Network Externalities, Market Quality and Trading Activity

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Abstract

This paper analyzes the impact of network externalities and market quality on trading costs and activity. The price impacts of trades of stocks cross-listed on two international stock exchanges are found to be significantly lower on one of the exchanges. Foreign exchange conversion costs, and differences in tick size and the network externalities associated with how the upstairs markets on the two exchanges are regulated do not fully explain the difference in price impacts. Furthermore, neither exchange dominates the other in terms of information flow. Rather we attribute the lower trading cost and greater trading activity on the one exchange to superior market quality as measured by better quoted prices and greater depth at the market in its limit order book as well as to better price continuity. Consistent with this finding, individual trades are most likely to occur on the market which offers better quoted prices and greater depth on its limit order book. Clientele effects are also important in determining the trading venue.

Key Words: trade execution costs, cross-listed

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Abstract

This paper analyzes the impact of network externalities and market quality on trading costs and activity. The price impacts of trades of stocks cross-listed on two international stock exchanges are found to be significantly lower on one of the exchanges. Foreign exchange conversion costs, and differences in tick size and the network externalities associated with how the upstairs markets on the two exchanges are regulated do not fully explain the difference in price impacts. Furthermore, neither exchange dominates the other in terms of information flow. Rather we attribute the lower trading cost and greater trading activity on the one exchange to superior market quality as measured by better quoted prices and greater depth at the market in its limit order book as well as to better price continuity. Consistent with this finding, individual trades are most likely to occur on the market which offers better quoted prices and greater depth on its limit order book. Clientele effects are also important in determining the trading venue.

Network Externalities, Market Quality and Trading Activity

The purpose of this study is to examine the impact of network externalities[1] and market quality on trading costs and activity. The global integration of financial markets, evidenced by the worldwide increase in cross-border activity on the part of issuers and investors, necessitates a better understanding of the differences in order execution due to network externalities and market quality. Pulatkonak and Sofianos (1999) report that the number of non-US companies listed on the New York Stock Exchange (NYSE) increased from 54 in 1985 to 379 in 1998. Since its opening in 1985, London's SEAQ International (SEAQ-I) has attracted a considerable number of cross-listings from continental Europe. The growth in cross-border trading is a key factor behind the proposed mergers and alliances of international exchanges. Competition between exchanges and the recent explosive growth of Electronic Communications Networks (ECNs) and anonymous order entry systems, such as Island and Instinet raises the question of which market structure is most operationally efficient. Analyzing the impact of network externalities and market quality on order execution is essential in order to explain the emergence and continuation of these trends.

We examine the effect of network externalities by studying order execution costs on two exchanges where the primary difference is regulatory structure. The paper also studies the impact of market quality on trading activity. By examining the same securities cross-listed on the New York and the Toronto stock exchanges, we can isolate the impact of network externalities and market quality. Both the New York and the Toronto stock exchanges operate during identical trading hours in the same time zone, open as call markets, function as continuous auction markets after the open, and employ a similar market making structure.[2] The two primary consequences of differences in regulation between the markets are order exposure and the development of an upstairs market as discussed in Smith, Turnbull and White (2000).

The regulatory structure of the NYSE inhibits the growth of the upstairs market. In contrast, the regulatory structure of the Toronto Stock Exchange (TSE) permits the development of a very active upstairs market. Since the upstairs market is a non-anonymous market and the primary function of the upstairs market is to provide liquidity and price improvement, the exchange with the more developed upstairs market should exhibit greater operational efficiency. Liquidity-motivated orders will be matched in the upstairs market and information-laden orders will be routed to the anonymous downstairs market.

Market quality reflects the ability to trade a given number of shares with minimal price impact. It is expected that the exchange with superior market quality will attract more trading volume. We test this hypothesis by comparing several dimensions of market quality on the two exchanges including best quoted price, volume at best quoted price and the continuity of trading prices.

In addition to network externalities and market quality, a third factor expected to affect trading activity between markets is the clientele effect. That is, investors are expected to trade in their home market for reasons of convenience and familiarity. The variable used to capture this is the currency in which the financial statements of the cross-listed firms are reported. We test whether trading of securities which use the US dollar as the reporting currency are more likely to trade on the NYSE.

The following specific questions about trades of cross-listed securities are addressed by the paper. How do the price impacts of trades differ during the first quarter of 1999 between the NYSE and TSE? From the perspective of an investor based in the U.S.A., is it more expensive to transact in the security on the TSE than to transact in the same security on the NYSE? Do differences in the upstairs market mechanisms of the two exchanges affect transaction costs? How do differences in tick size across the two exchanges affect transaction costs? Is the NYSE the 'senior' exchange where news is released first and,

thus, does it bear greater information price impacts than the TSE? Are trades executed on the exchange with better market quality? In particular, do factors such as relative attractiveness of the quote on the opposite of the limit order book and reporting currency affect the likelihood of a trade being executed on the NYSE versus the TSE?

Research into trading costs across international markets has focused on the London versus other European markets. De Jong, Nijman, and Röell (1995) analyze the costs of trading French stocks on the Paris Bourse compared to the London SEAQ International (SEAQ-I). They find smaller trades can be executed at lower cost on the Paris Bourse whereas larger trades can be conducted with greater immediacy and at lower cost on the London SEAQ-I. Degryse (1999) compares the costs of trading Belgian equities between the Brussels CATS market and the London SEAQ-I and reports similar results to those of De Jong et al. (1995). The authors attribute part of the trading cost differences between the markets to the fact that the London SEAQ-I is a dealer market whereas the Paris Bourse and the Brussels CATS markets are order-driven.[3] In this study, both markets are order driven.

The next section of the paper discusses institutional similarities and differences between the NYSE and the TSE that may affect trading costs. Sections II the paper discusses research methods and results. Conclusions are presented in the final section.

I. Institutional Similarities and Differences between the TSE and NYSE

The NYSE and the TSE are similar in how they operate. As noted above, both markets open as call markets and thereafter function as continuous auction markets. On both exchanges, all trades are routed through member firms. On each exchange, the member firms operate an upstairs market where client orders

are often matched and sent to the exchange as crosses. In the downstairs market, both exchanges rely on specialists who are responsible for making an orderly market for a number of stocks.

The most significant structural difference between the NYSE and the TSE is their upstairs markets. On the TSE, the market makers can put crosses through the order book at a price that is at or between the best bid and ask quotes on the limit order book. Thus, the crosses on the TSE observe price but not time priority rules. In contrast, as described in Hasbrouck, Sofianos and Sosebee (1993), the rules on the NYSE for crossing orders are generally more restrictive than those on the TSE. NYSE Rule 76 requires that brokers, before proceeding with a cross, must make a bid on behalf of both sides of the cross, offering at a price one tick higher than their bid. The broker's orders are subject to the market's order-priority, order-exposure and price-improvement principles. This leads to orders sometimes being broken up as existing limit orders and to floor brokers taking precedence over the orders entered on behalf of both sides of the cross. No such rules apply on the TSE.

There are special rules on the NYSE that allow for block orders to be crossed outside the prevailing quote. When a member of the NYSE receives a block order that cannot be absorbed by the market, NYSE Rule 127 requires the member to explore crowd interest. The member wanting to cross a block of stock at a specific price outside the quotes must announce a clean up price to the crowd and then fill all limit orders in the book up to that price, in the crowd and all better-displayed Intermarket Trading System (ITS) quotes as well as the "reasonable needs" of the specialist at that price. In contrast, on the TSE, when the price of the cross is outside the prevailing quotes, the upstairs trader must fill better-priced orders on the book, but does so at the standing price of the limit orders. From the viewpoint of the

member institution and client trying to expedite an aggressive order through a cross, the NYSE rules are more costly than the TSE's.

In addition to the NYSE upstairs market described above, the National Association of Securities Dealers (NASD) has a third market in which over-the-counter trading of NYSE-listed securities occurs among institutional investors and broker/dealers for their own accounts. Blocks of stock are traded off the floor of the exchange and transactions are recorded on NASDAQ for reporting purposes only. Like the upstairs market on the TSE, the third market of the NASD operates in a non-anonymous way.

