNVAR}_{it} \\ & + \alpha\,\mathrm{DLIST}_{it} + \epsilon_{it}, \quad i = 1,\dots,N \text{ and } t = 1,2. \end{aligned} \tag{3}$$

The independent variables in this model are the same as those for regression (1).

Table 4
Cross-sectional regressions relating depth to price, volume and volatility

Independent variables	All listings (126)		LSE Listings (68)		TSE Listings (58)	
	(1)	(2)	(1)	(2)	(1)	(2)
Intercept	3.42 ***	3.57 ***	3.58 ***	3.17 ***	2.99 ***	3.70 ***
	(17.46)	(13.14)	(13.43)	(5.15)	(7.72)	(10.29)
LNPRC	−0.71 ***	−0.75	−0.77 ***	−0.71 ***	−0.59 ***	−0.77 ***
	(−15.33)	(−11.81)	(11.55)	(−6.06)	(−8.18)	(−8.94)
LNVOL	0.47 ***	0.47 ***	0.48 ***	0.52 ***	0.47 ***	0.46 ***
	(26.86)	(21.01)	(17.26)	(14.42)	(18.54)	(13.35)
LNVAR	−0.07 ***	−0.06	−0.06	−0.22 ***	−0.10*	−0.04
	(−2.02)	(−1.46)	(−1.35)	(−2.43)	(−1.77)	(−0.75)
DLIST	0.03	−0.27	−0.01	0.03	0.08	−0.26
	(0.55)	(−0.69)	(−0.10)	(0.04)	(1.17)	(−0.50)
DLIST * LNPRC		0.08		0.17		−0.05
		(0.90)		(1.18)		(−0.37)
DLIST * LNVOL		0.00		−0.10 *		0.08
		(0.07)		(−1.96)		1.34
DLIST * LNVAR		−0.03		0.17		−0.10
		(−0.38)		(1.50)		(−1.02)
Adjusted-R^2	0.78	0.78	0.75	0.83	0.83	0.75

*** and * indicate significance at the 0.01 and 0.10 level, respectively.
Estimates of cross-sectional regressions of the following form: (1) $\mathrm{LNDEPTH}_{it} = \beta_0 + \beta_1 \mathrm{LNPRC}_{it} + \beta_2 \mathrm{LNVOL}_{it} + \beta_3 \mathrm{LNVAR}_{it} + \alpha\,\mathrm{DLIST}_{it} + e_{it}$; (2) $\mathrm{LNDEPTH}_{it} = \beta_0 + \beta_1 \mathrm{LNPRC}_{it} + \beta_2 \mathrm{LNVOL}_{it} + \beta_3 \mathrm{LNVAR}_{it} + \alpha\,\mathrm{DLIST}_{it} + \beta_4 \alpha\,\mathrm{DLIST}_{it} \mathrm{LNPRC}_{it} + \beta_5 \alpha\,\mathrm{DLIST}_{it} \mathrm{LNVOL}_{it} + \beta_6 \alpha\,\mathrm{DLIST}_{it} \mathrm{LNVAR}_{it} + e_{it}$; $i = 1,\dots,N$ and $t = 1,2$, where $\mathrm{LNDEPTH}_{it}$ is the natural logarithm of the median of daily weighted quoted depth spread in the pre- or post-period, and LNPRC_{it}, LNVOL_{it} and LNVAR_{it} are the corresponding price, volume and variance. The dummy variable DLIST_{it} is one in the post-change period and 0 otherwise. Our sample of 126 firms listed on a U.S. Exchange which were subsequently listed on the London Stock Exchange (LSE) or the Tokyo Stock Exchange (TSE) between 1983 and 1989 met the following criteria: (a) the stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, and (b) there was no stock split in the 250-day period around the listing.

