INFORMED TRADERS OF CROSS-LISTED SHARES TRADE MORE IN THE DOMESTIC MARKET AROUND EARNINGS RELEASES

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Comments are welcomed.

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ABSTRACT

This paper examines informed trading and price discovery for Canadian shares cross-listed on the Toronto Stock Exchange (TSX) and the main U.S. exchanges. The domestic Canadian market can absorb higher demand for liquidity but offers no trading cost advantage. During earnings non-announcement periods, the intra-market probability of informed trading (PI) is similar on both national markets, and both national markets contribute to price discovery. The magnitude and elapsed time over which trading volumes are increased when earnings are announced are higher in the domestic Canadian market. Around earnings announcements, PI decreases only on the U.S. market and the Canadian market contributes more to price discovery. To infer the fundamental values of the underlying cross-listed firms, market participants should monitor both markets, and intensify their monitoring of the Canadian market during earnings announcement periods.

JEL classifications: G14, G15.

Keywords: Cross-listing, market fragmentation, information asymmetry, liquidity, probability of informed trading, regime-switching model, error correction model.

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1. INTRODUCTION

The determination of the trading venue where privately informed traders direct their orders for execution is an important issue for fragmented markets. Firstly, informed traders are more likely to guide the market towards the fundamental value during the price discovery process. Informed traders can reduce deviations between observed and theoretical market prices by arbitrage trading, and hence contribute to market efficiency (Black, 1986). Other investors will make noisy inferences about the fundamental value by searching out information from all trades, orders and order imbalances. These other investors can minimize their search costs by concentrating their search on a single trade venue if informed traders concentrate their trades on that trade venue. Secondly, market regulators in satisfying their regulatory requirements designed to protect less sophisticated (primarily retail) investors can concentrate their oversight activities on the market with high private information activity if informed traders concentrate their trades on one of the trade venues.[1]

Thus, this paper addresses the issue of where do informed traders trade for a specific fragmented market; namely, the fragmented market for Canadian shares cross-listed on the Toronto Stock Exchange (TSX) and the main U.S. exchanges. Previous studies for shares cross-listed in the U.S. and Canada (e.g., Eun and Sabherwal, 2003) provide direct and clear evidence that both markets provide mutual feedback which suggests that informed traders are present on both trading venues. [2] While this evidence may

[1] One should distinguish between insider and privately informed trading. The former is a subset of the latter. Insider trading is prohibited by laws and regulations of securities commissions and private market watchdogs. These regulatory watchdogs include the Securities and Exchange Commission (SEC) and the Financial Industry Regulatory Authority (FINRA) in the U.S. and the Investment Industry Regulatory Organization of Canada (IIROC) in Canada. We distinguish between informed and uninformed traders later in the paper.

[2] See Xu and Fung (2002) for shares cross-listed on the Hong Kong and New York stock exchanges. Also, some papers in the rich literature dealing with the impact of initial cross-listing are of relevance herein. The finding by Sarkissian and Schill (2004) that cross-listing only reduces home bias minimally suggests that home bias may be a strong determinant of the ongoing viability of multi-trading venues for cross-listed firms. Noronha *et al.* (1996) find that quoted spreads on the U.S. market do not decrease initially for U.S. firms cross-listed on the LSE and TSE as the increased competition hypothesis would suggest. They attribute this to an increase in information based trading

suggest that informed traders execute their orders on both markets, these results are based on tests that do not measure informed trading activity but rather one of its potential effects which is market informativeness. However, market informativeness can also be simply the result of public information disclosure and trading, and non-synchronous liquidity needs.

Halling *et al.* (2008) use various factors to explain where traders of cross-listed shares trade (i.e., the distribution of trades between the domestic and the foreign market). They include variables that can proxy for information based trading such as the firm's size, growth and industry, and the geographical distance between the cross-listing venues. Our paper differs from Halling *et al.* (2008) in that we infer information asymmetry directly from trading activity. Second, we explicitly allow for differences in information asymmetry and information trading between the domestic and the foreign markets. Third, we consider the liquidity of either market based on intradaily measured trading activity.

Using idiosyncratic volatility to proxy for price informativeness, Fernandes and Ferreira (2008) find that cross-listing increases price informativeness for companies originating from developed countries. Our paper differs from that of Fernandes and Ferreira in that we investigate whether informed trading between the trading venues is different for already cross-listed companies. We do not specifically test whether cross-listing changes information production. In our paper, we directly measure the magnitude of informed trading on the competing fragmented markets by using a dynamic framework where informed trading is time varying, and where we quantify the trading activity of informed traders around the public release of major corporate news (corporate earnings announcements).[3]

(i.e., the attraction of additional informed trades to the cross-listing venues). Bailey *et al.* (2002) find that volume and trading volatility increase upon cross-listing for firms making earnings announcements, although firms willingly choose to disclose more information to reduce informational asymmetry by cross-listing.

[3] Tribukait-Vasconcelos (2002, 2005) studies the incorporation of earnings announcement information into stock prices for not cross-listed and cross-listed companies. He finds that not cross-listed shares incorporate the news announcements well ahead of their public release and cross-listed shares incorporate the news around their announcement dates. He concludes that cross-listing in the U.S. protects investors against insider trading. Our paper is different from his in many ways. First, we concentrate on Canadian shares cross-listed on the U.S. market and not ADRs. Canadian companies are already subject to stringent rules aimed at protecting investors against insider trading. Second, we do not compare informed or insider trading around earnings announcements for cross-listed versus not cross-listed shares. Instead, we compare informed trading for cross-listed shares between cross-listing venues.

By privately informed investors, we do not exclusively refer to insiders. Informed traders are those who possess additional material information that is not yet known and reflected in current market prices. As in Black (1986) and Grossman and Stiglitz (1980), privately informed investors may pay a price to acquire additional material information or to receive a private signal about the future cash flows of the firm. Liquidity traders are those who trade because of their own liquidity purposes. Investors who need cash liquidate their financial assets while those who hold cash that is not immediately needed opt to invest and buy these assets. As in Black (1986), noise traders are those traders who trade on noise as if it was information.

The market fragmentation issue has been extensively investigated in the literature. Fragmentation has the potential of both improving and worsening trading operational efficiency. Through inter-market or venue competition, better trading mechanisms can be attained to reduce trading costs and better match orders. This encourages the members of a trade venue to achieve a better trading mechanism and to pass the benefits along to traders. Fragmentation can negatively impact market efficiency and price discovery. Since the information content of trading is split or even lost with fragmentation, informed traders benefit because they have more time to profit from their nonpublic information. Also, if orders are not subject to an international best bid and offer (IBBO), then traders are not guaranteed best execution. Furthermore, the market maker may not have the monopolistic power needed to face informed traders given order-book splitting. Madhavan (1995) shows that fragmented markets, where fragmentation is related to the degree of order-flow disclosure, are exploited by large liquidity traders and by dealers given reduced price competition. Davis and Lightfoot (1998) find that stocks trading under rule 19c-3 that permitted off the board trading (market fragmentation) had higher spreads than stocks under rule 390 that prohibited such trading (market concentration). Bennett and Wei (2003) report that listing switches from NASDAQ to NYSE exhibit higher variance reductions and lower execution costs for pre-switch markets that are more fragmented. Amihud *et al.* (2003) find that trading consolidation is valuable with increased trading volume, lower implicit spreads, and positive abnormal returns upon consolidation due to enhanced liquidity, and that these effects are greater for higher levels of fragmentation. For cross-listed firms, Baruch *et al.* (2007) argue that trading is more frequent in the market where the cross-listed security has a higher correlation with other shares listed on that exchange. The high correlation is used to infer price direction by both liquidity providers and uninformed traders. Halling *et al.* (2008) show that the Baruch *et al.* measure is not significant in explaining trading activity on the foreign market. Moreover, they report that foreign trading activity increases when the correlation of the cross-listed share with the U.S. market is low.

The empirical evidence reported in this paper supports the hypothesis of the equality of the probability of trading against an informed trader for the domestic Canadian market and the foreign U.S. market for Canadian shares cross-listed in the U.S. The probability to trade against an informed trader is around 20% for both markets. In addition, we document a very interesting phenomenon around earnings announcements. While the probability of informed trading remains constant at 20% on the domestic Canadian market, it falls to 14% on the U.S. foreign market around earnings announcements. Both informed and uninformed traders intensify their trading activity for different reasons. Uninformed traders trade for liquidity purposes and especially portfolio rebalancing to adjust for changes in valuations and relative market weights. Informed traders, who are motivated to capture profits from their private information, use changes in uninformed trading activity to keep their trades stealth. On the Canadian market, where market depth is highest, traders change their trading patterns in a manner that keeps relative trading intensity constant on the domestic Canadian market. In contrast, the relative decrease in trading activity is higher for informed versus uninformed traders in the U.S. market.

According to the strategic trading behavior argument, rational uninformed traders should accordingly shift all their orders to the U.S. (foreign) market during the earnings announcement period. This argument fails because of the relatively greater reduction in market depth and liquidity for this event on the U.S. market. As the announcement is short lived, equilibrium is established shortly thereafter. The difference in market informativeness around earnings announcements is not caused by a delay in financial reporting between the Canadian and U.S. markets. Since all of the Canadian cross-listed firms fall under the Multi-jurisdictional Disclosure System for issuing shares in the U.S., they benefit from simplified ongoing and periodic reporting requirements which essentially require simultaneous disclose to the SEC of what these firms disclose domestically. Hence, these firms do not need to specifically change their disclosure practices to meet U.S. requirements.[4]

This finding that the domestic market becomes more informative during periods when earnings are announced should be of interest to market participants, regulators and researchers. While both markets contribute to the price discovery mechanism (as reported by Eun and Sabherwal, 2003),[5] our findings show that the contribution changes around earnings announcements where the domestic market becomes more informative and needs to be monitored more closely. Our implementation of the Eun and Sabherwal price discovery methodology supports this result. Our findings also suggest that the results of the various tests using event study methodology could be better understood by examining for changes in trade behavior by the (un)informed around the studied event, especially for stocks that trade on more than one trade venue (including ECNs).

The remainder of the paper is organized as follows. Section 2 presents the hypotheses that are tested in this paper. Section 3 describes the sample, data set and basic statistical tests used herein. Section 4 reports and discusses the results for trading activity and liquidity comparisons between the two national markets for the Canadian cross-listed shares studied herein. Section 5 infers the level of information asymmetry using a regime-switching model and estimates the time-varying probability of informed trading on both national market venues. Section 6 implements the Eun and Sabherwal price discovery methodology to assess if each market's contribution to price discovery differs between earnings announcement and non-announcement periods. Section 7 concludes the paper.