In summary, the NYSE upstairs trading rules impose greater costs on upstairs trades and lead to more broken-up upstairs orders than the TSE. This is consistent with the finding that crosses are much less frequent on the NYSE than the TSE. According to Hasbrouck, Sofianos and Sosebee (1993), only 14% of total volume was upstairs-facilitated block trades on January 12, 1993, whereas Smith, Turnbull and White (2000) report that the comparable figure for the TSE during June 1997 was 54% of total volume. Furthermore, as documented in Smith, Turnbull and White (2000), on the TSE, the permanent price impact of upstairs trades is significantly lower than that of downstairs trades as information laden orders are screened out and sent to the downstairs market.

As discussed in Pulatkonak and Sofianos (1999), unlike almost all stocks from other countries, Canadian stocks are listed on the NYSE as ordinary shares rather than as American Depository Receipts (ADRs). Likewise US stocks are listed on the TSE as ordinary shares. Canadian stocks listed as ordinary shares do not involve the conversion fees of switching from an ADR to the underlying home security. Furthermore, there are no legal restrictions on the cross-border ownership and trading of the Canadian stock listed on the NYSE and US stocks listed on the TSE. The extent of integration of the exchanges is

shown by the fact that many of the cross-listed Canadian firms report their financial statements and pay dividends in US dollars.

The only significant characteristics identified by Pulatkonak and Sofianos (1999) that make the Canadian cross-listed securities less than fully fungible are as follows. Canadian stocks bought on the NYSE must clear through the US Depository Trust Company (DTC), must be held in a US dollar account and must pay US dollar dividends. If the dividend is paid in Canadian dollars, an intermediary is needed to convert dividends from Canadian into US dollars in New York. Canadian stocks purchased on the TSE must clear through the Canadian Depository for Securities, must be held in a Canadian dollar account and must receive dividends in Canadian dollars. If a dividend is paid in US dollars, the dividend must be converted to Canadian dollars. Pulatkonak and Sofianos (1999) argue that the requirements of separate clearance and settlement arrangements in the US and Canada encourage a clientele effect whereby Canadians buy cross-listed stocks on the TSE and US investors do so on the NYSE. However, conversations with TSE officials indicated that additional costs associated with clearance and settlement arrangements for a US investor to trade a cross-listed security on the TSE are minimal. We suspect that this clientele effect may be more of a US than Canadian phenomenon. Most of the major brokerage firms in Canada have operations in the United States. US dollar denominated brokerage accounts are very popular in Canada and major Canadian brokerage firms give clients the choice of trading on the NYSE or TSE for cross-listed securities.

Furthermore, any existing clientele effect is expected to be offset by the fact that arbitrage is relatively costless and riskless between the two exchanges. The large Canadian investment dealers employ traders who look for arbitrage opportunities between the two exchanges. Foreign exchange risk is not

expected to be a significant factor as the exchange rate between the two countries' currencies is relatively stable.

One further difference between the NYSE and TSE is the difference in tick sizes.[4] On April 15, 1996, the TSE reduced the tick size from C$1/8 to C$0.05 for stocks priced above C$5. For stocks priced between C$3 and C$5, the tick size was lowered from C$0.05 to C$0.01. The tick size was not affected for stocks priced under C$3. The NYSE lowered the tick size from one-eighth to one-sixteenth of a US dollar on June 24, 1997. There are also some NYSE stocks trading below US$1 whose tick size is one thirty-second of a dollar. Thus, over the period of the study, January through March of 1999, for cross-listed stocks trading over C$5, the tick size was one-sixteenth of a US dollar (6.67 US cents) on the NYSE versus five Canadian cents (which at the time was worth approximately 3.5 US cents). The extent to which differences in the tick size across the two exchanges affect transaction cost will accordingly be considered in the analysis.

II. Analysis of Trading of Cross-listed Securities

The paper conducts a series of tests to identify differences in trade execution costs and trading activity between the two exchanges and then examines the extent to which the differences arise because of market externalities, market quality and clientele effects. This study uses intraday quotes, trade prices and times gathered for both the TSE and the NYSE for the first quarter of 1999. The primary sources of data are:[5]

1. The NYSE's TAQ Data Files,
2. TSE Equity history files and

3. Intraday (10-minute interval) bid and ask quotes on C$/US$ exchange rates provided by the Bank of Canada.

We exclude trades of securities which did not trade at least once a day on either exchange during the period October 1 to December 31, 1998. On this basis, six of 73 firms are removed from the sample; 26 of the firms reported financial statements in US dollars and 41 reported in Canadian dollars.[6] A trade is excluded if there are no available foreign exchange bid and ask quotes within 15 minute of the trade. Throughout this study, all prices are stated in U.S. dollars. Canadian prices are converted to their U.S. equivalent using the nearest intraday exchange rate quotes updated in 10 minute intervals.

Table I presents descriptive statistics for trades of securities cross-listed on the TSE and NYSE during the first quarter of 1999. There are approximately one million trades on the TSE and nearly 300,000 trades on the NYSE. However, as the trades on the NYSE tend to be larger than those on the TSE (average value of US$84,475 on the NYSE versus average value of US$34,230 on the TSE), only about 60% of the total dollar volume of trading of cross-listed shares on the TSE and NYSE is on the TSE. In addition, the TSE has only 53.94% of the block trades of the cross-listed securities. Thus, there appears to be more institutional trading on the NYSE than the TSE. The average price volatility of stocks that are traded on the TSE is 2.71% versus 2.88% for stocks that are traded on the NYSE. Thus, the more volatile cross-listed shares tend to be traded more frequently on the NYSE.

We compare trade execution costs across the two exchanges. Trading costs are a combination of price impacts and commissions. Officials of the TSE indicate that the commissions for trades on the NYSE and TSE are virtually identical when one compares commissions for the same stocks traded in both markets on the same day. Thus, differences in trade execution costs are measured by differences in the price impact

across the exchanges. The average total price impact of trades on the TSE is 0.21% versus 0.27% for trades on the NYSE. Thus, the mean total price impact of trades on the TSE is 0.06% lower than on the NYSE. On a $100,000 dollar trade, the difference in price impact would be $60. Most of this difference is attributable to the lower average temporary price impact of trades on the TSE (0.12%) versus the NYSE (0.17%). The permanent price impacts are marginally lower on the TSE than the NYSE (0.09% versus 0.10%).

In measuring the price impact of a trade, we translate all prices to US dollars. Thus, we assume the perspective of a US investor who, when buying shares on the TSE, first must buy Canadian dollars with her US dollars. As Canadian currency is quoted in Canadian dollars per US dollar, we multiply the ask quote of the Canadian dollar by the stock price on the TSE to get a measure of the cost of buying the stock in US dollars. Likewise, for a seller-motivated trade, we multiply the bid quote of the Canadian dollar by the stock price on the TSE to estimate the proceeds for selling shares in US dollars. Because of the spread in the Canadian dollar, our analysis should be biased against finding lower trade execution costs on the TSE.

We next analyze whether trades are executed on the exchange with the best available prices. For each buyer-initiated (seller-initiated) trade, we investigate whether it could have been executed on the other exchange at a better price given the best available quoted ask (bid) price and depth. Trade direction is measured by the tick test.[7]

As shown in Table II, 73.13% and 50.08% of TSE and NYSE trades, respectively, were executed on the exchange that provided better prices. However, for 23.28% of TSE trades and 33.52% of NYSE trades of the cross-listed securities, there were better quoted prices at sufficient depth on the other market. Thus, a large percentage of trades on both markets do not get best execution. In addition, the fact that a

larger percentage of the trades on the NYSE would have been better executed on the TSE is consistent with larger price impacts on the NYSE than TSE. It suggests that there are factors other than superior prices that affect the decision as where to execute a trade. For example, it is expected that clientele effects may influence the choice of trading venue. Panel B of Table II indicates that the NYSE handles a higher concentration of larger orders. Over 30% of NYSE trades could not have been executed on the TSE without changing the price due to insufficient volume at the market. Less than 10% of the TSE trades would have had a similar problem on the NYSE.