Table 5
Impact of international dual listing on summary informativeness of stock trades

	All listings (126) [b]	LSE listings (68) [b]	TSE listings (58) [b]
Pre-listing [c]	0.265	0.210	0.304
Post-listing [c]	0.313	0.288	0.335
Z-statistic	3.32 * * *	3.16 * * *	1.42
Proportion for which informativeness of stock trades increases	58.62 *	61.11 *	54.69

Changes in the summary informativeness of stock trades for a sample of 126 firms listed on a U.S. Exchange which were subsequently listed on the London Stock Exchange (LSE) or the Tokyo Stock Exchange (TSE) between 1983 and 1989 [a]. The sample also met the following criteria: (a) the stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, and (b) there was no stock split in the 250-day period around the listing * * * and * indicate significance at 0.01 and 0.10 levels, respectively, in a two-tailed Wilcoxon test (z-statistic) or binomial test (proportion).

[a] The summary informativeness of stock trades is estimated using the vector autoregressive (VAR) approach developed in Hasbrouck (1991). An increase in the informativeness of price implies an increase in the amount of asymmetric information.

[b] Figure in parentheses is the sample size.

[c] The 100-day pre-listing period starts 125 days and ends 26 days before the listing date, while the 100-day post-listing period starts 26 days and ends 125 days after listing.

The dependent variable is the natural logarithm of depth of the quote (LNDEPTH). The parameter estimates of this regression are presented in Table 4. As expected, the estimates of the slope coefficients on volume and return variance are opposite to those for the relative spread. However, the return variance is not significantly related to the depth for the U.K. listings. Price affects the depth in the same way as it affects relative spread: a higher price implies a higher cost of inventory and therefore a reduced depth. Similar to the spread equation, the parameter estimate on the post-listing period is insignificant. Thus, there are no changes in the depth of the quote beyond those which can be explained by changes in other micro-structure variables.

Also, similar to Eq. (2) for spreads, we estimate the following regression model:

$$\begin{aligned}\mathrm{LNDEPTH}_{it} = {} & \beta_0 + \beta_1 \mathrm{LNPRC}_{it} + \beta_2 \mathrm{LNVOL}_{it} + \beta_3 \mathrm{LNVAR}_{it} \\ & + \beta_4 \mathrm{DLIST}_{it} * \mathrm{LNPRC}_{it} + \beta_5 \mathrm{DLIST}_{it} * \mathrm{LNVOL}_{it} \\ & + \beta_6 \mathrm{DLIST}_{it} * \mathrm{LNVAR}_{it} + \alpha \mathrm{DLIST}_{it} + \epsilon_{it}, \\ & i = 1,\ldots,N \text{ and } t = 1,2. \end{aligned} \tag{4}$$

The results reported in model (2) of Table 5 show that after dual listing depth becomes less sensitive to volume for our Tokyo sub-sample. Everything else remains unchanged.

4. Impact of dual listing on informed trading

Freedman (1992) argues that dual listing will attract informed traders because it increases their opportunity to trade on their inside information and hence, increase their opportunity to profit. Specifically, it permits them to trade for extended hours and on a foreign exchange with a greater degree of anonymity. This increase in informed trading could lead to an increase in the adverse selection component which the specialists maintain in their spread. [9] So even though increased competition reduces the monopoly rents that specialists can earn, their cost of providing liquidity increases because of an increased probability of trading with agents with superior information.

We use three different approaches developed by Hasbrouck (1991), Madhavan and Smidt (1991), and George et al. (1991) to measure the change in the degree of asymmetric information after dual listing. As pointed out in the Introduction, the advantage of these approaches is that they are elegant and straightforward to implement on intraday data. In addition, they explicitly model the effects of trade size on price and quote revisions.