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[4] Since July 2002, Canadian firms cross-listed in the U.S. need to comply with requirements of the Sarbanes-Oxley Act. This requirement is mandated for the fiscal year 2003. Our sample data cover the year 2002, when requirements on both markets were the same.

[5] Grammig *et al.* (2005) find that, while the majority of price discovery typically occurs in the home market, price discovery across international markets is not only more complex and richer during trading overlap periods but that the role for U.S. price discovery increases as the ratio of U.S.-to-home-market liquidity increases. Since U.S. and Canadian markets share common opening hours and the ratio of U.S.-to-home-market liquidity is likely to vary between information- and noninformation-event periods, this raises the unresolved issue of how price discovery and informativeness vary between competing national markets for Canadian cross-listed shares.

2. HYPOTHESES

Our conjecture is that informed traders trade on both trading venues when firms are cross-listed given the survival of both markets. If informed traders are concentrated on one market only, then an equilibrium argument from game theory can be used to show that only one market (namely, the market with the lowest cost and higher disclosure requirements) will prevail.[6] This argument is based on the strategic trading behaviour of uninformed traders established initially by Admati and Pfleiderer (1988) and extended by Chowdhry and Nanda (1991).[7] Since we show that trading costs are not much different between the two markets examined herein, they do not support a trading venue preference argument. Second, disclosure requirements are very similar between the U.S. and Canada (especially, for cross-listed firms). Thus, there is no apparent need to adjust for the relationship between the probability of informed trading and investor protection identified by Brockman and Chung (2008) or to examine differences in the relationship between earnings quality and the value relevance of earnings due to differences in accounting practices and investor protection between the U.S. and Canada (Cahan *et al.*, 2009). The empirically testable implication of these observations can be expressed as the following testable hypothesis:

H_0^1 : *There is no difference in the probabilities of trading against informed traders between both national markets for Canadian cross-listed shares*.

Deviations from this equality will result in uninformed investors, regardless of their domestic affiliation, fleeing toward the market with the least information asymmetry. Informed investors have no choice but to follow them as they need the uninformed to trade against to make their informational profit.

[6] See Pagano (1989), Chowdhry and Nanda (1991), Huddart *et al.* (1999), among others.

[7] Baruch *et al.* (2007) do not explicitly solve for the optimal trading quantities of informed and liquidity traders but it can be inferred that both trade more frequently on the market where the cross-listed firm has higher correlations with local stocks. Hence, we can conjecture that a stable equilibrium between both trader types is maintained. Halling *et al.* (2008) find that comparative trading activity between the foreign and the domestic market depends on various factors for shares of firms from developed countries that are cross-listed on U.S. exchanges. Their relative U.S. trading volume is higher for small, more volatile and technology-oriented firms. The higher the information asymmetry about a company, the higher is the relative foreign trading activity.

However, the viability of each market requires the trading presence of both informed and uninformed traders.

Informed trading is of particular importance because it is the portion of all trading activity that has a permanent impact on share prices and reveals privately held firm-specific information to the public. Since informed traders act to eliminate sufficient-sized deviations of market prices from "true" fundamental values (Black, 1986), informed traders make an important and permanent contribution to price formation and discovery (i.e., the informational efficiency of the market). Uncovering the place where informed traders trade directs us to that market to observe price discovery.

As information asymmetry changes during corporate announcements, we also investigate changes in the trading intensity of both informed and uninformed traders around periods of such disclosures. Earnings announcements are a natural and good candidate for this purpose. First, not only is trading activity usually amplified for material corporate announcements but public announcements also have multiple and complex effects on the pool of active (un)informed traders and their trade behaviors. In turn, this provides an empirical opportunity to observe changes in these trader pools and their behaviors on the competing venues.[8] Secondly and from a methodological perspective, earnings announcements are recurring events that have the advantage of increasing the sample size beyond the number of cross-listed firms.[9] Given the ongoing existence and resilience of the less dominant U.S. markets in terms of trade activity for Canadian cross-listed firms, we expect nevertheless that the U.S. trade venues still play a non-negligible role in terms of price informativeness, and that the preponderance of information discovery occurs in the Canadian or home trade venue for material information disclosures.

The empirically testable hypothesis that follows from this discussion can be expressed as:

H_0^2 : *There is no difference in the probability of trading against informed traders between both national markets for Canadian cross-listed shares during earnings announcement periods*.

[8] Krinsky and Lee (1996), among others, examine changes in spreads around earnings announcements.
[9] The cost of this sample enlargement is that statistical tests must account for the loss of independence between observations for the same firm.

The alternative hypothesis is that informed trading is relatively higher on the Canadian market during earnings announcement periods. We expect the extent of information asymmetry to change upon announcement due to (i) the disclosure of new public information about the earnings generation capacity of the firm and (ii) a changing mix of (un)informed traders on the different national trade venues. While information asymmetry is reduced by the disclosure of new information, it also depends on the proportional change in the mix of informed to uninformed traders. As discussed by Easley *et al.* (2001) for stock split events based on the trade concentration theory of Admati and Pfleiderer (1988) and Chowdhry and Nanda (1991), the effect of public announcements that are ultimately assumed to reduce information asymmetry through disclosure of private information will be mitigated either partially or fully. As information asymmetry reduces and more traders become active in the market, it becomes profitable for active traders to seek and acquire new private information as they perceive an opportunity to exploit the larger uninformed pool. This reduces the overall decline in private information asymmetry.

3. SAMPLE, DATA COLLECTION AND BASIC STATISTICAL TESTS

Data on quarterly earnings announcements are collected for 172 Canadian firms cross-listed on the U.S. exchanges for the calendar year 2002. The earliest announcement dates for each event are obtained by searching the press releases in SEDAR, company websites, the CBCA, Lexis Nexis and Bloomberg. All announcement dates with announcement window overlap for the same company are deleted, where each announcement window covers 41 trading days centered on the announcement date. Similarly, announcement dates with windows during which the stock switched U.S. listing venue or stocks traded at a price below a dollar are deleted.[10] The resulting sample consists of 493 events for 135 companies (specifically, 58, 187 and 248 events on the AMEX, NASDAQ and NYSE, respectively). No announcements occur on the weekend, and no day-of-the-week pattern is evident in the earnings announcements, although most occur mid-week (80% on Tuesday through Thursday).

[10] The minimum trade price increment and board lot size change at one dollar on the TSX.

Based on the descriptive company statistics reported in table 1, Canadian cross-listings on the NYSE are much bigger than those on the AMEX and NASDAQ based on all three size proxies that we use. Canadian cross-listings on the NYSE are traded more heavily on the TSX. Comparisons between Canadian cross-listings on the AMEX and NASDAQ are hindered by the more heterogeneous composition of the AMEX cross-listings where some big and liquid outliers shift the mean but not the median upward. Based on the first two digits of the North American Industry Classification System (NAICS), most of these firms are in manufacturing (56 firms), mining (25 firms) and information (21 firms).

[Please insert table 1 about here.]

Trading data are obtained from the TSX's Equity Trades and Quotes History (ETQH) and the TAQ databases. Record deletion occurs for any quote or trade outside of regular trading hours (9:30 to 16:00 eastern time), open trades, trades with zero number of shares traded, cancelled or corrected trades, trades with delayed delivery, trades with special settlement conditions, trades representing a tick that exceeds 50%, quotes where the bid exceeds the ask price or where either equals zero or their relative spread exceeds 30%, and quotes posted during a trading halt or on a non-U.S. listing venue (the latter to avoid autoquote problems, as in Chordia *et al.*, 2001).[11]

The t- (Wilcoxon) test is used to determine if the mean (median) of any measure (or estimate) is statistically different from zero. Bootstrapped p-values are computed to deal with the lack of independence caused by some firms being represented up to four times in the sample. The bootstrapping procedure begins by running a regression of the appropriate measure on a vector of ones to get an estimate of the mean measure and its associated t-statistic. To generate the empirical distribution of this t-statistic under the null hypothesis, the residuals (mean deviations) are computed from the regression and then N samples of pseudo-random residuals are generated by drawing with replacement from the computed residuals. Each sample corresponds to a bootstrapped sample of the dependent variable (the

[11] These filters eliminate 2.2067% and 0.4585% of the quotes and trades, respectively, on the TSX, and 0.6121% and 0.0023% of the quotes and trades, respectively, on the U.S. markets.

measure) under the null since the latter corresponds to the mean being zero. By regressing each of these N samples on a vector of ones and computing the t-statistic of each intercept, which is the only explanatory variable, we obtain a vector of N t-statistics simulated under the null hypothesis. The original t-statistic is then inserted into this empirical distribution to determine the corresponding p-value from the cumulative empirical distribution (Davidson and MacKinnon, 2004; Greene, 2003). For the choice of N (i.e., the number of replications), both a fixed 999 repetitions and alternatively the three-step procedure suggested by Andrews and Bushinsky (2000) are used.

4. TRADING ACTIVITY AND LIQUIDITY OF SAMPLE FIRMS

Statistics on the cross-sectional distributions of various trading activity and liquidity measures are reported in table 2. Because of differences in trading mechanisms, we do not report aggregate statistics over the three main U.S. listing venues examined herein, but rather report results for each market separately. We especially pay attention to the NASDAQ market where volume is documented to be higher as a result of its dealer quote-driven nature. The resulting phenomenon of double counting is well documented in the literature (see for example Atkins and Dyl, 1997). As expected, the Canadian market is the trade venue of choice for trades of Canadian cross-listed firms on the NYSE and the AMEX. On average, 371 daily trades [572,600 shares] occur on the NYSE market versus 686 trades [875,400 shares] on the Canadian market. The cross-sectional mean [median] of the ratios of the number of trades in Canada versus the U.S. of 5.66 [3.30] implies that 84.99% [76.74%] of the trades occur in Canada for an average [typical] cross-listed firm on the NYSE.[12] The market share of the TSX is even higher using share volume as the measure of trade activity. Specifically, the mean [median] ratio of Canadian to NYSE share volume of 13.74 [5.13] suggests that trading on the Canadian market represents up to 93.22% [83.69%] of total trading. For NASDAQ cross-listed shares, the mean [median] number of trades is higher [lower] in

[12] The mean ratio differs from the ratio of means due to cross-sectional variation in the ratios. For instance, if we consider the number of trades for the shares cross-listed on either the NYSE or the AMEX, the ratio of means is 1.81 (i.e., 5.82/3.22) while the mean ratio (i.e., the cross-sectional mean of the ratios) is 4.85. As the variance of the cross-sectional ratios increases, the difference between the mean ratio and the ratio of means widens. For the share volume, the contrast is even higher with a mean ratio of 11.36 and a ratio of means of 1.54.

the U.S. The cross-sectional average ratio of 2.50 and 6.25 for number of trades and share volume, respectively, indicates that the Canadian market still captures most of the trades for an average firm cross-listed on NASDAQ.[13]

[Please insert table 2 about here.]