We test the hypothesis that the trade execution costs of the NYSE and the TSE are not significantly different after adjusting for differences in trade size, price volatility and firm size. The regression of price impact on explanatory factors, including the choice of trading venue is as follows:[8]

$$O_{i,j} = C_0 + C_1\ TradeSize_{i,j} + C_2\ PriceVol_{i,j} + C_3 FirmSize_{i,j} + C_4\ TSE_{i,j} + C_5\ TSE_{i,j} + TradeSize_{i,j} + e_{i,j} \quad \textbf{(1)}$$

where

$O_{i,j}$ = $ln(P_{i,j}/E_{i,j})$ for buyer-initiated trades and $ln(E_{i,j}/P_{i,j})$ for seller-initiated trades: price impact of trade j for stock i

$E_{i,j}$ = the mean of the best bid-ask prices immediately before trade j for stock i translated into US dollars using the midquote of the Canadian/US dollar exchange rate[9]

$P_{i,j}$ = the price of trade j for stock i in US dollars

$TradeSize_{i,j}$ = the trade size divided by the median daily number of shares traded over all trading days during the three month period ending in the month prior to the month of the observation,

$PriceVol_{i,j}$ = the standard deviation of the daily return (US$) on the stock during the three month period ending in the month prior to the month of the observation

$FirmSize_{i,j}$ = log of the US dollar market capitalization of the firm as at the end of the last trading day of the month prior to the month of the observation

$TSE_{i,j}$ = dummy variable equal to one if trade is on TSE and zero otherwise

Consistent with Easley and O'Hara (1987), we expect C_1 to be positive. That is, informed traders will place larger orders to profit from any informational advantage they hold. Given the evidence from Burdett and O'Hara (1987), Seppi (1990), Madhavan and Cheng (1997) and Smith, Turnbull and White (2000), larger order execution costs are expected for larger trades. As in Griffiths, Smith, Turnbull and White (2000), the coefficient for *PriceVol*, C_2, is expected to be positive. Greater volatility means that a stock is riskier to hold in a market maker's inventory because of potential holding losses. Higher order execution costs compensate liquidity providers for this risk. Thus, greater price volatility is expected to increase order execution costs. The coefficient for *FirmSize* is expected to be negative because information content is expected to be greater for smaller firms. If the fixed and variable costs of executing a trade on the TSE are lower than on NYSE, the sign of the coefficients, C_4 and C_5, respectively, should be negative.

The regression analysis is repeated after excluding the TSE upstairs trades. It is expected that with the exclusion of these trades, that the NYSE will have a lower trade execution cost than the TSE. This is because the upstairs market on the TSE has been shown in Smith, Turnbull and White (2000) to have lower permanent price impacts than the downstairs market. Thus, exclusion of these trades should bias the test in favor of finding lower costs on the NYSE.

Table III shows that the total price impact is significantly lower on the TSE than the NYSE after controlling for differences in trade size, price volatility and market capitalization. The fixed and variable component of total price impact is significantly negative. As expected, trade size and price volatility are positively related to total price impact of trades. Also, firm size is negatively related to the total price impact of trades. These relationships hold whether all trades are considered or whether the sample excludes upstairs trades on the TSE. Because the TSE upstairs market is non-anonymous, it is expected that permanent price impact and thus total price impact is significantly smaller in this market. Furthermore, whether the sample is divided between block and non-block trades makes no difference. The TSE appears less expensive than the NYSE.

Regressions with the same independent variables are also run to compare the permanent and temporary price effects across the exchanges. The permanent price effect is measured as $ln(A_{i,j}/E_{i,j})$ for buyer-initiated trades and $ln(E_{i,j}/A_{i,j})$ for seller-initiated trades where $A_{i,}$ is the mean of the best bid-ask prices 15 seconds after trade j for stock i. The temporary effect is measured as $ln(P_{i,j}/A_{i,j})$ for buyer-initiated trades and $ln(A_{i,j}/P_{i,j})$ for seller-initiated trades. It is expected that differences in the structure of the upstairs markets lead to differences in search costs which in turn lead to differences in temporary price effects for larger trades. Furthermore, the rules of the TSE which facilitate more upstairs market-making may lead to lower information costs given the non-anonymous trading environment upstairs.

As shown in Tables IV and V, the permanent and temporary price impacts exhibit a pattern that is similar to that of the total price impact. That is, the fixed and variable components of the permanent and temporary price impacts are smaller on the TSE than the NYSE. While one can attribute a lower variable component of the temporary price impact on the TSE to its lower tick size, the lower permanent price impact and lower fixed component of the temporary price impact are not expected with lower tick size.

Because the TSE has a smaller tick size than the NYSE, it is expected that it will have lower temporary price impacts, and as a result lower total price impacts. It is also possible that difference in tick size may affect the permanent price impact. To test whether difference in tick size has any effect on the permanent price impact, we analyse some indirect evidence. First, since many of the TSE and NYSE cross-listed securities trade on NASD's third market, we compare whether the price impacts on NYSE are higher than those on NASD's third market for these securities. On the NYSE and NASD's third market, the tick size is the same over the period of analysis. The difference in currency is also not an issue for these two markets. Furthermore, the analysis is useful in that the NASD's third market facilitates trading in a non-anonymous environment similar to the upstairs market on the TSE. Using only the trades on NASD's third market and the NYSE, we estimate the following model for price impact of a trade:

$$O_{i,j} = C_0 + C_1\, TradeSize_{i,j} + C_2\, PriceVol_{i,j} + C_3 FirmSize_{i,j} + C_4\, ThirdMkt_{i,j} + C_5\, ThirdMkt_{i,j} * TradeSize_{i,j} + e_{i,j} \qquad (2)$$

where:

$ThirdMkt_{i,j}$ = dummy variable equal to one if trade was on NASD's third market and zero otherwise

The coefficient of ThirdMkt measures any difference in price impact associated with the trade being executed on that exchange rather than NYSE. A significant difference in price impact would indicate that factors other than tick size and foreign exchange conversion costs are at play.

As shown on Table VI, we find that while total price impact is larger on NASD's third market than the NYSE, the permanent price impact is lower. The higher total price impact on NASD's third market is not surprising as it reflects higher implicit execution costs that compensate for no commissions. There are significantly lower permanent price impacts for NASD third market trades. This suggests that the non-

anonymous dealer market of NASD's third market allows for better screening of orders with adverse information than does the NYSE. In addition, since NASD's third market and NYSE have the same tick sizes for these stocks, the lower permanent price impact on NASD's third market trades also suggests it is not differences in tick size that lead to lower permanent price impacts on the TSE than the NYSE.

We use a second indirect approach to analyzing whether differences in total and permanent price impacts are associated with tick size across the exchanges by comparing trading costs of firms with different size ticks on each exchange. The model for total price impact of a trade is:

$$\begin{aligned} O_{i,j} = {} & C_0 + C_1\, TradeSize_{i,j} + C_2\, PriceVol_{i,j} + C_3\, FirmSize_{i,j} + \\ & + C_4\, SmallTick_{i,j} + C_5\, SmallTick_{i,j} * TradeSize_{i,j} + e_{i,j} \end{aligned} \qquad \textbf{(3)}$$

where:

$SmallTick_{i,j}$ = dummy variable equal to one if trade involved a stock with a lower tick size than other stocks on the respective exchange and zero otherwise; on the TSE, a lower tick occurs where stock price is below $5 and on the NYSE, a lower tick would be 1/32nd versus 1/16th

If smaller tick size leads to lower trading costs, then the coefficient of the variable *SmallTick* will be negative. If the coefficient is not significantly less than zero, then there is no evidence that tick size affects permanent price impacts on these exchanges.

For the TSE sample of trades, Table VII shows that the price impact of stocks with a price less than $5 (and lower tick size) is different from those whose price was at least $5. The trades of smaller tick stocks had significantly higher total and permanent price impacts than those of larger tick stocks. Likewise,

the trades of stocks with only a tick size of 1/32 on the NYSE had significantly higher total and permanent price impacts than those with a tick size of 1/16 on the NYSE. Thus, the tick size does not seem to be a factor leading to lower permanent price impacts on the TSE.

As a larger market, it is possible that the NYSE plays a more important role than the TSE for news dissemination. If this is the case, the permanent price impacts should be larger on the NYSE than the TSE. On the other hand, since most of the firms cross-listed on the TSE and NYSE have head offices in Canada, it is possible that the TSE plays the role of senior exchange for these securities. To test the hypothesis that the NYSE is a senior exchange to the TSE, we examine which market is more likely to lead the other market. In particular, we test whether, it is more likely that a buyer-initiated block trade on the NYSE is followed by a similar trade on the TSE than a buyer-initiated block trade on the TSE is followed by a similar trade on the NYSE. We measure the percentage of consecutive pairs of trades categorized by different sequences. The sequence of trades is delineated by the exchange where the first and second trade are executed as well as the trades' respective size and initiator. A large (small) trade includes at least (less than) 10,000 shares.[10]

The transition matrix reported in Table VIII indicates that neither the TSE nor NYSE is a senior market to the other. Panel B of Table VIII indicates there are no statistically significant differences between the percentage of cases where the TSE was the first exchange to have a trade type followed by a similar trade type in the other exchange versus the percentage of cases where this was true of the NYSE. The fact that the NYSE is not a senior market to the TSE indicates that this is not an explanation for the higher permanent price impacts on the NYSE.