4.1. *Informativeness of trades*

As stated above, this test is based on the vector autoregression (VAR) representation of the quote revision and trade process suggested in Hasbrouck (1991). In this model, the quote midpoint, q_t, is defined as the sum of the true price, m_t, and a term that embodies microstructure imperfections, s_t. The efficient price is assumed to evolve as a random walk, i.e., $m_t = m_{t-1} + w_t$, where the innovation w_t reflects updates to the public information set and has the properties $Ew_t = 0$, $Ew_t^2 = \sigma_w^2$, $Ew_t w_\tau = 0$ for $t \neq \tau$. In this framework, a summary measure of information asymmetry is defined as:

$$R_w^2 = \mathrm{Var}\left[E\left(w_t | x_t - E\left(x_t | \Phi_{t-1}\right)\right)\right] / \mathrm{Var}\left[w_t\right] = \sigma_{w.x}^2 / \sigma_w^2 \tag{5}$$

where x_t is a vector of trade attributes, and Φ_{t-1} is the public information set prior to the trade at t. Intuitively, R_w^2 is interpreted as the coefficient of

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

determination in a regression of w_t on the trade innovation and implies that percentage of variation in the random walk component of the efficient price is attributable to trades. A higher R_w^2 thus implies that there is more information in the trade.

To measure R_w^2, Hasbrouck (1991) uses a VAR model for quote revisions, r_t $(= q_t - q_{t-1})$, and trade attributes, x_t, defined as:

$$r_t = a_1 r_{t-1} + a_2 r_{t-2} + \cdots + b_0 x_t + b_1 x_{t-1} + \cdots + v_{1,t},$$

$$x_t = c_1 r_{t-1} + c_2 r_{t-2} + \cdots + d_1 x_{t-1} + d_2 x_{t-2} + \cdots + v_{2,t}, \tag{6}$$

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

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

$$x_t = c_1^* v_{1,t} + c_2^* v_{1,t-1} + \cdots + v_{2,t} + d_1^* v_{2,t-1} + \cdots. \tag{7}$$

In this framework, $\sigma_{w,x}^2 = \Sigma b^* \Omega \Sigma b^{*\prime}$ and $\sigma_w^2 = \sigma_{w,x}^2 + (\Sigma a^*)^2 \sigma_1^2$.

In the implementation of this technique we use one trade attribute defined as $+(\text{trade volume})^{1/2}$ or $-(\text{trade volume})^{1/2}$ if the trade is above or below the quote midpoint, five lags in the VAR model and ten lags in the VMA representation. [10] R_w^2 is computed for each firm in the pre- and post-listing period. The null hypothesis is that R_w^2 will increase in the post-listing period. The results of this analysis are presented in Table 5. As can be seen from the table, the value of R_w^2 increases after listings in our complete sample and both the sub-samples, suggesting that trades in the underlying stock become more informative following dual listing. This again implies that more informed traders are attracted to the market after listing on a foreign exchange as suggested by Freedman (1992).

4.2. Weight placed on public information

An alternative technique to measure the impact of trades on the quote revision process is based on a model for intraday security price movements developed by Madhavan and Smidt (1991). In this model, market makers use Bayesian rules to update their beliefs about the expected value of the stock. In this framework, the expected stock value is represented as a combination of the prior mean (based on prior information) and a revision due to a noisy signal based on private information contained in the current order flow. The weight placed on the prior beliefs is

[10] The sign assigned to the trade attribute variable follows the technique in Lee and Ready (1991). The lags used for our VAR and VMA representation follow other studies, e.g. Kumar et al. (1995).

Table 6
Impact of international dual listing on the weight placed on public information

	All Listings (126) [b]	LSE Listings (68) [b]	TSE Listings (58) [b]
Pre-listing [c]	0.837	0.834	0.838
Post-listing [c]	0.836	0.793	0.858
Z-statistic	−1.78 *	−3.00 * * *	1.61
Proportion for which weight placed on public information increases	49.51	38.98 *	63.64 *

Changes in the estimate of the weight placed on public information for a sample of 126 firms listed on a U.S. Exchange which were subsequently listed on the London Stock Exchange (LSE) or the Tokyo Stock Exchange (TSE) between 1983 and 1989 [a]. The sample also met the following criteria: (a) the stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, and (b) there was no stock split in the 250-day period around the listing.