Various papers compare the trade costs of cross-listed firms after the cross-listing decision. Kryzanowski and Zhang (2002) find that execution costs depend on the trade venue for Canadian stocks cross-listed on U.S. markets, and that midspread differences help to explain differentials in execution costs.[14] They find a reduction in the total trade cost advantage of the Canadian market over the U.S. markets after the tick size reductions in 1996 and 1997. Ahn *et al.* (1998) find that TSX decimalization only affected (small reduction) spreads of Canadian stocks cross-listed on the NASDAQ, and that U.S. traders did not switch trade venues due to the higher benefits of trading on U.S. markets. Table 2 also shows that the TSX offers a deeper market for traders in the cross-listed firms on the NYSE or the NASDAQ, which represent more than 85% of the total sample. The AMEX where depth is statistically equal between the U.S. and the Canadian markets generates much of the cross-sectional variability in depths for the U.S. trade venues.[15]

As for trading costs, the results do not show a cost advantage for the Canadian market over the U.S. market for our cross-listed samples. In fact, the posted trading costs are globally very similar between competing listing venues. For example, the median proportional quoted spreads are almost the same at 0.38% and 0.36% for the U.S. and Canadian markets, respectively. There is even some evidence of lower proportional effective spreads on some U.S. markets compared to the domestic Canadian market. For

[13] We formed three groups of the NASDAQ cross-listed shares based on their total trading volume. For the thinly traded shares, the Canadian market is highly dominant and represents on average over 91% of total trading. In contrast, for the highly active issues, the Canadian market only captures 36% of the volume, i.e. almost one third of the volume is realized on the TSX while two thirds on the NASDAQ. This is further evidence on the double counting issue related to the NASDAQ market with volume on NASDAQ almost twice that of the TSX for actively traded issues.

[14]Price differences for Canadian cross-listed stocks should be arbitraged out. In contrast, perfect arbitrage is not possible for ADRs that are not fully fungible at zero cost due to differential trading costs and barriers (e.g., Gagnon and Karolyi, 2004).

[15] Outliers also exist on NYSE and AMEX. For example, the average depth for Nortel Networks is 162,276 shares during the third quarter of 2002 on the NYSE. This is more than 15 times the standard deviation above the mean of 2,557 shares for all NYSE observations.

example, the mean effective proportional spread is significantly higher on the domestic Canadian market (0.80%) than on the NYSE or AMEX (0.68%).[16] This result is not induced by the nature of the order flow. The realized spread, when measured as twice the absolute difference between the trading price and the subsequent midspread, exhibits similar results. To illustrate, the mean [median] realized spread is 0.39% [0.27%] in Canada and 0.41% [0.29%] on the NYSE.

5. INFORMED TRADING AND SPREAD COMPONENT CHANGES FROM A REGIME-SWITCHING APPROACH

We now address the issue posed in the introduction related to the differential in information asymmetry between the domestic Canadian and foreign U.S. trading venues for Canadian shares cross-listed in the U.S. We test this equality both for regular (no information) periods (H_0^1) and during "hot" trading periods associated with information disclosures (H_0^2) to determine how and when information is imbedded in prices and which market reacts first (as evidenced by trading) to the public announcement of earnings. The main difference between this approach and one that infers information from the price impact is that we allow for temporary trading imbalances that are caused purely by liquidity needs.

As a first proxy for information, we consider volume around earnings announcements as in Chae (2005). Figure 1 shows the dynamics of the cross-sectional mean and median volumes as measured by daily number of traded shares for the period [-20,+20] centered on earnings announcement dates for the U.S. and Canadian markets for Canadian shares cross-listed in the U.S. Consistent with the findings of Chae, volume increases around the announcements, specifically for days 0 and +1. While this result holds for both the U.S. and Canadian markets, the highest increase occurs on the Canadian market. Hence, we suspect that the liquidity traders trade relatively more intensely on the Canadian market upon announcement in accordance with the Chae results. The effect of the relative rebalancing of trading from

[16] This is based on all trades regardless of their order size, trade-side initiator, time of the day and implied probability of informed trading.

different types of traders will impact information asymmetry following Admati and Pfleiderer (1988) and Chowdhry and Nanda (1991).

We now conduct a more formal event study of the changes in trading volumes around earnings announcements. Following Chae, we compute abnormal volume as volume less average volume for the period [-40,-11]. We use a logarithmic transformation of volume as measured by number of traded shares.[17] Hence, abnormal volume can be interpreted as the percentage change in volume with respect to the reference benchmark. Based on the (cross-section) results reported in table 3, we clearly observe a non-symmetrical increase in trading volume around and beyond earnings announcement dates on both markets. The magnitude and time length for the increase are higher in Canada where volume increases significantly for six successive trading days compared to three in the U.S. As far as the magnitude of change is concerned, we can infer that volume increases by about 33% in Canada on the announcement date compared to 8% in the U.S. Our results do not support the findings of Chae that volume decreases significantly before the announcement date.

[Please insert table 3 about here.]

The changes in trading volumes may reflect changes in the composition of the trading pool between informed and uninformed traders. We specifically address this issue by measuring the information asymmetry content of every trade and daily averages using a regime switching model based on Glosten and Harris (1988). However, unlike the somewhat similar model of Nyholm (2003), trading costs are directly dependent on trading volumes for three trade size categories.

5.1 The model

Following Nyholm (2003), we model the change in (logarithm of) price as:

$$dp_t = I_t \times Z_t \times s_t + I_t \times C_t - I_{t-1} \times C_{t-1} + e_t \quad (1)$$

where I_t is the trade indicator at time *t* (-1 for seller initiated, and +1 for buyer initiated),

[17] Similar results are obtained when we use number of trades per day and dollar volume.

Z_t is the adverse information cost given that the trade is information based (i.e., has a permanent impact on the "true" price or fundamental value of the asset),

C_t is the order processing cost (i.e., the temporary component of the bid-ask spread),

s_t is a state variable related to the nature of the trade that is equal to 1 for information-based trades and to 0 otherwise (i.e., for purely liquidity-based trades), and

e_t is related to the public news released during the interval between *t-1* and *t*.

In (1), dp_t depends on the state variable s_t. The change in the transaction price is $dp_t = I_t \times Z_t + I_t \times C_t - I_{t-1} \times C_{t-1} + e_t$ if an informed trader initiates the transaction, otherwise the market maker changes the transaction price by $dp_t = I_t \times C_t - I_{t-1} \times C_{t-1} + e_t$. Since Glosten and Harris (1988) assume that both C_t and Z_t are related to the size of the transaction at time *t*, size is used as a determinant of the trading cost.[18]

Based on the findings of Barclay and Warner (1993), Chakravarty (2001), among others, on stealth trading and the association of medium-size trades with informed trades, trades are divided into three categories that are expected to have different marginal price impacts. Small trades are those involving 500 or less shares, as in Barclay and Warner (1993), Chakravarty (2001), and Koski and Michaely (2000). Medium-size trades are transactions of 501 to 5,000 shares, and large trades are transactions of 5,001 shares and more (e.g., as in Bessembinder, 2003; Koski and Michaely, 2000; SEC rule 11Ac 1-5). Since block trades on the NYSE and NASDAQ are defined as trades of 10,000 shares and more, this would be a natural definition of a large trade. This break point is not adopted herein because block trade delineation should depend on share price and trading activity (Bessembinder and Venkataraman, 2004). For the sample under investigation, no transactions of more than 10,000 shares occur for some firms, especially for trades on NASDAQ.

[18] Nyholm uses a fixed cost per size category. We argue that since the cut off points are arbitrary, allowing size variability within each trade size class can alleviate the classification problem, especially for the medium size trades that are considered as the ones with the highest proportion of informed trading.

Hence, we have:

$$C_t = c_0 + c_1 V_t DS_t + c_2 V_t DM_t + c_3 . V_t DL_t \tag{2a}$$

$$Z_t = z_0 + z_1 V_t DS_t + z_2 V_t DM_t + z_3 V_t DL_t \tag{2b}$$

where V_t is the trade size or volume in number of shares; and DS_t, DM_t and DL_t are dummy variables equal to zero or one, where a one occurs for trade sizes below 500 shares, between 501 and 5,000 shares, and over 5,000 shares for the respective dummies. Therefore, the change in the trading price is:

$$\begin{cases} \text{If state 1: } dp_t = \alpha_1 + c_0 dI_t + c_1 d\left(I_t V_t DS_t\right) + c_2 d\left(I_t V_t DM_t\right) + c_3 d\left(I_t V_t DL_t\right) + e_t \\ \text{If state 2: } dp_t = \alpha_2 + c_0 dI_t + c_1 d\left(I_t V_t DS_t\right) + c_2 d\left(I_t V_t DM_t\right) + c_3 d\left(I_t V_t DL_t\right) \\ \qquad + z_0 I_t + z_1\left(I_t V_t DS_t\right) + z_2\left(I_t V_t DM_t\right) + z_3\left(I_t V_t DL_t\right) + e_t \end{cases} \tag{3}$$

where *d(x)* is the first order difference of the variable *x*.