The next step in the analysis is to examine the factors that explain why a trade occurs in one market versus the other. One of the factors that should affect trade location is the market which can supply more

liquidity to the side of the trade that corresponds to the liquidity-seeking order. While it would be most useful to have information on the full side of a limit order book, the only available information on the NYSE order book is the best market quote. Thus, we use the depth of the best market quote to measure available liquidity.

We test the factors that lead to a trade being executed on a particular market using a logit regression. We estimate the following equation:

$$Exch_{i,t} = f(NYSEVRel_{i,t}, TSEVRel_{i,t}, PriceRel_{i,t}, Domestic_{i,t}) \quad (4)$$

where,

$Exch_{i,t}$ = 1 if on TSE and 0 if on NYSE

$NYSEVRel_{i,t}$ = number of shares in trade t for security i divided by number of shares at ask (bid) on NYSE immediately prior to trade t for buyer- (seller-) initiated trades

$TSEVRel_{i,t}$ = number of shares in trade t for security i divided by number of shares at ask (bid) on TSE immediately prior to trade t for buyer- (seller-) initiated trades

$PriceRel_{i,t}$ = ask price on the TSE divided by ask price on the NYSE immediately prior to trade t for security i for buyer-initiated trades; bid price on the NYSE divided by bid price on the TSE immediately prior to trade t for security i for seller-initiated trades

$Domestic_{i,t}$ = 1 if financial statements of company listing security i are reported in Canadian dollars and 0 otherwise.

We expect the coefficient of $NYSEVRel_{i,t}$ to be significantly positive as a large trade relative to the order book on the NYSE suggests that the NYSE is less able to absorb the trade. The trade is more likely to have occurred on the TSE. On the other hand, we expect the coefficient of $TSEVRel_{i,t}$ to be significantly

negative as a larger order relative to volume of the TSE would suggest the TSE is less able to absorb the trade and we expect it is more likely to be executed on the NYSE. $PriceRel_{i,t}$ measures the price competitiveness of one market versus the other. If, from the perspective of the trade initiator, the TSE's price is worse than that available on the NYSE, $PriceRel_{i,t}$ will be greater than one and we would expect the trade to go to the NYSE. The coefficient on $PriceRel_{i,t}$ should be negative. $Domestic_{i,t}$ is expected to reflect where the majority of investors are domiciled. We expect firms that report in Canadian dollars to be predominately owned by Canadian shareholders and traded on the TSE. Likewise, we expect firms that report in US dollars to be mainly owned by Americans and traded on the NYSE. Thus, the coefficient on $Domestic_{i,t}$ is expected to be positive.

The results of the logit regression, shown in Table IX, indicate that stocks trade in the market that offers greater liquidity. In particular, if the trade size is high relative to the depth of the limit order book at the market on the NYSE, then the stock tends to trade in Canada. Likewise, if the trade size is high relative to the depth of the limit order book on the TSE, then the trade is less likely to occur on the TSE. If the quoted stock price at the market is better on the TSE than the NYSE, the trade is more likely to occur on the TSE. All of these findings suggest that the market is highly responsive to shifts in liquidity from one market to the other. Finally, if a company reports its financial statements in Canadian dollars, then it is likely that the firm's stock will trade on the TSE. This suggests that the residency of the majority of the firm's shareholders has a significant impact on choice of trading venue.

We also hypothesize that trading occurs on the exchange with the highest quality. A cross-sectional regression is run for the estimation period, January 1999 to March 1999.

$$Ln(Total\ Volume\ on\ TSE/Total\ Volume\ on\ NYSE)_i = k_0 + k_1 * AvgPrice_i + k_2 * AvgVol_i + k_3 * LRCont_i \quad (5)$$

$AvgPrice_i$ = ((Percentage of time TSE has a bid at least as high as NYSE) + (Percentage of time TSE has an ask quote at least as low as NYSE))/2

$AvgVol_i$ = ((Percentage of time TSE has an offered volume at least as large as NYSE) + (Percentage of time TSE has a wanted volume at least as large as NYSE))/2

$LRCont_i$ = ln(percentage of trades on TSE that resulted in a price change of 1/8 or less/percentage of trades on the NYSE that resulted in a price change of 1/8 or less)

We expect that there will be a positive relationship between each of the variables $AvgPrice_i$, $AvgVol_i$ and $LRCont_i$ and the relative volume on the TSE versus the NYSE. That is, more trading will take place on the TSE versus the NYSE when the market offers more favorable quote prices and depth. The variable $LRCont_i$ is included in the analysis because volume at the market and best quoted prices are not sufficient to measure market quality.

Table X reports the results of a cross-sectional regression of the relative volume of trading on the TSE versus the NYSE on three variables that reflect market quality. We find that trading is more likely to occur on the TSE when the prices are more attractive. In addition, trading is more likely to happen in Canada when the depth of the limit order book at the market is superior on the TSE than NYSE. Finally, if there is greater price continuity on a stock on the TSE than the NYSE, trading is more likely to occur on the TSE. Overall, the results suggest that market quality is the main determinant of whether trading occurs on the TSE or the NYSE.

III. Conclusion

This paper measures the impact of network externalities and market quality on trading activity and trade execution costs of 67 stocks cross-listed and actively traded on both the NYSE and the TSE. First,

nearly 80% of the number of trades and 60% of the US dollar volume of the cross-listed securities occur on the TSE. Trading on the NYSE of these cross-listed securities is concentrated among much larger trades than the TSE. Thus, it is not surprising that the average total price impact of trades from a US investor on the NYSE is 0.27% versus 0.21% for trades on the TSE. However, the finding of lower price impacts holds even after controlling for differences in trade size, price volatility and firm size.

We investigate whether the lower trading cost is attributable to differences in the upstairs markets on the exchanges as well as the execution of block trades. Whether or not we exclude trades in the TSE upstairs market and whether we divide the sample into block and non-block trades makes no difference. The differences in network externalities between the two exchanges do not appear important in affecting trade execution cost. Furthermore, an examination of the trading cost of stocks of lower tick size on each of the exchanges indicates that lower tick size is associated with higher permanent and total price impact. Thus, the lower tick size on the TSE does not seem to be a factor in explaining why the TSE trades have a lower permanent price impact.

The sample of securities also traded on NASD's third market over the period of study. It was found that while total price impact was higher on NASD's third market than the NYSE, the permanent price impact was lower on NASD's third market. This suggests that NASD's third market had trades of less adverse information similar to the upstairs market on the TSE. It highlights the advantage of a non-anonymous market for handling large liquidity-motivated trades. Furthermore, since tick sizes are the same on NASD's third market and NYSE, there is no evidence that a larger tick size leads to higher permanent price impacts on the NYSE.

The paper finds that neither the TSE nor the NYSE act as a senior exchange to the other. Thus, this does not offer an explanation for the lower permanent price impacts on the TSE than NYSE.

We find that approximately one-quarter of the trades on the TSE and one-third of the trades on the NYSE could have been executed on the other exchange at a better price. The larger percentage of NYSE trades that were executed at sub-optimal prices is consistent with higher price impacts on the NYSE. However, in the majority of trades, on the other exchange, there was either a worse price or insufficient depth to handle the order.

A logit regression of the factors associated with a trade occurring on the TSE rather than the NYSE illustrates that trading gravitates to the exchange with superior market quality. Trades tend to occur in the market that offers better quoted prices and depth. However, after controlling for these factors measuring market quality, the trades of stocks of firms which report their financial reports in Canadian (US) dollars are more likely to be executed on the TSE (NYSE). Thus, there appears to be a clientele effect. Investors prefer to trade in their home market. This finding is consistent with the non-trivial number of trades that occur at worse prices to those available on the other exchange.

We conduct a cross-sectional regression on the relative amount of trading done on the TSE versus the NYSE across stocks and find a larger proportion of trading in a stock is done on the exchange which, on average, offers better prices and depth in its limit order book for that stock. In addition, trading tends to occur on the exchange which offers superior price continuity.