* * * and * indicate significance at 0.01 and 0.10 levels, respectively, in a two-tailed Wilcoxon test (z-statistic) or binomial test (proportion).

[a] The technique suggested by Madhavan and Smidt (1991) is used to estimate the weight placed by traders on public information. A decrease in the weight implies an increase in the amount of asymmetric information.

[b] Figure in parentheses is the sample size.

[c] The 100-day pre-listing period starts 125 days and ends 26 days before the listing date, while the 100-day post-listing period starts 26 days and ends 125 days after listing.

then a measure of the degree of information asymmetry in the market. Formally, the revision in transaction price is given by:

$$\Delta P_{jt} = \beta_{1j} q_{jt} + \beta_{2j} D_{jt} - \beta_{3j} D_{jt-1} + \epsilon_{jt} - Z_j \epsilon_{jt-1} \tag{8}$$

where q_{jt} is the signed transaction size, and D_{jt} equals $+1$ for a buy and -1 for a sell.[11] The ϵ's are white noise error terms and Z_j is treated as a parameter for estimation. The weight placed by the market maker on public information is measured as $\text{PRIOR}_j = \beta_{3j}/\beta_{2j}$. Larger values of PRIOR_j imply lower information asymmetry.

The above model is estimated for the pre- and post-listing period for each of the firms in the sample. Again, we would expect the values of PRIOR to be lower in the post-listing period if dual listing causes an increase in informed trading.

The results of this analysis are presented in Table 6. As can be seen from this table, the weight placed on public information (as measured by PRIOR) decreases after U.K. listings, suggesting that market makers place less importance on the information contained in the most recent trade in determining the new quote. This, again, is supportive of the hypothesis that the dual listing causes an increase in informed trading. On the other hand, for the Tokyo listing sample, a marginally significant increase in PRIOR is not consistent with this hypothesis.

[11] The classification of a buy or a sell follows that used in Lee and Ready (1991).

4.3. Adverse selection component of spread

We calculate the adverse selection component of the bid–ask spread using the procedure in George, Kaul, and Nimalendran. Specifically, for each security in both the pre and post dual listing period we estimate the relative adverse selection component as

$$\text{Adverse Selection Component} = \frac{\text{Quoted Spread} - \text{Estimated Spread}}{\text{Quoted Spread}}. \quad (9)$$

Quoted Spread is the average of the bid and ask price and the Estimated Spread $= 2\sqrt{-\text{COV}}$, where COV is the serial covariance of the difference between returns based on the last transaction price at 1:00 p.m. on each day and the return based on the bid price quoted subsequent to the time of this transaction. A higher adverse selection component post-listing reflects an increase in informed trading.

Our estimates of this analysis are presented in Table 7. Consistent with our earlier results, we find that the adverse selection component is higher post-listing for our total sample and the London listing sub-sample. We find no change in the information component of the spread for our Tokyo sub-sample.

Table 7
Impact of international dual listing on the relative size of the adverse selection component

	All Listings (126) [b]	LSE Listings (68) [b]	TSE Listings (58) [b]
Pre-listing [c]	0.128	0.168	0.127
Post-listing [c]	0.152	0.195	0.121
Z-statistic	2.09 * *	1.82 *	0.87
Proportion for which the adverse selection component of the spread increases	57.14	60.00	53.85

Changes in the estimate of the relative size of the adverse selection component of the bid–ask spread for a sample of 126 firms listed on a U.S. Exchange which were subsequently listed on the London Stock Exchange (LSE) or the Tokyo Stock Exchange (TSE) between 1983 and 1989 [a]. The sample also met the following criteria: (a) the stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, and (b) there was no stock split in the 250-day period around the listing.

* * * and * indicate significance at 0.01 and 0.10 levels, respectively, in a two-tailed Wilcoxon test (z-statistic) or binomial test (proportion).

[a] The adverse selection component of the bid–ask spread is estimated using the procedure in George et al. (1991). An increase implies a greater degree of information asymmetry.