Following Nyholm (2003) and assuming that the state of nature follows a Markov chain, we use the Maximum Likelihood Estimation method to estimate the parameters of the regime switching model. The density vectors of the residuals are formed assuming that they are normally distributed. Using Hamilton's notation, this vector η is given by:

$$\eta_t = \begin{pmatrix} \eta_{1,t} \\ \eta_{2,t} \end{pmatrix} = \begin{pmatrix} \dfrac{1}{\sqrt{2\pi\sigma_1^2}} \exp\left(-\begin{pmatrix} dp_t - \alpha_1 - c_0 dI_t - c_1 d\left(I_t V_t DS_t\right) \\ -c_2 d\left(I_t V_t DM_t\right) - c_3 d\left(I_t V_t DL_t\right) \end{pmatrix} \right) \\ \\ \dfrac{1}{\sqrt{2\pi\sigma_2^2}} \exp\left(-\begin{pmatrix} dp_t - \alpha_1 - c_0 dI_t - c_1 d\left(I_t V_t DS_t\right) \\ -c_2 d\left(I_t V_t DM_t\right) - c_3 d\left(I_t V_t DL_t\right) \\ -z_0 I_t - z_1\left(I_t V_t DS_t\right) - z_2\left(I_t V_t DM_t\right) \\ -z_3\left(I_t V_t DL_t\right) \end{pmatrix} \right) \end{pmatrix} \tag{4}$$

Two different intercepts are included in (4) to account for differences not explained by the regressors. Model (4) is unrestricted with unequal variances, although a restricted model with $\sigma_1^2 = \sigma_2^2$ also is estimated.[19]

The state vector ξ_t is updated according to the motion equation: $\xi_{t+1|t} = P\xi_{t|t}$ (5)

where P is the transition matrix given by:

$$P = \begin{pmatrix} P_{11} & 1-P_{22} \\ 1-P_{11} & P_{22} \end{pmatrix} \tag{6}$$

In (6), P_{11} and P_{22} correspond to the probability that the state variable remains at states 1 and 2, respectively. $\xi_{t|t}$ is the conditional probability of the state vector based on the data up to time *t*. $\xi_{t+1|t}$ is the conditional expectation of the one-step-ahead state vector, which is a posterior update on the state vector given data up to time *t*.

By the conditional probability definition, $\xi_{t|t}$ can be inferred from:

$$\xi_{t|t} = \frac{\xi_{t|t-1} * \eta_t}{1'(\xi_{t|t-1} * \eta_t)} \tag{7}$$

where $*$ denotes the element-by-element multiplication. The model is estimated using a quasi maximum likelihood approach where the likelihood function to be maximized is the intertemporal sum of the natural logarithms of the numerator in equation (7).[20] Specifically, the estimation is based on:

$$\underset{\theta}{Max}\sum_{t=1}^{T} Log\left[1'(\xi_{t|t-1} * \eta_t)\right] \tag{8}$$

where the vector of parameters is $\theta = \left(\alpha_1, c_0, c_1, c_2, c_3, z_0, z_1, z_2, z_3, \alpha_2, \sigma^2, P_{11}, P_{22}\right)$.[21]

[19] While allowing for state-dependent variances is appealing, it reduces the number of cases with convergence. For this reason, only the restricted model results are reported herein.

[20] The optimization techniques and algorithms used here are the BFGS, DFP and Hill Climbing (each with various starting points to avoid a local maximum solution).

[21] To use a free maximization procedure and to avoid the constraints, an exponential transformation is made for σ and a logistic transformation is made for both probability parameters P_{11} and P_{22}.

The smoothed estimates of the state vectors using the Kim (1993) algorithm also are generated. These inferences are not one-step-ahead "forecasts" but rather use all the data up to time *T*. Technically, these smoothed estimates, which use all data, are computed as backward iterations starting from $t = T\text{-}1$ and based on the expression:

$$\xi_{t|T} = \xi_{t|t} * \left(\mathrm{P}' \cdot \left[\xi_{t+1|T} \left(\div \right) \xi_{t+1|t} \right] \right) \tag{9}$$

5.2 The Results

The results from estimating system (1) to (8) are reported in table 4. Separate estimations are run using trades on the U.S. and Canadian markets over the 41 trading days centered on the earnings announcement for each share observation. Due to differences in trading mechanisms, we continue to treat NASDAQ trades separately.

[Please insert table 4 about here.]

Glosten and Harris (1988) note that they adopted a linear specification for C_t, the transitory spread component to allow for possible economies or diseconomies of scale in the provision of liquidity services. With regard to the expected sign of the coefficients in C_t, they state on page 133 that:

> "Theoretical considerations concerning the specification of the transitory component are ambiguous. Although cost considerations suggest that the total transitory component should be positive, the sign of the volume coefficient, c_1, depends on whether the per-share cost of supplying liquidity services is increasing, constant, or decreasing in transaction size. If the cost is constant, c_0 will be positive and c_1 will be zero. If it is increasing, as inventory models suggest, c_1 will be positive. If it is decreasing or there are substantial fixed costs of filling an order, c_1 will be negative. We let the specification search determine the best model."

Based on table 4, all $\hat{c}_0$ are positive for both Canadian and U.S. based trades. The mean $\hat{c}_1$ and $\hat{c}_2$ are negative and significant for the Canadian trades, which indicates that trading costs decrease with higher trading volumes up to the large trade category. The $\hat{c}_3$ are positive and significant (i.e., for large trades) for the U.S. trades. This indicates that the order processing cost is higher for large transactions as inventory models suggest and because of the need of dealers to manually allocate trades and spend more effort to fill large trades in the low depth U.S. market.

As for the permanent cost, the argument is that the higher the trading volume the more likely the trader who acts aggressively is informed. Thus, the estimated z parameters are expected to be positive and significant. However, Barclay and Warner (1993), amongst others, argue that the z estimates are trade size specific since informed trading is concentrated in the medium size trade category. Thus, our expectation is that z_2 will be significantly positive indicating that average size trades are hiding orders from privately informed traders, while z_3 is probably of smaller magnitude and insignificant as large trades are normally not information motivated but are arranged before execution.

As expected, the $\hat{z}_1$ and $\hat{z}_2$ are positive, which implies that the information asymmetry cost increases with higher trade sizes for small and medium sized trades on both markets. However, the mean and median $\hat{z}_3$ are negative for Canadian trades, which indicate that the information asymmetry cost decreases with larger trade sizes for large trades in this market. This finding is consistent with the results reported in the literature that large trades are not usually motivated by private information. The average $\hat{z}_3$, which is positive for the U.S. trades, is inconsistent with expectations and can be explained as follows. A large, liquidity-motivated trader is more likely to submit an order to the deeper (Canadian) market since such an order is likely to work up or down the book to less attractive limit orders before being filled. If such traders submit their orders to the thinner U.S. market, there is a higher probability that the order is information motivated.

The continuation probabilities of states one and two are reported in table 4 where P_{11} [P_{22}] is the probability that the next trade by the liquidity provider will be against an uninformed [informed] trader given that the present trade is against an uninformed [informed] trader. The continuation of state 1 which corresponds to successive trades by uninformed traders is the more likely based on its higher means and medians for both Canadian and U.S. trades. The unreported cut-off points of the cross-sectional distribution at the first and the third quartiles also confirm this finding. The distribution of the P_{11} parameter for the U.S. trades dominates that from the Canadian trades, and its mean of 82.58% is higher than the corresponding mean for Canadian trades of 77.98%. The P_{22} parameter estimate exhibits a similar but less pronounced pattern for the two trade venues. While the parameter estimate for the U.S. trades dominates that for Canadian trades in terms of the first quartile, the median and the third quartile, it has a wider distribution than for the Canadian trades. This is supported by the matched-sample t-test but not the Wilcoxon test. The mean of P_{22} of 30% for the Canadian trades indicates that market makers expect an informed trade to be followed by an uninformed trade with a probability of 70%, almost 2.5 times the likelihood of trading again with an informed trader. This contrasts with the likelihood of trading with an informed trader after dealing with an uninformed trader of 17.42% and 22.02% for the U.S. and Canadian trade venues, respectively. The corresponding odds ratios are respectively 4.74 and 3.54 times. These odds ratios provide some initial evidence that informed trading is less likely on the U.S. market.

To investigate this issue further, the unconditional estimates of trading against uninformed and informed traders (i.e., the probabilities that states 1 and 2 continue) are computed for both trading venues. The unconditional probabilities are given by the limit of the transition matrix, whose first element is equal to:

$$P_1 = (1 - P_{22})/(2 - P_{11} - P_{22}) \tag{10}$$

The results reported in Table 4 show that there is no significant difference between the domestic Canadian market and the U.S. market in terms of the unconditional measure of the informed trading probability. The mean [median] informed trading probability or probability of informed trading (PI) is around 20% [5%] for both trading segments.[22] Canadian shares cross-listed on either the NYSE or the AMEX have identical results. Even for NASDAQ cross-listed shares, the conclusion is the same.

The above methodology cannot be used to examine changes around the earnings announcements dates, and whether any changes are symmetrical between trading venues. To compute a probability of

[22] The probability of informed trading (PI) is one less the probability of uninformed trading, i.e. 1-P_1.

trading against (un)informed traders for both markets at both announcement and non-announcement dates, an inference on the realization of the state vector s_t is required. To that end, the vector $\xi_{t|T}$ is built, which corresponds to the conditional probability of the state vector for each trade based on smoothing all the available data, and a sub-vector from $\xi_{t|T}$ is built that only uses trades from the announcement period. To allow for event date indeterminacy, we assume that the event window covers a three-day period centered on the event date; i.e., the announcement window covers the day of the announcement, and the preceding and the following day. The probability of state 2 over the earnings announcement window is the sum of the second column of the sub-vector $\xi_{t|T}$ divided by the corresponding number of trades. By analogy, the probability for the days that exclude the earnings announcements uses the $\xi_{t|T}$ components that do not correspond to trades that occur during the earnings announcement window.[23]

The resulting estimates for both trading venues are reported in table 5 for PI on the Canadian (U.S.) market in the announcement (non-announcement) periods. The mean and median PI are not significantly different between the two windows for the Canadian market. In contrast, the PI declines for U.S.-based trades (from 19.76% to 14.18% for the mean). This decline is observed for shares cross-listed on NASDAQ (mean falls from 22.04% to 16.23%) and NYSE/AMEX (mean falls from 19.01% to 13.51%).

[Please insert table 5 about here.]

Based on column *(i)* in panel A of table 5, no significant difference exists in the likelihood of information trading between the two national trade venues for the non-announcement period. Column *(ii)* shows no significant difference between announcement and non-announcement periods for Canadian based trades. In the absence of changes in trader mix behavior, one expects the probability of informed trading to fall around earnings announcements as a direct result of the reduction of information asymmetry from the announced information. Simply put, managers reduce information asymmetry through the regulated disclosure of earnings. However, as discussed earlier, trade concentration theories

[23] The probability of state 1 (i.e., trading against the uninformed) is obtained using the same methodology employed to obtain the values reported in the first column of the vector $\xi_{t|T}$.

linked to Admati and Pfleiderer (1988) and Chowdhry and Nanda (1991) show that trading patterns will change due to the strategic behavior of both trading groups as information asymmetry changes. For instance, if the PI falls as a result of an earnings announcement, uninformed traders will intensify their trading as their expected losses to better informed traders are reduced. The increased pool of uninformed provides an incentive to some investors to acquire and search for new private information. Hence, the overall effect of an earnings announcement on PI is much less than expected and can be neutral as we observe herein.[24]

The most significant effect is contained in columns (iii) and (iv) in panel A of table 5. Column (iii) shows that PI in Canada is higher by a significant mean [median] of 652 [105] basis points compared to the U.S. during the three-day announcement period. Column (iv) shows that PI declines around the announcement by a mean [median] 558 [152] basis points compared to the regular non-announcement period for U.S. trades. These results are consistent for the NASDAQ and NYSE/AMEX samples (panels B and C of table 5, respectively).