In summary, the paper illustrates how market quality is the primary determinant of trading activity of cross-listed securities. Clientele effects are a secondary factor. Differences in network externalities in the case of the two international markets studied do not have a significant impact on trade execution costs. The findings suggest that competition for international cross-listings will intensify as exchanges vie on the basis of market quality.

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Endnotes

1. Network externalities include the regulatory and operational structure of the exchange.

2. Both markets employ specialists (Designated Registered Trader on the TSE) to maintain an orderly market in their securities and fill small retail orders. There is, however, a significant difference in how orders are displayed between markets. In Toronto, all orders are fully disclosed in the limit book whereas in New York, the specialist may (and often does) withhold a portion of the order from the market for a time. In New York, the specialist is the only market participant that always knows the true depth of the market; in Toronto, all participants know the true depth.

3. This is similar to the difficulty in comparisons of trading costs on the NYSE versus the NASDAQ discussed in papers such as Huang and Stoll (1996), Chan and Lakonishok (1997), Keim and Madhavan (1997), LaPlante and Muscarella (1997), and Jones and Lipson (1999).

4. Recent moves to lower tick size on the NYSE and the TSE are partly in response to the need to lower execution costs in the face of international competition. Ahn, Cao and Choe (1997) and MacKinnon and Nemiroff (1999) analyze stocks cross-listed on the TSE and US exchanges over a five and three month period, respectively, surrounding the April 15, 1996 switch to decimalization on the TSE. Both papers report that liquidity significantly increased for these securities on the TSE. On the other hand, the papers find that there is no impact on liquidity of these securities on US exchanges with the exception that Ahn, Cao and Choe (1997) report an 8% reduction in spread on NASDAQ for TSE cross-listed stocks. Interestingly, the two papers differ in their conclusion as to the impact of decimalization on volume of shares traded. Ahn, Cao and Choe (1997) report no change in volume of securities

traded on either US or Canadian exchanges from before to after decimalization whereas MacKinnon and Nemiroff (1999) report a significant increase in the average proportion of shares traded on the TSE versus the US exchanges.

5. The use of the two databases provides comparable information. Jacquillat and Gresse (1998) note problems in comparing volume of French stocks traded on the Paris Bourse to the SEAQ-I which are not present in the NYSE/TSE databases.

6. For the firms reporting financial statements in US dollars, 55.65 % of volume traded was on the TSE and for the firms reporting in Canadian dollars, 83.67% of the volume traded was on the TSE.

7. Lee and Ready (1991) argue that in some cases the quote data is stale in terms of trades since posting of trades takes precedence over posting of quotes on the NYSE. However, current research underway by the authors has an alternate hypothesis that the perceived effect is attributable to order aggressive and price improvement in the upstairs market.

8. The large number of observations in our regressions means that we must be careful in interpreting the levels of statistical significance using t-statistics. As Zellner (1984) discusses, a large sample size drives the standard error of the coefficient estimates toward zero and produces large t-statistics. Given the considerable risk of type I error, we follow Griffiths and White (1993) and conduct a posterior odds ratio test as an alternate method of determining a critical t-value.

9. No adjustment was made to eliminate book clearing trades before upstairs trades. Smith, Turnbull and White (2000) identify that less than 0.2% of all upstairs trades on the TSE have trades in the fifteen minutes prior to the trade that were done to clear the limit order book to

accommodate an aggressive upstairs order. Keim and Madhavan (1996) discuss how block trades are "shopped" and that this activity may involve a leakage of information. They suggest that a portion of the price impact is experienced in the days prior to the trade, as buyer-initiated (seller-initiated) block trades are preceded by stock price increases (decreases). Thus, on the TSE, it is likely that traders informally "shop" orders without entering them in their order entry systems. For the NYSE, we had no means of distinguishing upstairs from downstairs trades.

10. We conduct an alternative test of the senior market hypothesis. We redo the price impact regressions after eliminating all trades with confounding events within a 30 second information window (centered on the trade time). The findings are unchanged from the price impact regressions reported in the paper. They are also consistent with the findings of the transition matrix analysis that neither exchange is 'senior' to the other.

Table I

Descriptive Statistics for Trades of Securities Cross-listed on the NYSE and TSE During the First Quarter of 1999

This table presents general descriptive statistics for all trades of securities cross-listed on the NYSE and TSE during the first quarter of 1999. The data are extracted from the TSE Equity History files and the NYSE TAQ CD-ROMs. To be included, the cross-listed securities had to be continuously listed on both exchanges over the period October 1, 1998 through March 31, 1999. Trades of the six securities which did not trade at least once a day on either exchange during the period October 1, 1998 to December 31, 1998 are excluded. For buyer-initiated trades, i) the total price impact is measured by the logarithm of trade price divided by the mean of the market quotes immediately prior to the trade ii) the permanent price impact is measured by the logarithm of the mean of the market quotes 15 seconds after the trade to the mean of the market quotes immediately prior to the trade and iii) the temporary price impact is measured by the logarithm of trade price divided by the mean of the market quotes 15 seconds after the trade. For seller-initiated trades, the price impacts are the logarithm of the inverse of the ratios of those of the buyer-initiated trades. The Price Volatility variable is the standard deviation of daily returns in the three-month period immediately prior to the month of the trade. The market capitalization of the firm is measured at the end of December 1998.

	Market on Which Trades of Cross-Listed Stocks Occur	
Variable	**TSE**	**NYSE**
Number (Percentage) of Trades	1,046,085 (78.45%)	287,372 (21.55%)
Millions (Percentage) of Shares Traded	1,547 (69.57%)	677 (30.43%)
US $ Value (Percentage) of Shares Traded	35,807 (59.60%)	24,276 (40.40%)
Number (Percentage) of Block Trades i.e. $10,000 shares	16,528 (53.94%)	14,116 (46.06%)
Mean (Standard Deviation) of Number of Shares in Trade	1,479 (19,501)	2,355 (8,727)
Mean (Standard Deviation) of US $ Value of Shares in Trade	34,230 (381,359)	84,475 (307,247)
Time Weighted Average Spread in US cents	13.14 (16.27)	15.31 (7.09)
Mean of Depth at Best Quote on Opposite Side of Book Prior to Trade (Number of Shares)	5,488	6,559
Mean (Standard Deviation) of Total Price Impact of Trade	0.21% (0.32%)	0.27% (0.53%)
Mean (Standard Deviation) of Permanent Price Impact of Trade	0.09% (0.30%)	0.10% (0.37%)
Mean (Standard Deviation) of Temporary Price Impact of Trade	0.12% (0.36%)	0.17% (0.54%)
Price Volatility	2.71% (1.24%)	2.88% (1.15%)
Average Market Capitalization of Cross-listed Firms in $US billions	4.479	4.479
Percentage of Trades where reporting currency is Canadian dollars	67.17%	30.11%

Table II

An Analysis of Whether Trading Occurs in the Market with the Best Execution During the First Quarter of 1999

This table analyzes whether trades of securities cross-listed on the NYSE and the TSE would have been executed at more favorable prices on the other exchange. In particular, for trades on the Toronto Stock Exchange, Panel A shows the percentage that would have been executed at better, same and worse prices on the New York Stock Exchange based on available depth in the NYSE limit order book. For a buyer-motivated trade, a better price is defined as an ask quote in the limit book of the other exchange that is lower than the price of the trade. For a seller-motivated trade, a better price is defined as a bid quote in the limit book of the other exchange that is higher than the price of the trade. All trades of securities cross-listed on the New York and the Toronto stock exchanges over the first quarter of 1999 are included in this table. There are 1,046,085 and 287,372 trades on the Toronto and the New York stock exchanges, respectively. All traded and quoted prices are converted into US dollars at the exchange rate time-stamped within five minutes of the trade.