[b] Figure in parentheses is the sample size.

[c] The 100-day pre-listing period starts 125 days and ends 26 days before the listing date, while the 100-day post-listing period starts 26 days and ends 125 days after listing.

5. Order flow effect of dual listing

The findings of the previous section also have implications for the effects of dual listing on trading volume. Specifically, since dual listing provides informed traders more opportunity to trade on their inside information, additional informed traders are attracted to the market following dual listing. [12] Thus, overall trading activity increases as a consequence of the increase in informed trading.

Alternatively, the increase in informed trading may drive liquidity traders out of the market and also, as suggested by Freedman (1992) and Chowdhry and Nanda (1991), there may be some diversion of trading activity to the foreign exchange, leading to a decline in trading in the domestic exchange.

To examine the impact of dual listing on the trading activity we estimate the median of the standardized daily trading volume in the 100-day post-listing period (day +26 to day +125) and the median of the standardized daily trading volume in the pre-listing period (day −125 to day −26), where standardized daily trading volume is defined as the trading volume divided by the average trading volume on the same day for all stocks listed on the CRSP Daily Returns File.

We see from Panel A of Table 8 that the trading volume increases after listing for both our overall sample and the sample of listings on the London Stock Exchange. However, there is no statistically significant effect on the sample of listings on the Tokyo Stock Exchange. This is consistent with the findings of Damodaran et al. (1992), but is inconsistent with the prediction of Freedman's (1992) model. She argues that even though the overall volume in the stock will increase because of increased informed trading, the volume in the domestic exchange will decrease because of diversion of trades to the foreign exchange. One argument which can be used to reconcile her model with our empirical findings is that the increase in informed trading is more than the diversion of trading activity to the foreign exchange. Thus, the trading activity in the domestic exchange also increases.

The transaction data base which we employ in our analysis permits us to examine the source of this increased trading. We can analyze whether this increase in trading is a consequence of an increased number of transactions or of larger-sized trades. This can help us determine if there is any change in the mix of the investor base. If the number of trades increases, it may indicate greater interest in the stock, with the profile of the investor remaining unchanged. On the other hand, if the size of the trade increases, we could infer that dual listings make the stock more attractive to the institutional trader who typically trades in larger quantities. It can

[12] Increased opportunity to exploit private information could also result in an increase in the number of informed traders and competition from other informed traders could actually result in a decrease in informed trading. Freedman's (1992) argument will hold, assuming there are sufficiently high costs to becoming informed.

Table 8
Impact of international dual listing on the order flow

	All listings (126) [b]	LSE listings (68) [b]	TSE listings (58) [b]
Panel A: Standardized trading volume			
Pre-listing [c]	0.263	0.070	0.351
Post-listing [c]	0.264	0.151	0.373
Z-statistic	2.55 **	2.88 ***	0.54
Proportion for which depth increases	56.41	59.38	52.83
Panel B: Transaction frequency			
Pre-listing [c]	113.5	33.5	184.0
Post-listing [c]	126.0	59.5	187.5
Z-statistic	3.26 ***	3.53 ***	0.69
Proportion for which transaction frequency increases	57.26	63.28	50.0
Panel C: Transaction size			
Pre-listing [c]	14.205	13.570	15.246
Post-listing [c]	15.398	14.111	16.470
Z-statistic	1.97 **	2.36 **	0.08
Proportion for which transaction size increases	54.70	61.72 *	46.23

Changes in the standardized trading volume, transaction frequency, and transaction size for a sample of 126 firms listed on a U.S. Exchange which were subsequently listed on the London Stock Exchange (LSE) or the Tokyo Stock Exchange (TSE) between 1983 and 1989 [a]. The sample also met the following criteria: (a) the stock has data on the Institute for the Study of Security Markets (ISSM) transaction data file for 250 trading days around the listing date, and (b) there was no stock split in the 250-day period around the listing.