In summary, the probability of informed (PI) trading is about 20% on both national markets for Canadian shares cross-listed in the U.S. for non-announcement periods, falls sharply to 14% on the foreign U.S. market and remains constant at 20% on the domestic Canadian market during the event periods. The U.S. PI reverts back to its pre-announcement level of 20% post-announcement. The temporary fall in the PI for the U.S. is consistent with uninformed investors, whose concern is immediacy or portfolio rebalancing, limiting their order flow to U.S. markets for execution due to the higher depth in Canada.[25] Since informed traders search out the larger pool of uninformed traders for trade purposes, the informed trade more intensively on the domestic Canadian market during the announcement period.

5.3 Trading Cost and Spread Components

The implied bid-ask spread and its permanent and transitory components can be computed from the regime-switching estimates computed earlier. By examining how these components change between non-

[24] A contributing explanation is that the announcement does not come as a complete surprise. Investors do have expectations about earnings. This reduces the primary effect of the announcement on the PI measure.
[25] Rahman *et al.* (2005) show that differences in opinion between informed and uninformed traders influence depth..

announcement and announcement periods, we can infer if liquidity providers have altered the compensation that they require for asymmetric risk exposure. Since the permanent cost component relates to both the intensity of informed trading and the extent of the information asymmetry, an increase [decrease] in the permanent component indicates higher [lower] informed trading. This may confirm the above reported finding that informed traders do trade more on the Canadian versus U.S. markets during announcement versus non-announcement periods.

Based on equations (2a) and (2b), the half quoted spread is estimated by:

$$\hat{S}_t = \hat{C}_t + \hat{Z}_t = \hat{c}_0 + \hat{z}_0 + \left(\hat{c}_1 + \hat{z}_1\right) \times V_t \times DS_t + \left(\hat{c}_2 + \hat{z}_2\right) \times V_t \times DM_t + \left(\hat{c}_3 + \hat{z}_3\right) \times V_t \times DL_t \qquad (11)$$

where the hat over each variable refers to its estimated value from the regime-switching model. The half permanent variable and half temporary fixed costs are given respectively by:

$$\hat{Z}_t = \hat{c}_0 + \hat{z}_0 + \hat{z}_1 \times V_t \times DS_t + \hat{z}_2 \times V_t \times DM_t + \hat{z}_3 \times V_t \times DL_t \text{ , and} \qquad (12)$$

$$\hat{C}_t = \hat{c}_0 + \hat{c}_1 \times V_t \times DS_t + \hat{c}_2 \times V_t \times DM_t + \hat{c}_3 \times V_t \times DL_t . \qquad (13)$$

A drawback of this Glosten-Harris-like approach is that it can yield negative estimates of the implied spread or its components, which is usually caused by one dominant (usually permanent) component being negatively related to volume.[26] However, this problem is greatly alleviated by relating the *z* parameter to the trade size itself in a piecewise linear manner.

The cross-sectional distribution of the half spreads and their components for trades in both national markets and for the (non-)announcement periods are reported in table 6. The total implied half spread is on average 0.29% [0.25%] for the earnings [non-]announcement periods for the Canadian based trades.[27] This value is well below the expected posted half spread (of 0.71%) and is closer to the effective half spread of 0.54%. The reason is that the implied spreads are driven by transaction prices so that they account for trades that occur inside the posted quotes. The estimates based on the U.S. trades are similar

[26] This is more likely for small trades. Theoretically, when the estimated z_0 parameter is negative and the z_1 parameter is a small positive value, the sign of the permanent component is dominated by the negative sign of the intercept.

[27] Yohn (1998) also reports a temporary increase in spreads during the earnings announcement window.

with a mean implied half spread of 0.21% [0.22%] during the [non-]announcement period. Thus, both the quoted and implied spreads are lower for the U.S. venues.

[Please insert table 6 about here.]

The statistical significance of the implied half spread differential between Canadian and U.S. trades during the announcement windows are reported in Panel B of table 6.[28] The change in the proportional temporary component is not significant based on the t-test, and is statistically significant and higher for the Canadian trade venue based on the Wilcoxon test. However, the difference is not economically significant at 1 basis point. Both parametric and nonparametric tests find that the proportional permanent cost component is higher for Canadian-based trades. The mean [median] differentials for the half spread and the half permanent cost are a significant 8 [5] basis points above the U.S. estimates. We conclude that liquidity providers do protect themselves more against informed traders around announcement periods on the domestic versus foreign U.S. market for Canadian shares cross-listed in the U.S. This supports our earlier conclusion that more informed trades occur on the domestic Canadian market for the announcement periods. Based on table 6, the reverse occurs during the non-announcement periods where the permanent spread cost is higher on the U.S. market. This further supports our earlier conclusion that the impact of the announcement is mostly on the U.S. permanent cost component. In other words, liquidity providers expect most of the informed traders to trade on the domestic Canadian market during announcement periods. Therefore, liquidity providers increase [decrease] the compensation required to bear this higher [lower] risk on the Canadian [U.S.] market.

With regard to the announcement-induced change, the permanent cost component increases [remains unchanged] and the temporary component exhibits no change on the Canadian [U.S.] market. [29] As a result, the overall implied spread increases significantly on average (by 4.17 basis points) only on the Canadian market. The increase in the permanent cost for Canadian-based trades is a reaction by the

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[28] The implied absolute spreads and components are not reported because they are expressed in different currencies. The estimates on the Canadian market are naturally higher because they differ on average by the average U.S./Canadian FX rate of approximately 1.57 during 2002.

[29] Cong *et al.* (2009) also report an overall increase in information asymmetry during the earnings announcement window for a subsample of TAQ firms with full Compustat data over the ten-year period 1993-2002.

liquidity providers to the intensified presence of informed traders, primarily on the Canadian trade venue. The (re)direct of trading by most informed traders to the Canadian domestic market during the announcement period explains the decline in the PI measure on the U.S. markets that was reported previously. Informed investors take advantage of the higher uninformed trading intensity of impatient traders who are rebalancing or are reacting to the news announcements. Since these investors are more likely to be present on the same side of the market, the depth that the Canadian market offers is very valuable to them.

To further investigate the effect of earnings announcements on information asymmetry, we also compare the probability of informed trading and the permanent cost component pre- and post-announcement.[30] We split the non-announcement period into two windows; namely, the pre-announcement window which covers the window [-40,-2] and the post-announcement window which covers the window [+2,+20] with day 0 corresponding to the announcement date. The mean and median differences (and tests of their significance) between the pre- and the post-announcement windows for respectively the Canadian and the U.S. based trading venues are reported in table 7. A positive difference implies that the statistic is higher during the pre- compared to the post-announcement window.

[Please insert table 7 about here.]

Based on panel A of table 7, the mean PI in Canada [U.S.] is higher during the pre- versus post-announcement period by 164 [162] basis points (both significant at the 10% significance level). Shares cross-listed on the NASDAQ experience a more pronounced fall in the PI with a mean of 275 [262] basis points for Canadian [U.S.] based trades. Both differences are significant at the usual 5% significance level.

Similarly, based on panel B of table 7, the total proportional spread falls significantly by 2.94 basis points for Canadian based trades. The change is caused by a decrease in the permanent spread component of 3.28 basis points. Even if the economic magnitude is small, the decrease is quite significant from a permanent cost of 6.75 basis points during the pre-announcement window to 3.47 basis points post-

[30] We thank an anonymous referee for suggesting this comparison.

announcement. Both of these values are considerably lower than the permanent cost of 12.27 basis points during the announcement window (see table 6). U.S. based trades show similar but weaker results. The mean permanent spread component is 2.26 basis points higher during the pre- versus post-announcement window. However, the median change in the permanent spread component is not significant.

Based on these additional tests, we conclude that there is evidence that information asymmetry as proxied by either PI or the permanent spread component is lower after than before the earnings announcements. This implies that earnings announcements are informative and that they contribute to reducing information asymmetry.

6. CONTRIBUTION TO PRICE FORMATION

As an alternative method to quantify the presence of informed trading, we also determine the contribution to price formation of each national market during announcement and non-announcement periods using the methodology of Eun and Sabherwal (2003).[31] The underlying notion is that when informed trading increases relatively on either market, its contribution to price formation is increased as informed traders are deemed to permanently and more profoundly impact prices. For each observation in our sample, we construct intradaily ten-minute, equally spaced quotes and derive corresponding midquotes on both markets separately. To ensure better estimation, we delete all thinly traded securities, which are defined as those securities that have an average daily turnover of less than 20 trades per day during either announcement or non-announcement periods on both U.S. and Canadian markets. This criterion greatly reduces stale quotes when compared to Eun and Sabherwal who used a minimum average of 16.12 trades per day. As in Eun and Sabherwal, we convert the U.S. price series into Canadian dollars using the Olsen & Associates database for FX rates which includes intradaily bid and ask C$/US$ quotes with a New York time stamp. We match each U.S. stock midquote to a corresponding FX midquote to infer its C$ value. Thus, we have two data sets for each observation. The first (second) data

[31] This approach is close to that of Grammig *et al.* (2005), except that we use only two price time series instead of using the C$/US$ as a third series. We instead convert the US$ prices into C$ using appropriate FX rates as indicated later. Unlike Chae (2005), this approach does not rely on variance decomposition and price ordering.

set contains intradaily prices on the Canadian and the U.S. market both in C$ during non-announcement (announcement) days. For each data set, we run a Johansen (1988) cointegration between the two price series. As prices in Canada and the U.S. should be very close since they are basically claims on exactly the same cash flows, we expect to find a single cointegrating vector between the series which is equal to [1,-1]. The final sample contains 318 observations after deleting thinly traded shares and five observations where the existence of two cointegrating vectors can not be ruled out.