Panel A: Trades Executed on Toronto Stock Exchange

Trade Size	**Sufficient Depth on NYSE**			**Insufficient Depth on NYSE**		
	NYSE Quote Relative to TSE Price			**NYSE Quote Relative to TSE Price**		
	NYSE Better	**NYSE Same**	**NYSE Worse**	**NYSE Better**	**NYSE Same**	**NYSE Worse**
< 1,000 Shares	19.45%	0.05%	52.15%	1.04%	0.00%	1.40%
1,000 # Shares < 10,000	3.79%	0.01%	14.72%	2.14%	0.00%	3.66%
$10,000 Shares	0.04%	0.00%	0.28%	0.33%	0.00%	0.92%
Total	23.28%	0.06%	67.15%	3.52%	0.01%	5.98%

Panel B: Trades Executed on New York Stock Exchange

Trade Size	**Sufficient Depth on Toronto Stock Exchange**			**Insufficient Depth on Toronto Stock Exchange**		
	TSE Quote Relative to NYSE Price			**TSE Quote Relative to NYSE Price**		
	TSE Better	**TSE Same**	**TSE Worse**	**TSE Better**	**TSE Same**	**TSE Worse**
< 1,000 Shares	23.68%	0.00%	21.96%	4.75%	0.00%	4.04%
1,000 # Shares < 10,000	9.67%	0.00%	10.78%	9.60%	0.00%	10.61%
$10,000 Shares	0.17%	0.00%	0.20%	2.06%	0.00%	2.49%
Total	33.52%	0.00%	32.94%	16.40%	0.00%	17.13%

Table III

Regression Analysis of Determinants of Total Price Impact of Trades for Cross-listed Securities During the First Quarter of 1999

This table shows the coefficients (multiplied by 100), t-statistics (in parentheses) and adjusted R^2 of regression (1) for trades on the TSE and NYSE for cross-listed securities in the period January 1 through March 31, 1999. To be included, the cross-listed securities had to be continuously listed on both exchanges over the period October 1, 1998 through March 31, 1999. Trades of the six securities which did not trade at least once a day on either exchange during the period October 1, 1998 to December 31, 1998 are excluded. One and two asterisks indicate significance at the 5-percent and 1-percent levels, respectively. A '#' means that the posterior odds ratio indicates that the odds against the null hypothesis of the mean equalling zero is greater than 20:1. The model for price impact of a trade is:

$$O_{i,j} = C_0 + C_1\ TradeSize_{i,j} + C_2\ PriceVol_{i,j} + C_3\ FirmSize_{i,j} + \\ + C_4\ TSE_{i,j} + C_5\ TSE_{i,j} * TradeSize_{i,j} + e_{i,j}$$

where:

$O_{i,j}$ = $ln(P_{i,j}/E_{i,j})$ for buyer-initiated trades and $ln(E_{i,j}/P_{i,j})$ for seller-initiated trades: price impact of trade j for stock i

$E_{i,j}$ = the mean of the best bid-ask prices immediately before trade j for stock i

$P_{i,j}$ = the price of trade j for stock i

$TradeSize_{i,j}$ = the trade size divided by the median daily number of shares traded over all trading days during the three month period ending in the month prior to the month of the observation,

$PriceVol_{i,j}$ = the standard deviation of the daily return (US$) on the stock during the three month period ending in the month prior to the month of the observation

$FirmSize_{i,j}$ = log of the market capitalization of the firm as at the end of the last trading day of the month prior to the month of the observation

$TSE_{i,j}$ = dummy variable equal to one if trade is on TSE and zero otherwise

	All Trades	**Excluding Upstairs Trades on TSE**	**Block Trades Only**	**Non-Block Trades**
Constant	2.458 (455.08)**#	2.460 (451.41)**#	4.344 (73.12)**#	2.288 (415.47)**#
***TradeSize*$_{i,j}$**	0.653 (46.43)**#	0.652 (46.22)**#	0.141 (5.52)**#	3.978 (66.94)**#
***PriceVol*$_{i,j}$**	7.060 (279.60)**#	7.070 (277.48)**#	12.20 (53.32)**#	6.764 (270.68)**#
***FirmSize*$_{i,j}$**	-0.105 (-478.39)**#	-0.105 (-474.64)**#	-0.191 (-79.09)**#	-0.098 (-437.10)**#
***TSE*$_{i,j}$**	-0.077 (-114.04)**#	-0.077 (-113.25)**#	-0.248 (-37.69)**#	-0.065 (-94.60)**#
***TSE*$_{i,j}$* *TradeSize*$_{i,j}$**	-0.624 (-43.67)**#	-0.614 (-42.10)**#	-0.135 (-5.25)**#	-1.390 (-19.31)**#
Adjusted R-Square	0.294	0.293	0.442	0.290

Number of Trades	1,333,457	1,317,739	30,648	1,302,809

Table IV

Regression Analysis of Determinants of Permanent Price Impact of Trades for Cross-listed Securities During the First Quarter of 1999

This table shows the coefficients (multiplied by 100), t-statistics (in parentheses) and adjusted R^2 of regression analysis of permanent price impact for trades on the TSE and NYSE for cross-listed securities in the period January 1 through March 31, 1999. To be included, the cross-listed securities had to be continuously listed on both exchanges over the period October 1, 1998 through March 31, 1999. Trades of the six securities which did not trade at least once a day on either exchange during the period October 1, 1998 to December 31, 1998 are excluded. One and two asterisks indicate significance at the 5-percent and 1-percent levels, respectively. A '#' means that the posterior odds ratio indicates that the odds against the null hypothesis of the mean equalling zero is greater than 20:1. The model for permanent price impact of a trade is:

$$I_{i,j} = C_0 + C_1\ TradeSize_{i,j} + C_2\ PriceVol_{i,j} + C_3\ FirmSize_{i,j} + C_4\ TSE_{i,j} + C_5\ TSE_{i,j} * TradeSize_{i,j} + e_{i,j}$$

where:

$I_{i,j}$ = $ln(A_{i,j}/E_{i,j})$ for buyer-initiated trades and $ln(E_{i,j}/A_{i,j})$ for seller-initiated trades: price impact of trade j for stock i

$A_{i,j}$ = the mean of the best bid-ask prices immediately after trade j for stock i

$E_{i,j}$ = the mean of the best bid-ask prices immediately before trade j for stock i

$TradeSize_{i,j}$ = the trade size divided by the median daily number of shares traded over all trading days during the three month period ending in the month prior to the month of the observation,

$PriceVol_{i,j}$ = the standard deviation of the daily return (US$) on the stock during the three month period ending in the month prior to the month of the observation

$FirmSize_{i,j}$ = log of the market capitalization of the firm as at the end of the last trading day of the month prior to the month of the observation

$TSE_{i,j}$ = dummy variable equal to one if trade is on TSE and zero otherwise

	All Trades	Excluding Upstairs Trades on TSE	Block Trades Only	Non-Block Trades
Constant	0.927 (177.70)**#	0.937 (178.05)**#	1.892 (30.12)**#	0.716 (135.58)**#
***TradeSize*$_{i,j}$**	0.461 (33.97)**#	0.458 (33.64)**#	0.078 (2.88)*	3.803 (66.79)**#
***PriceVol*$_{i,j}$**	3.834 (157.27)**#	3.853 (156.58)**#	7.026 (28.98)**#	3.738 (156.08)**#
***FirmSize*$_{i,j}$**	-0.041 (-194.80)**#	-0.042 (-195.27)**#	-8.443 (-33.07)**#	-0.033 (-151.47)**#
***TSE*$_{i,j}$**	-0.013 (-19.67)**#	-0.012 (-17.80)**#	-0.139 (-20.02)**#	-0.0053 (-7.99)**#
***TSE*$_{i,j}$* *TradeSize*$_{i,j}$**	-0.457 (-33.09)**#	-0.412 (-29.26)**#	-0.096 (-3.53)**	1.121 (16.25)**#
Adjusted R-Square	0.08	0.081	0.149	0.089

Number of Trades	1,333,457	1,317,739	30,648	1,302,809

Table V

Regression Analysis of Determinants of Temporary Price Impacts of Trades for Cross-listed Securities During the First Quarter of 1999

This table shows the coefficients (multiplied by 100), t-statistics (in parentheses) and adjusted R^2 of regression of temporary price impact for trades on the TSE and NYSE for cross-listed securities in the period January 1 through March 31, 1999. To be included, the cross-listed securities had to be continuously listed on both exchanges over the period October 1, 1998 through March 31, 1999. Trades of the six securities which did not trade at least once a day on either exchange during the period October 1, 1998 to December 31, 1998 are excluded. One and two asterisks indicate significance at the 5-percent and 1-percent levels, respectively. A '#' means that the posterior odds ratio indicates that the odds against the null hypothesis of the mean equalling zero is greater than 20:1. The model for temporary price impact of a trade is:

$$C_{i,j} = C_0 + C_1\ TradeSize_{i,j} + C_2\ PriceVol_{i,j} + C_3\ FirmSize_{i,j} + C_4\ TSE_{i,j} + C_5\ TSE_{i,j} * TradeSize_{i,j} + \varepsilon_{i,j}$$

where:

$C_{i,j}$ = $ln(P_{i,j}/A_{i,j})$ for buyer-initiated trades and $ln(A_{i,j}/P_{i,j})$ for seller-initiated trades: price impact of trade j for stock i

$P_{i,j}$ = the price of trade j for stock i

$A_{i,j}$ = the mean of the best bid-ask prices immediately after trade j for stock i

$TradeSize_{i,j}$ = the trade size divided by the median daily number of shares traded over all trading days during the three month period ending in the month prior to the month of the observation,

$PriceVol_{i,j}$ = the standard deviation of the daily return (US$) on the stock during the three month period ending in the month prior to the month of the observation

$FirmSize_{i,j}$ = log of the market capitalization of the firm as at the end of the last trading day of the month prior to the month of the observation

$TSE_{i,j}$ = dummy variable equal to one if trade is on TSE and zero otherwise

	All Trades	Excluding Upstairs trades on TSE	Block Trades Only	Non-Block Trades
Constant	1.531 (228.85)**#	1.523 (225.58)**#	2.452 (32.52)**#	1.57 (229.22)**#
***TradeSize*$_{i,j}$**	0.192 (11.00)**#	0.194 (11.08)**#	0.063 (1.95)*	0.174 (2.35)*
***PriceVol*$_{i,j}$**	3.226 (103.13)**#	3.217 (101.91)**#	5.199 (17.87)**#	3.026 (97.21)**#
***FirmSize*$_{i,j}$**	-0.064 (-234.34)**#	-0.064 (230.89)**#	-0.107 (-34.77)**#	-0.066 (-234.36)**#
***TSE*$_{i,j}$**	-0.064 (-76.72)**#	-0.065 (-77.54)**#	-0.109 (-13.02)**#	-0.060 (-69.80)**#
***TSE*$_{i,j}$* *TradeSize*$_{i,j}$**	-0.168 (-9.46)**#	-0.202 (-11.17)**#	-0.039 (-1.19)	-2.511 (-28.00)**#
Adjusted R-Square	0.079	0.078	0.112	0.079
Number of Trades	1,333,457	1,317,739	30,648	1,302,809

Table VI

Regression Analysis of Determinants of Price Impacts of Trades on NYSE versus the NASD third Market for Securities Cross-listed on NYSE and TSE During the First Quarter of 1999

This table shows the coefficients (multiplied by 100), t-statistics (in parentheses) and adjusted R^2 of regression (2) for trades on the NYSE versus those executed in the NASD third market in the period January 1 through March 31, 1999. The NASD third market includes over-the-counter trading of NYSE-listed securities among institutional investors and broker/dealers for their own accounts. In the third market, large blocks of stock are traded off the floor of the exchange and the transactions are recorded on NASD for reporting purposes only. To be included, the securities had to be continuously listed on both the NYSE and TSE over the period October 1, 1998 through March 31, 1999. Trades of the six securities which did not trade at least once a day on either exchange during the period October 1, 1998 to December 31, 1998 are excluded. One and two asterisks indicate significance at the 5-percent and 1-percent levels, respectively. A '#' means that the posterior odds ratio indicates that the odds against the null hypothesis of the mean equalling zero is greater than 20:1. The model for price impact of a trade is:

$$O_{i,j} = C_0 + C_1\ TradeSize_{i,j} + C_2\ PriceVol_{i,j} + C_3\ FirmSize_{i,j} + C_4\ ThirdMkt_{i,j} + C_5\ ThirdMkt_{i,j} * TradeSize_{i,j} + e_{i,j}$$

where:

$O_{i,j}$ = $ln(P_{i,j}/E_{i,j})$ for buyer-initiated trades and $ln(E_{i,j}/P_{i,j})$ for seller-initiated trades: price impact of trade j for stock i

$E_{i,j}$ = the mean of the best bid-ask prices immediately before trade j for stock i

$P_{i,j}$ = the price of trade j for stock i

$TradeSize_{i,j}$ = the trade size divided by the median daily number of shares traded over all trading days during the three month period ending in the month prior to the month of the observation,

$PriceVol_{i,j}$ = the standard deviation of the daily return (US$) on the stock during the three month period ending in the month prior to the month of the observation

$FirmSize_{i,j}$ = log of the market capitalization of the firm as at the end of the last trading day of the month prior to the month of the observation

$ThirdMkt_{i,j}$ = dummy variable equal to one if trade is on NASD's third market and zero otherwise

	All Trades		**Block Trades Only**	
	Total Price Impact	**Permanent Price Impact**	**Total Price Impact**	**Permanent Price Impact**
Constant	3.209 (227.99)**#	0.804 (74.76)**#	4.875 (46.57)**#	2.18 (24.33)**#
$TradeSize_{i,j}$	0.217 (10.21)**#	0.516 (31.67)**#	0.024 (0.73)	0.061 (2.13)*
$PriceVol_{i,j}$	21.00 (293.51)**#	0.235 (43.00)**#	22.50 (47.80)**#	5.26 (13.00)**#
$FirmSize_{i,j}$	-0.156 (-276.07)**#	-0.034 (-79.04)**#	-0.230 (-54.98)**#	-0.095 (-26.49)**#
$ThirdMkt_{i,j}$	0.145 (62.20)**#	-0.094 (-52.87)**#	0.366 (12.26)**#	-0.347 (-13.55)**#
$ThirdMkt_{i,j}$* $TradeSize_{i,j}$	2.887 (36.20)**#	-0.783 (-12.85)**#	0.380 (2.97)**#	-0.210 (-1.92)
Adjusted R-Square	0.543	0.053	0.530	0.138

Number of Trades	342,402	342,402	14,795	14,795

Table VII

Regression Analysis of Determinants of Total and Permanent Price Impact of Trades for Small Versus Large Tick Securities Cross-listed on NYSE and TSE During the First Quarter of 1999

The first and second columns of this Table show the coefficients (multiplied by 100), t-statistics (in parentheses) and adjusted R^2 of regression (3) for trades on the TSE for securities cross-listed on the NYSE and TSE in the period January 1 through March 31, 1999. The third and fourth columns of this Table show the comparable figures for trades on the NYSE for the same securities. To be included, the securities had to trade every trading day from January 1 through March 31, 1999 and had to be continuously listed on both exchanges over the period October 1, 1998 through March 31, 1999. One and two asterisks indicate significance at the 5-percent and 1-percent levels, respectively. A '#' means that the posterior odds ratio indicates that the odds against the null hypothesis of the mean equalling zero is greater than 20:1. The model for total price impact of a trade is:

$$O_{i,j} = C_0 + C_1\, TradeSize_{i,j} + C_2\, PriceVol_{i,j} + C_3\, FirmSize_{i,j} + C_4\, SmallTick_{i,j} + C_5\, SmallTick_{i,j} * TradeSize_{i,j} + e_{i,j}$$

where:

$O_{i,j}$ = $ln(P_{i,j}/E_{i,j})$ for buyer-initiated trades and $ln(E_{i,j}/P_{i,j})$ for seller-initiated trades: price impact of trade j for stock i

$E_{i,j}$ = the mean of the best bid-ask prices immediately before trade j for stock i

$P_{i,j}$ = the price of trade j for stock i

$TradeSize_{i,j}$ = the trade size divided by the median daily number of shares traded over all trading days during the three month period ending in the month prior to the month of the observation,

$PriceVol_{i,j}$ = the standard deviation of the daily return (US$) on the stock during the three month period ending in the month prior to the month of the observation

$FirmSize_{i,j}$ = log of the market capitalization of the firm as at the end of the last trading day of the month prior to the month of the observation

$SmallTick_{i,j}$ = dummy variable equal to one if trade involved a stock with a lower tick size than other stocks on the respective exchange and zero otherwise; on the TSE and NYSE, a lower tick occurs where stock price is below $5 and $1, respectively