***, ** and * indicate significance at 0.01, 0.05 and 0.10 levels, respectively, in a two-tailed Wilcoxon test (z-statistic) or binomial test (proportion).

[a] Standardized trading volume is defined as the trading volume divided by the average trading volume on the same day for all stocks listed on the CRSP Daily Returns File. Transaction frequency is the number of transactions per day. Transaction size is defined as the number of shares purchased/sold in a transaction.

[b] Figure in parentheses is the sample size.

[c] The 100-day pre-listing period starts 125 days and ends 26 days before the listing date, while the 100-day post-listing period starts 26 days and ends 125 days after listing.

be argued that institutional investors are more likely to be able to take advantage of the ability to trade in overseas markets. In addition, the performance of institutional investors is assessed using close-to-close returns and, therefore, managers of the portfolio wish to match their actual trades as nearly as possible to the performance benchmark. The ability to trade when markets are closed gives them an additional opportunity to meet or exceed these bench marks and enables them to avoid paying higher transactions costs typical of the closing period.

Panels B and C of Table 8 report the transaction frequency and the transaction size, respectively. The transaction frequency is the total number of transactions per day and the relative transaction size is the average transaction size (defined as the total daily volume divided by the number of transactions). We find that similar to our results of the standardized volume, there is an increase in the number of transactions and average transaction size for both the complete sample and the LSE listings. Thus we can conclude that the increase in volume cannot be attributed solely to the increased interest by the institutional investor.

6. Conclusions

In this paper we provide further insights into the phenomenon of firms choosing to list their shares on foreign stock exchanges in addition to those in their home country. We specifically examine if the increase in liquidity in the home market is one of the major reasons for listing abroad.

We find that liquidity as measured by the bid–ask spread is not enhanced after U.S. listed stocks are subsequently listed on the London or Tokyo Stock Exchanges. This is inconsistent with the argument that increased competition from market makers in foreign exchanges reduces the bid–ask spread. However, specialists can also improve their competitiveness by increasing the depth of the quotes. Our evidence indicates that the number of shares the specialist is willing to purchase at the quoted bid and ask prices increases significantly after international dual listing. However, this apparent increase in depth disappears once we account for changes in price, volume and return variance.

We further investigate if the lack of improvement in the spread of the quote is a consequence of increased informed trading. It is possible that even though increased competition reduces the monopoly rents specialists can earn, their cost of providing liquidity increases because of an increased probability of trading with investors with superior information. Consistent with that hypothesis we find that there is an increase in informed trading after London listings. This effect is, however, much less prevalent for Tokyo listings. Similarly, we also find that there is an increase in the trading activity corresponding to an increase in informed trading after stocks get dual listed in the U.K.

The weak results for Tokyo may be due to the generally low volume of trading in U.S. stocks on the Tokyo Stock Exchange. Since 1990 the foreign stocks listed on the Tokyo Stock Exchange has declined form 125 to 108 – a possible reaction by firms to lower than expected activity in their stocks on Tokyo. In announcing its decision to delist from the Tokyo Stock Exchange in 1992, General Motors explained that the average daily trading volume of its shares in Tokyo was 1300 shares compared to an average of 2.1 million shares on the New York Stock Exchange (Wall Street Journal, 1992). The recent delisting of foreign firms on the Tokyo Stock Exchange presents an interesting area for future research once a reasonably large sample of delisters is available. Also, the weaker results for Tokyo, relative to London, may be related to the fact that the TSE is a centralized auction market (since large institutional investors dislike exposing their orders in an auction market) and that the prices are quoted in yen, unlike London's SEAQ International, thus necessitating foreign exchange transactions for a stock trade by a non-Japanese investor on the Tokyo Stock Exchange.

To summarize, we find that the quality of quotes is not enhanced after an international listing. However, the dual listing increases trading volume and the flow of information to the underlying stock markets, thus possibly enhancing efficiency. The weaker results for Tokyo listings need further investigation.

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