We estimate the following error correction model for each observation separately for announcement and non-announcement periods:

$$\begin{aligned}\Delta P_t^{CAN} &= \alpha^{CAN}\left(P_{t-1}^{CAN}+\beta^{US}P_{t-1}^{US}+\alpha_1\right)+\sum_{i=1}^{p}\gamma_i\Delta P_{t-i}^{CAN}+\sum_{i=1}^{p}\delta_i\Delta P_{t-i}^{US}+\varepsilon_t^{CAN}\\ \Delta P_t^{US} &= \alpha^{US}\left(P_{t-1}^{CAN}+\beta^{US}P_{t-1}^{US}+\alpha_1\right)+\sum_{i=1}^{p}\phi_i\Delta P_{t-i}^{CAN}+\sum_{i=1}^{p}\psi_i\Delta P_{t-i}^{US}+\varepsilon_t^{US}\end{aligned} \quad (14)$$

In the cointegration expression $\left(P_{t-1}^{CAN}+\beta^{US}P_{t-1}^{US}+\alpha_1\right)$, the coefficient on the Canadian price is set to one for identification. We expect the β^{US} coefficient to be -1 as prices in Canada and the U.S. should be very close. α^{CAN} [α^{US}] corresponds to the reaction of Canadian [U.S.] prices to deviations between the two markets. As β^{US} is expected to take a -1 value, α^{CAN} [α^{US}] is expected to be negative [positive] to correct for price deviations between both markets. As in Eun and Sabherwal, we define price adjustment on the Canadian market as a result of trading on the U.S. market by $CanAdj$ as $\left|\alpha^{CAN}\right| / \left(\left|\alpha^{CAN}\right|+\alpha^{US}\right)$. Alternatively, $CanAdj$ captures the relative contribution of the U.S. market to price discovery, and the relative contribution of informed trading on the U.S. compared to the Canadian market. Since higher $CanAdj$ values indicate a higher contribution of the U.S. based trades to price formation, they also imply relatively more informed trading on the U.S. versus Canadian market.

[Please insert table 8 about here.]

Table 8 reports the cross-sectional distribution statistics from estimating model (14). For both announcement and non-announcement periods, estimated parameters behave as expected. Specifically, all

β^{US} estimates are near -1. The estimates of α^{CAN} and α^{US} are negative and positive, respectively. The cross-sectional quantile distribution of $\left|\alpha^{US}\right|$ is higher than that of α^{CAN}, which indicates that the Canadian market contributes more to price formation than the U.S. market. This is confirmed by the inferred $CanAdj$. The mean [median] contribution of the U.S. market to the price formation is 42.7% [43.3%] during regular non-announcement periods,[32] and the mean [median] $CanAdj$ falls to 36.2% [38.7%] during the earnings announcement period. Moreover, all of the cross-sectional quantiles are lower during announcement days when compared to non-announcement days. The parametric and nonparametric tests on the paired matched samples find a statistically significant decrease in $CanAdj$ around earnings announcement dates. This finding corroborates our earlier result that the informativeness of the U.S. market declines around earnings announcements for Canadian shares cross-listed in the U.S.

7. CONCLUDING REMARKS

Cross-listing is an example of market fragmentation where several trading platforms survive together. For this market situation to hold, minimum trading conditions must be met so that one market does not become dominant and force the others to close. The dynamics of the trading game between informed and uninformed traders and the liquidity providers allows the survival of all markets only if all market participants are present to a “sufficient” extent and time on all of the markets. This appears to be the general case for the cross-listed sample of Canadian stocks examined herein. Although the domestic Canadian market is deeper than its U.S. competitor and can absorb higher demand for liquidity, there is at best no cost advantage from trading on the domestic Canadian market and even some weak evidence that the U.S. market has the cost advantage. Based on changes in inferred trading behavior across periods with changing information structures, we find that informed traders intensify their trades on the domestic (Canadian) market for earnings announcements.

[32] These estimates are slightly higher than those reported by Eun and Sabherwal (2003) who find a cross-sectional mean [median] of 38.1% [36.2%]. The difference may be explained by a different sample composition and time period (2002 herein versus 1998 in Eun and Sabherwal).

This evidence for Canadian cross-listed shares is unique in that it supports two opposing conjectures. The evidence for the non-announcement periods is consistent with that reported in a few other papers that both national markets participate in stock price formation through feedback effects since investors infer the price and update their beliefs by observing both national markets simultaneously. This is counter to other cross-listings where all (or most) price discovery occurs in the domestic market (e.g., Grammig *et al.*, 2005). However, we show that this is the tendency around earnings announcements.

Since informed investors trade more on the Canadian market ahead and upon information announcements, this market's aggregation power and informativeness are stronger. The U.S. market is still a significant but reduced contributor to the price formation of Canadian shares cross-listed on the U.S. during announcement periods. This implies that market participants should intensify their monitoring of the Canadian market to infer the fundamental values of the underlying cross-listed firms during announcement periods. This is a very important extension to the findings reported by Eun and Sabherwal (2003) referred to earlier.

In its Statement of Priorities for Fiscal 2007/2008, the Ontario Securities Commission (OSC) clearly states that its mandate is: "[t]o provide protection to investors from unfair, improper or fraudulent practices and to foster fair and efficient capital markets and confidence in capital markets." Similarly, the mandate of IIROC, which is embodied in its Universal Market Integrity Rules (UMIR), is "to foster investor confidence and ensure market integrity through the administration, interpretation and enforcement of a common set of market integrity principles applied to all regulated persons, including dealers, in all marketplaces regulated by IIROC" (www.iiroc.ca).[33] As the probability of informed trading is higher on the domestic Canadian market compared to the U.S. market for earnings announcements, Canadian market regulators such as IIROC need to be particularly vigilant during such periods to determine if the informed trading is insider (illegal) or non-insider (legal). If the former, regulation enforcement services need to act expeditiously to fulfill their role to protect investors from unfair and

[33] IIROC is the independent regulation services provider for Canadian equity marketplaces (such as the TSX) and is recognized by various provincial securities commissions (such as the OSC) to "regulate the trading of securities on these marketplaces by participant firms and their trading and sales staff".

fraudulent trading practices. If it is the later because traders have legally acquired “private information” through research, analysis and deduction in order to arbitrage current market price deviations from rationale underlying values, these trades contribute to market efficiency and facilitate the mandate of the regulating authorities.

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Table 1. Descriptive statistics

This table provides descriptive statistics for the Canadian cross-listed shares in our sample for "All venues" and by U.S. listing venue (namely, the AMEX, NASDAQ and NYSE). Market cap is the total market capitalization. Total assets (variable AT in the S&P Compustat database) and total capitalization (variable PRCC_C multiplied by data variable CSHO in Compustat) are in millions of Canadian dollars as of calendar year-end 2002. Trading volume is the number of shares traded on the TSX for the calendar year 2002 (i.e., data variable CSHTR_C in Compustat). Equity is book value of equity in millions of Canadian dollars.

	All venues (493 observations)				AMEX (58 observations)			
	Total assets	**Trad. volume**	**Equity**	**Market cap**	**Total assets**	**Trad. volume**	**Equity**	**Market cap**
Min	17.03	0.03	5.22	12.07	29.63	0.03	5.22	12.97
Median	959.39	43.21	519.10	867.60	197.47	12.37	92.02	213.71
Mean	13310.38	152.58	1810.41	3250.94	990.22	113.99	463.80	1315.76
Max	376956.00	6101.72	17238.00	38485.12	11868.00	1183.91	5212.00	16995.79
SD	51061.97	545.30	2968.78	5674.58	2910.93	288.94	1276.59	4062.04
Skewness	5.58	9.92	2.64	3.24	3.95	3.59	3.89	4.05
Kurtosis	31.70	107.64	7.90	13.28	15.73	13.52	15.37	16.57
	NASDAQ (187 observations)				NYSE (248 observations)			
	Total assets	**Trad. volume**	**Equity**	**Market cap**	**Total assets**	**Trad. volume**	**Equity**	**Market cap**
Min	17.03	0.15	5.36	12.07	117.13	1.42	78.03	219.50
Median	220.47	14.10	152.63	224.63	6705.16	110.25	2069.03	3616.66
Mean	493.96	29.73	282.16	501.42	27404.52	266.48	3412.64	6084.89
Max	2874.51	400.12	1428.44	3259.77	376956.00	6101.72	17238.00	38485.12
SD	645.56	58.78	341.28	639.92	71830.46	762.78	3598.52	6950.29
Skewness	2.21	5.10	1.77	2.19	3.73	7.34	1.78	2.43
Kurtosis	5.16	30.59	2.87	5.87	13.34	56.66	3.26	7.45

Table 2. Trading activity and liquidity measures for Canadian shares cross-listed on U.S. exchanges

This table reports the means and median of various trading activity and liquidity measures for shares cross-listed on U.S. exchanges differentiated by trade venue for our sample of earnings announcements. Share volume, share depth and number of trades are in millions, thousands and hundreds, respectively. Percent spread and percent effective spread are the quoted and effective spreads relative to midspreads and trading price, respectively. Mean_d_r (mean difference or ratio) and Median_d_r (median difference or ratio) correspond to the Canada-U.S. matched mean or median [difference] ratio for [spread measures] share volume, number of trades and quoted depth. The ratio of the mean statistic inferred from the Canadian trades over the mean statistic inferred from the U.S. trades are computed for the volume and the depth variables after matching the statistics of each company for the U.S. and the Canadian market. The cross-sectional mean [median] ratio over the cross-listed observations is reported as Mean_d_r [Median_d_r]. For the percentage spread variables, the difference between the Canadian and the U.S. based mean statistics is computed for each cross-listed share. The cross-sectional average [median] over all cross-listed observations is then reported as Mean_d_r [Median_d_r]. Ratios [differences] are compared to a default value of one [zero]. P-values are bootstrapped values. [a, b] and [c] indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