	TSE		**NYSE**	
	Total Price Impact	**Permanent Price Impact**	**Total Price Impact**	**Permanent Price Impact**
Constant	1.881 (329.11)**#	0.774 (131.18)**#	2.673 (260.62)**#	0.902 (78.04)**#
***TradeSize*$_{i,j}$**	0.027 (11.49)**#	-0.001 (-0.56)	0.205 (14.35)**#	0.393 (24.44)**#
***PriceVol*$_{i,j}$**	3.208 (119.19)**#	2.897 (104.27)**#	13.20 (220.77)**#	3.410 (50.65)**#
***FirmSize*$_{i,j}$**	-0.079 (-323.97)**#	-0.034 (-136.69)**#	-0.123 (-297.16)**#	-0.040 (-85.29)**#
***SmallTick*$_{i,j}$**	0.238 (138.59)**#	0.155 (87.14)**#	3.591 (309.54)**#	0.073 (5.61)**#
***SmallTick*$_{i,j}$* *TradeSize*$_{i,j}$**	0.854 (44.08)**#	0.464 (23.21)**#	3.526 (27.21)**#	5.357 (36.71)**#
Adjusted R-Square	0.251	0.093	0.635	0.073
Number of Trades	1,046,085	1,046,085	287,372	287,372

Table VIII

Transition Matrix of Trades of Securities Cross-listed on the NYSE and the TSE during First Quarter of 1999

Panel A of this Table shows the percentage of consecutive pairs of trades categorized by different sequences. The sequence of trades are delineated by the exchange where the first and second trade were executed as well as the trades' respective size and initiator. A large (small) trade is one in which the number of shares traded is at least equal to (below) 10,000 shares. The trades are of securities cross-listed on the NYSE and TSE in the period January 1 through March 31, 1999. To be included, the securities had to trade every trading day from January 1 through March 31, 1999 and had to be continuously listed on both exchanges over the period October 1, 1998 through March 31, 1999. Trades of the six securities which did not trade at least once a day on either exchange during the period October 1, 1998 to December 31, 1998 are excluded. Panel B compares the percentages in selected cells of Panel A to identify if either the NYSE or TSE leads the other market.

Panel A: Transition Matrix				Next Trade: Exchange, Trade Size and Initiator								Total
				Toronto Stock Exchange				New York Stock Exchange				
				Large		Small		Large		Small		
				Buyer-Initiated	Seller-Initiated	Buyer-Initiated	Seller-Initiated	Buyer-Initiated	Seller-Initiated	Buyer-Initiated	Seller-Initiated	
Prior Trade: Exchange, Trade Size and Initiator	Toronto Stock Exchange	Large	Buyer-Initiated	0.36%	0.14%	0.59%	0.32%	0.03%	0.02%	0.16%	0.15%	1.77%
			Seller-Initiated	0.14%	0.46%	0.38%	0.78%	0.02%	0.03%	0.14%	0.16%	2.11%
		Small	Buyer-Initiated	0.76%	0.37%	22.47%	6.69%	0.41%	0.31%	2.57%	2.11%	35.68%
			Seller-Initiated	0.26%	0.81%	7.02%	22.77%	0.34%	0.42%	1.90%	2.85%	36.37%
	New York Stock Exchange	Large	Buyer-Initiated	0.02%	0.02%	0.52%	0.33%	0.22%	0.07%	0.36%	0.26%	1.78%
			Seller-Initiated	0.01%	0.03%	0.30%	0.55%	0.06%	0.18%	0.23%	0.36%	1.72%
		Small	Buyer-Initiated	0.13%	0.12%	2.62%	1.85%	0.49%	0.23%	3.22%	1.38%	10.04%
			Seller-Initiated	0.10%	0.16%	1.81%	3.09%	0.22%	0.47%	1.46%	3.22%	10.52%
Total				1.79%	2.10%	35.70%	36.38%	1.79%	1.72%	10.04%	10.49%	100.00%

Panel B: Test of Significance of Difference Between Percentage of Cases Where TSE Leads and Percentage of Cases Where NYSE Leads

Test of Difference Between Percentage of Cases 1) and 2)		t-statistic
1) NYSE large buyer-initiated trade is followed by TSE large buyer-initiated trade	2) TSE large buyer-initiated trade is followed by NYSE large buyer-initiated trade	-1.19
1)NYSE large seller-initiated trade is followed by TSE large buyer-initiated trade	2) TSE large seller-initiated trade is followed by NYSE large seller-initiated trade	-1.37
1)NYSE small buyer-initiated trade is followed by TSE small buyer-initiated trade	2) TSE small buyer-initiated trade is followed by NYSE small buyer-initiated trade	-0.46
1)NYSE small seller-initiated trade is followed by TSE small seller-initiated trade	2) TSE small seller-initiated trade is followed by NYSE small seller-initiated trade	-0.94

Table IX

Logit Regression Model of Likelihood of Trade of Securities Cross-listed on the TSE and NYSE being executed on TSE During the First Quarter of 1999

This table shows coefficients and z-statistics (in brackets) of a logit regression model for trades of 67 stocks cross-listed on the TSE and NYSE during the period from January 1 to March 31, 1999. To be included, the cross-listed securities had to be continuously listed on both exchanges over the period October 1, 1998 through December 31, 1999. Trades of the six securities which did not trade at least once a day on either exchange during the period October 1, 1998 to December 31, 1998 are excluded. One and two asterisks indicate significance at the 5-percent and 1-percent levels, respectively. A '#' means that the posterior odds ratio indicates that the odds against the null hypothesis of the coefficient equaling zero are greater than 20:1.

$$Exch_{i,t} = f(NYSEVRel_{i,t}, TSEVRel_{i,t}, PriceRel_{i,t}, Domestic_{i,t})$$

where,

$Exch_{i,t}$ = 1 if trade is on TSE and 0 if trade is on NYSE

$NYSEVRel_{i,t}$ = number of shares in trade t for security i divided by number of shares at ask (bid) on NYSE immediately prior to trade t for security i for buyer- (seller-) initiated trades

$TSEVRel_{i,t}$ = number of shares in trade t for security i divided by number of shares at ask (bid) on TSE immediately prior to trade t for security i for buyer- (seller-) initiated trades

$PriceRel_{i,t}$ = (ask price on the TSE / ask price on the NYSE) immediately prior to trade t for security i for buyer-initiated trades; (bid price on the NYSE / bid price on the TSE) immediately prior to trade t for security i for seller-initiated trades

$Domestic_{i,t}$ = 1 if financial statements of company listing security i are reported in Canadian dollars and 0 otherwise.

	All Trades
Constant	622.2 (19.94)**#
$NYSEVRel_{i,t}$	0.172 (9.24)**#
$TSEVRel_{i,t}$	-0.662 (-83.30)**#
$PriceRel_{i,t}$	-5.676 (-18.18)**#
$Domestic_{i,t}$	144.42 (314.24)**#
Number of Trades	1,329,260 [a]

[a] At the time of execution, quotes were unavailable in the other market for 4,197 of the 1,333,457 trades on the TSE and NYSE. Thus, 1,329,260 trades are analyzed in this regression.

Table X

Regression Model of Proportion of Trades of Securities Cross-listed on the TSE and NYSE being executed on the TSE During the First Quarter of 1999

This table shows coefficients and t-statistics (in brackets) of a cross-sectional regression model to explain the proportion of trading done on the TSE relative to that done on the NYSE across 67 cross-listed securities during the period from January 1 to March 31, 1999. To be included, the cross-listed securities had to be continuously listed on both exchanges over the period October 1, 1998 through March 31, 1999. Trades of the six securities which did not trade at least once a day on either exchange during the period October 1, 1998 to December 31, 1998 are excluded. One and two asterisks indicate significance at the 5-percent and 1-percent levels, respectively. A '#' means that the posterior odds ratio indicates that the odds against the null hypothesis of the coefficient equaling zero are greater than 20:1.

$$Ln(Total\ Volume\ on\ TSE/Total\ Volume\ on\ NYSE)_i = k_0 + k_1 * AvgPrice_i + k_2 * AvgVol_i + k_3 * LRCont_i$$

where for stock i

$AvgPrice_i$ = ((Percentage of time TSE has a bid price at least as high as NYSE) + (Percentage of time TSE has an ask price at least as low as NYSE))/2

$AvgVol_i$ = ((Percentage of time TSE has an offered volume at least as large as NYSE) + (Percentage of time TSE has a wanted volume at least as large as NYSE))/2

$LRCont_i$ = ln(percentage of trades on TSE that resulted in a price change of 1/8 of a US dollar or less/percentage of trades on the NYSE that resulted in a price change of 1/8 of a US dollar or less)

	All Cross-listed Stocks
Constant	-313.40 (-4.31)**
***AvgPrice*$_i$**	4.312 (4.42)**
***AvgVol*$_i$**	4.068 (6.00)**
***LRCont*$_i$**	510.9 (4.33)**
Adjusted R-Square	0.782
Number of Securities	67