	Shares volume		**Nb. of trades**		**Percent spread**		**Percent effective spread**		**Shares depth**	
AMEX/NYSE	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
Median	0.0626	0.3524	0.9173	3.7322	0.4887	0.4420	0.3649	0.3834	1.5310	2.3361
Mean	0.5225	0.7913	3.2156	5.8170	0.9337	0.9796	0.6800	0.8046	3.0478	3.1675
Median_d_r		3.2664[c]		2.3877[c]		-0.0379		0.0344[a]		1.4911[c]
Wilcoxon		11.2498		10.8962		1.5714		3.3634		12.9641
Mean_d_r		11.3600[c]		4.8469[c]		0.0458		0.1246[a]		1.5283[c]
T-stat		8.8603		11.1232		0.9256		3.0268		17.4145
AMEX listed										
Median	0.0632	0.0601	0.7100	0.6596	2.0853	1.7394	1.4514	1.4991	2.8087	2.2343
Mean	0.3143	0.4419	1.1670	1.4932	2.4537	2.8875	1.7636	2.2848	5.0889	4.6990
Median_d_r		0.8530		0.9305		-0.0521		0.0831[b]		0.9802
Wilcoxon		1.0607		0.6039		0.5033		2.2530		0.1161
Mean_d_r		1.4688[b]		1.4440[b]		0.4338[a]		0.5212[c]		1.0343
T-stat		2.3622		2.3020		1.8412		2.7275		0.6505
NASDAQ listed										
Median	0.0258	0.0457	0.3774	0.6674	1.6538	1.4786	1.3417	1.1569	1.0631	1.4622
Mean	0.1650	0.1207	2.6954	1.4831	2.2068	2.1804	1.7677	1.6980	1.1896	1.6292
Median_d_r		1.4581[c]		0.9807[c]		0.0230		-0.0073		1.3911[c]
Wilcoxon		5.0895		3.3812		0.6624		1.3030		11.3855
Mean_d_r		6.2575[c]		2.5001[c]		-0.0264		-0.0696		1.4423[c]
T-stat		4.8459		5.2569		-0.2269		-1.0255		16.7186
NYSE listed										
Median	0.0626	0.4243	1.0420	4.2648	0.3829	0.3602	0.2863	0.3257	1.4127	2.3610
Mean	0.5726	0.8754	3.7086	6.8576	0.5679	0.5204	0.4192	0.4484	2.5566	2.7990
Median_d_r		5.1318[c]		3.2991[c]		-0.0357		0.0261[b]		1.5922[c]
Wilcoxon		11.3644		11.1770		1.0746		1.9029		13.0110
Mean_d_r		13.7405[c]		5.6658[c]		-0.0475		0.0291		1.6471[c]
T-stat		9.0494		11.3929		-1.3204		1.6107		20.9421

Table 3. Abnormal volumes around earnings announcements on both Canadian and U.S. trade venues for Canadian shares cross-listed in the US

This table presents the cross-sectional mean abnormal volumes and tests of their significance for the 21 days centered on the earnings announcement date [0] for both the Canadian and U.S. trade venues for our sample of earnings announcements for Canadian shares cross-listed in the U.S. Volume is defined as the logarithm of the daily number of shares traded. Abnormal volume is the difference between the daily logarithm of the number of shares traded and the average over the period [-40, -11]. [a], [b] and [c] indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

	Canada		U.S.	
Trading Days	**Abnormal volume**	**t-stat**	**Abnormal volume**	**t-stat**
-10	0.0291	0.8204	0.0580	1.6819
-9	0.0061	0.1583	-0.0266	-0.6811
-8	-0.0485	-1.1748	-0.0081	-0.2252
-7	-0.0381	-0.9864	-0.0314	-0.7736
-6	-0.0254	-0.6419	-0.0204	-0.5327
-5	0.0292	0.7703	0.0166	0.4637
-4	0.0034	0.0932	-0.0184	-0.5027
-3	0.0351	0.8525	-0.0226	-0.6035
-2	0.0114	0.2964	0.0294	0.8179
-1	0.0081	0.1895	0.0385	0.9582
0	0.3309[c]	7.2823	0.0884[a]	1.9836
1	0.5192[c]	11.1555	0.3892[c]	9.1142
2	0.2190[c]	5.1187	0.1318[c]	3.2152
3	0.1505[c]	3.7891	0.0746	1.6416
4	0.1149[b]	2.4544	-0.0126	-0.3041
5	0.1279[c]	2.8241	0.0051	0.1139
6	0.0353	0.7239	-0.0707	-1.5358
7	0.0173	0.4171	-0.0542	-1.2273
8	-0.0492	-1.0883	-0.0372	-0.7819
9	0.0407	0.9387	-0.0508	-1.0978
10	-0.0079	-0.1782	-0.0586	-1.4142

Table 4. Regime switching estimates for the Canadian cross-listed firms

This table presents the estimates from the regime switching model presented in equations (1)-(10) for our sample of Canadian cross-listed firms. c_k and z_k are the constant part of the temporary and information asymmetry trading costs, respectively, when k = 0, and are the additional costs for trade volumes up to 500 shares, between 501 and 5,000 shares, and over 5,000 shares when k = 1, 2 and 3, respectively. P_{11} and p_{22} are the transition probabilities of states one and two, respectively, and p_1 is the unconditional measure of the probability of trading against informed traders. Since observations are dependent by nature, the p-values are simulated under the null of equality. [a, b] and [c] indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

Sample		10^4x c_0		10^6x c_1		10^6x c_2		10^6x c_3		10^4x z_0		10^6x z_1	
	Statistic	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
all	median	11.3276[c]	7.3022[c]	-1.8315[c]	1.9076[c]	-1.7035[c]	0.8577[c]	-0.0012	0.2786[a]	59.8971[c]	42.0794[c]	-0.4004	11.3764
	mean	19.5970[c]	23.1497[c]	-5.8499[c]	2.4053[c]	-2.7203[c]	1.2417[c]	0.1155	0.6240[b]	110.0495[c]	120.2338[c]	21.4732	86.6784
	t-stat	8.5231	5.5389	-5.6329	3.5235	-9.9366	5.5248	1.0816	2.4199	8.6142	5.0077	0.7647	0.7203
	median_dif		2.0627[b]		-4.8606[c]		-3.1914[c]		-0.2487[c]		2.2432		-9.4057[b]
	mean_dif		-3.5527[a]		-8.3001[c]		-3.9799[c]		-0.5078[a]		-10.8417		-65.0207
	t-stat		-1.7061		-6.6680		-10.6131		-1.8123		-0.5437		-0.5234
	wilcox		2.2330		7.0468		9.9302		7.0262		0.4528		1.8173
		10^6x z_2		10^6x z_3		p_{11}		p_{22}		p_1			
	Statistic	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.		
	median	-3.0152[c]	4.4706[a]	-0.3003[c]	2.0911[c]	0.9596[c]	0.9570[c]	0.1575[c]	0.2428[c]	0.9545[c]	0.9484[c]		
	mean	-8.2221[c]	15.5100[a]	-2.1752[c]	8.7311[c]	0.7798[c]	0.8258[c]	0.3074[c]	0.3334[c]	0.7761[c]	0.8034[c]		
	t-stat	-3.0664	1.6408	-3.7700	3.8067	25.1397	32.4749	11.2417	14.1518	26.2601	30.0324		
	median_dif		-7.6144[c]		-2.7771[c]		-0.0001		-0.0630[a]		0.0051		
	mean_dif		-20.5751[b]		-10.9094[c]		-0.0472		-0.0248		-0.0484		
	t-stat		-2.4260		-4.3806		-1.0710		-0.6356		-0.6461		
	wilcox		5.8223		6.2215		0.4425		2.2845		0.1173		

Table 4. Continued.

		10^4x c_0		10^6x c_1		10^6x c_2		10^6x c_3		10^4x z_0		10^6x z_1	
	Statistic	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
NASDAQ	median	23.2995[c]	26.2068[c]	-1.6398[c]	1.2687	-1.8521[c]	0.1097	0.0041	0.2612	112.2689[c]	126.1604[c]	2.4505	0.0730
	mean	40.8302[c]	59.5627[c]	-8.2672[c]	1.9412	-3.2520[c]	0.3732	0.5246	0.2578	179.9466[c]	183.0599[c]	11.5471	476.1953
	t-stat	5.1894	3.9600	-2.9547	1.5844	-4.6875	1.4755	1.2256	1.1025	4.4547	3.9847	0.8505	1.0390
	median_dif		-3.7516[b]		-5.9832[c]		-1.5033[c]		-0.1064[b]		-30.0408		3.0327
	mean_dif		-19.1514[b]		-10.4662[c]		-3.7148[c]		0.2822		-3.1308		-464.1752
	t-stat		-2.3286		-3.7190		-4.8237		0.5660		-0.1774		-1.0133
	wilcox		2.3251		3.7954		4.5135		2.0174		1.0087		0.8377

		10^6x z_2		10^6x z_3		p_{11}		p_{22}		p_1	
	Statistic	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
NASDAQ	median	1.0032	2.7978	-0.3402	-0.3045	0.9441	0.9598	0.1806	0.2480	0.9384	0.9498
	mean	8.1294	28.0085	-0.5950	3.9364	0.6324[c]	0.7714[c]	0.3809[c]	0.3210[c]	0.6626[c]	0.7898[c]
	t-stat	4.2531	4.0555	-1.3477	0.7943	8.2828	11.8547	6.0280	7.1660	9.4517	14.2310
	median_dif		-0.3057		-0.0085		-0.0196		-0.0581		-0.0103
	mean_dif		-19.6768		-4.4980		-0.1482		0.0668		-0.1353
	t-stat		-0.0743		-0.9097		-1.2458		0.7611		-1.2978
	wilcox		0.0855		0.3761		1.7951		0.0513		1.5387

		10^4x c_0		10^6x c_1		10^6x c_2		10^6x c_3		10^4x z_0		10^6x z_1	
	Statistic	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
NYSE-AMEX	median	9.3275[c]	5.4387[c]	-1.8334[c]	2.4595[c]	-1.6542[c]	0.9955[c]	-0.0031	0.2899[c]	52.4368[c]	32.6748[c]	-1.4410	13.4872
	mean	12.6515[c]	11.5793[c]	-5.0592[c]	2.5527[c]	-2.5464[c]	1.5177[c]	-0.0184	0.7404[b]	87.1860[c]	100.2704[c]	24.7201	-37.0934
	t-stat	12.7090	6.9399	-4.9172	3.1382	-8.9665	5.4132	-1.2766	2.2344	8.8569	3.5927	0.6673	-0.5996
	median_dif		2.4323[c]		-4.4732[c]		-3.3688[c]		-0.2845[c]		7.4586		-17.8068[b]
	mean_dif		1.0722		-7.6119[c]		-4.0641[c]		-0.7588[b]		-13.0844		61.8135
	t-stat		1.0552		-5.5300		-9.4286		-2.2922		-0.5222		0.8357
	wilcox		4.3341		5.9379		8.7817		6.8982		1.4716		2.3108

		10^6x z_2		10^6x z_3		p_{11}		p_{22}		p_1	
	Statistic	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
NYSE-AMEX	median	1.1247[c]	6.9871[c]	-0.2485[c]	2.9643[c]	0.9644[c]	0.9564[c]	0.1526[c]	0.2402[c]	0.9599[c]	0.9476[c]
	mean	6.425[c]	27.2203[c]	-2.6920[c]	10.2546[c]	0.8280[c]	0.8431[c]	0.2833[c]	0.3373[c]	0.8133[c]	0.8078[c]
	t-stat	4.3426	3.9500	-3.6071	3.9810	26.2116	31.9834	9.5579	12.1815	26.0638	26.3441
	median_dif		-14.0388[c]		-5.2062[c]		0.0065		-0.0630[b]		0.0106
	mean_dif		-20.4792[c]		-12.9467[c]		-0.0151		-0.0539		0.0055
	t-stat		-5.0005		-4.5174		-0.3431		-1.2510		0.1161
	wilcox		6.4849		6.5377		0.6418		2.6340		1.0117

Table 5. Probability of informed trading (PI) from the regime-switching model for the Canadian cross-listed firms

This table reports the the probabilities (PI) of trading against an informed trader by summing the smoothed vector of the state variable generated by the Kim (1993) algorithm, and then dividing by the number of trades over each period. Panels A, B and C report results for the entire sample, NASDAQ only, and the NYSE/AMEX only. The four tests correspond to the differences between the PIs of: (i) Canadian and U.S. trades for periods excluding the earnings announcement three-day window; (ii) earnings announcement windows and earnings non-announcement windows for Canadian trades; (iii) Canadian and U.S. trades for the earnings announcement windows; and (iv) earnings announcement windows and earnings non-announcement windows for U.S. trades. The means and mean differences under "Difference tests" are tested for equality with zero using bootstrapped p-values due to the dependent nature of the observations. [a], [b] and [c] indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

Panel A: all shares

	Announcement window PI		**Non-announcement window PI**	
PI estimates	*Canada*	*U.S.*	*Canada*	*U.S.*
Median	0.0542	0.0432	0.0536	0.0532
Mean	0.2070	0.1418	0.2066	0.1976
Difference tests	***(i)***	***(ii)***	***(iii)***	***(iv)***
Mean	0.0091	0.0004	0.0652[c]	-0.0558[c]
Median	0.0042	0.0004	0.0105[c]	-0.0152[c]

Panel B: NASDAQ Results

	Announcement window PI		**Non-announcement window PI**	
PI estimates	*Canada*	*U.S.*	*Canada*	*U.S.*
Median	0.0562	0.0443	0.0549	0.0545
Mean	0.2214	0.1623	0.2147	0.2204
Difference tests	***(i)***	***(ii)***	***(iii)***	***(iv)***
Mean	-0.0057	0.0067	0.0591[c]	-0.0581[c]
Median	0.0031	0.0012	0.0156[c]	-0.0133[c]

Panel C: NYSE and AMEX results

	Announcement window PI		**Non-announcement window PI**	
PI estimates	*Canada*	*U.S.*	*Canada*	*U.S.*
Median	0.0537	0.0420	0.0528	0.0531
Mean	0.2023	0.1351	0.2040	0.1901
Difference tests	***(i)***	***(ii)***	***(iii)***	***(iv)***
Mean	0.0138	-0.0017	0.0672[c]	-0.0550[c]
Median	0.0006	0.0006	0.0137[c]	-0.0161[c]

Table 6. Spread components from the regime-switching model for the Canadian cross-listed firms

This table reports results for implied proportional half-spreads and half-spread components (temporary and permanent) in percentages, which are derived from the Glosten and Harris (1988) model using a regime-switching framework (see table 4 and equations (11)-(13)), for (non-)announcement periods for Canadian and U.S. trades in panel A, and various paired match sample comparisons in panel B. The proportion in percentage of the implied spread that is attributed to the permanent component is given by (1-π). P-values are computed using a bootstrap method under the null that the mean or the median is zero. [a, b] and [c] indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

Panel A. Spread and spread components estimates

	Canada				U.S.			
	Earnings announcement window				*Earnings announcement window*			
Statistics	(1-π)	total	temporary	permanent	(1-π)	total	temporary	permanent
Median	0.1333	0.2297	0.1645	0.0812	0.1356	0.1815	0.1519	0.0403
Mean	0.2544	0.2948	0.1721	0.1227	0.3122	0.2062	0.1635	0.0427
	Non-announcement window				*Non-announcement window*			
	(1- π)	total	temporary	permanent	(1-π)	total	temporary	permanent
Median	0.1452	0.1594	0.1093	0.0422	0.1398	0.168	0.122	0.0563
Mean	0.3583	0.2533	0.2039	0.0494	0.2888	0.2193	0.1537	0.0656

Panel B. Spread and spread components difference tests

	Canada-U.S.					
	Announcement			*Non-announcement*		
	Total	Temporary	Permanent	Total	Temporary	Permanent
Mean	0.0887	0.0091	0.0794	0.0342	0.0504	-0.0163
t-stat	1.7146[a]	1.7539[a]	2.3778[c]	3.7353[c]	0.8555	3.7181[c]
Median	0.0491	0.0139	0.05	-0.0103	-0.0124	-0.0149
Wilcoxon	3.7101[c]	5.7740[c]	3.0678[c]	6.3014[c]	4.0556[c]	6.2475[c]

	Announcement – Non-announcement					
	Canada			*U.S.*		
	Total	Temporary	Permanent	Total	Temporary	Permanent
Mean	0.0417	-0.0322	0.0733	0.0212	0.0321	-0.0152
t-stat	2.4800[b]	-0.07	2.4785[b]	1.5408	2.1000[b]	-1.5295
Median	0.0709	0.0554	0.0394	0.0212	0.0321	-0.0152
Wilcoxon	1.4875	1.1596	2.1977[b]	1.0155	1.2089	1.9895[a]

Table 7. Tests of changes in the probability of informed trading (PI) and spread components from the pre- to the post-earnings announcement windows

This table reports tests of changes in the probabilities of trading against an informed trader (PI) from the pre- to the post-earnings announcement window for Canadian and for U.S. trades in panel A and of changes in the implied proportional half-spreads and half-spread components (temporary and permanent) in percentages in panel B. The PI are obtained by summing the smoothed vector of the state variable generated by the Kim (1993) algorithm, and then dividing by the number of trades over each window. The spreads and their components are derived from the Glosten and Harris (1988) model using a regime-switching framework (see table 4 and equations (11)-(13)) for each window. The pre-announcement window covers the window [-40,-2] and the post-announcement window covers the window [+2,+20]. The earnings announcement window is [-1,+1]. Tabulated values correspond to the differences in means and in medians. Differences in the means are tested for equality with zero using bootstrapped p-values due to the dependent nature of the observations. [a, b] and [c] indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

Panel A: Tests of changes in PI from the pre- to the post-earnings announcement window						
	All trades		**NASDAQ trades**		**NYSE/AMEX trades**	
Statistic	**Canada**	**U.S.**	**Canada**	**U.S.**	**Canada**	**U.S.**
Mean	0.0164[a]	0.0162[a]	0.0275[b]	0.0262[b]	0.0128[a]	0.0135[a]
Median	0.0012[b]	0.0009	0.0006	-0.0002	0.0032[b]	0.0011

Panel B: Tests of changes in spreads and their components from the pre- to post-earnings announcement window						
	Canada			***U.S.***		
Statistic	**Total**	**Temporary**	**Permanent**	**Total**	**Temporary**	**Permanent**
Mean	0.0294[b]	-0.0034	0.0328[b]	0.0196	-0.0030[a]	0.0226[a]
Median	0.0037	-0.0048	0.0162[a]	0.0049	-0.0001	-0.0062

Table 8. Each market's contribution to price formation using an error correction model

This table reports cross-sectional distributions of the estimated parameters of error correction models (ECM) for firms during both earnings announcement and non-announcement periods when a minimum average of 20 daily trades are available. The following ECM is estimated:

$$\Delta P_t^{CAN} = \alpha^{CAN}\left(P_{t-1}^{CAN} + \beta^{US} P_{t-1}^{US} + \alpha_1\right) + \sum_{i=1}^{p}\gamma_i \Delta P_{t-i}^{CAN} + \sum_{i=1}^{p}\delta_i \Delta P_{t-i}^{US} + \varepsilon_t^{CAN}$$

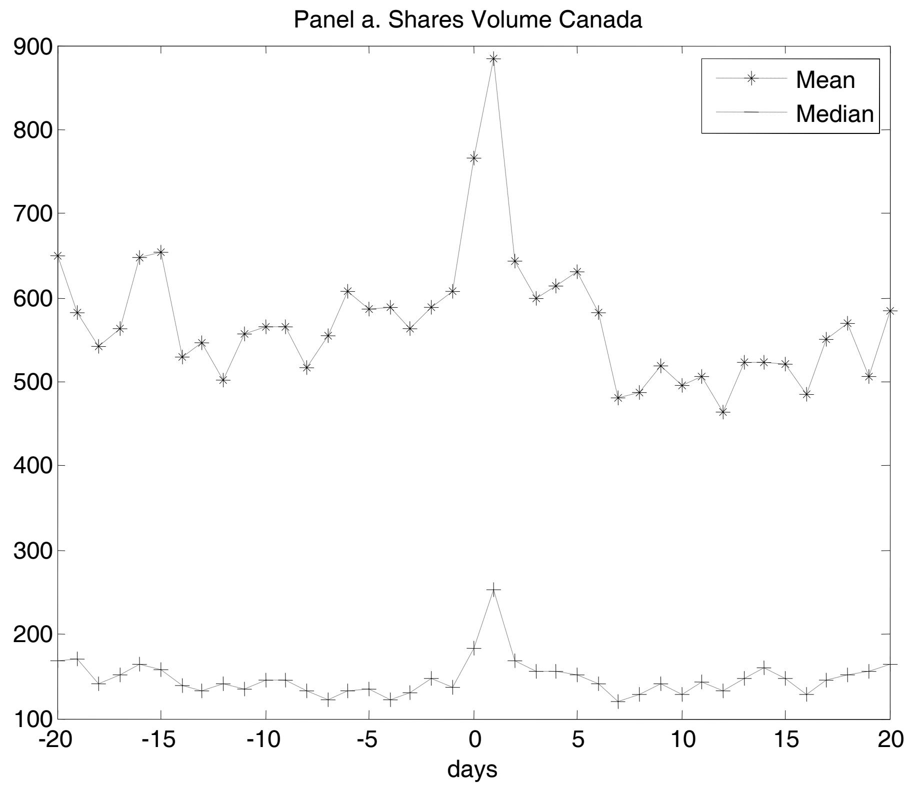
$$\Delta P_t^{US} = \alpha^{US}\left(P_{t-1}^{CAN} + \beta^{US} P_{t-1}^{US} + \alpha_1\right) + \sum_{i=1}^{p}\phi_i \Delta P_{t-i}^{CAN} + \sum_{i=1}^{p}\psi_i \Delta P_{t-i}^{US} + \varepsilon_t^{US}$$

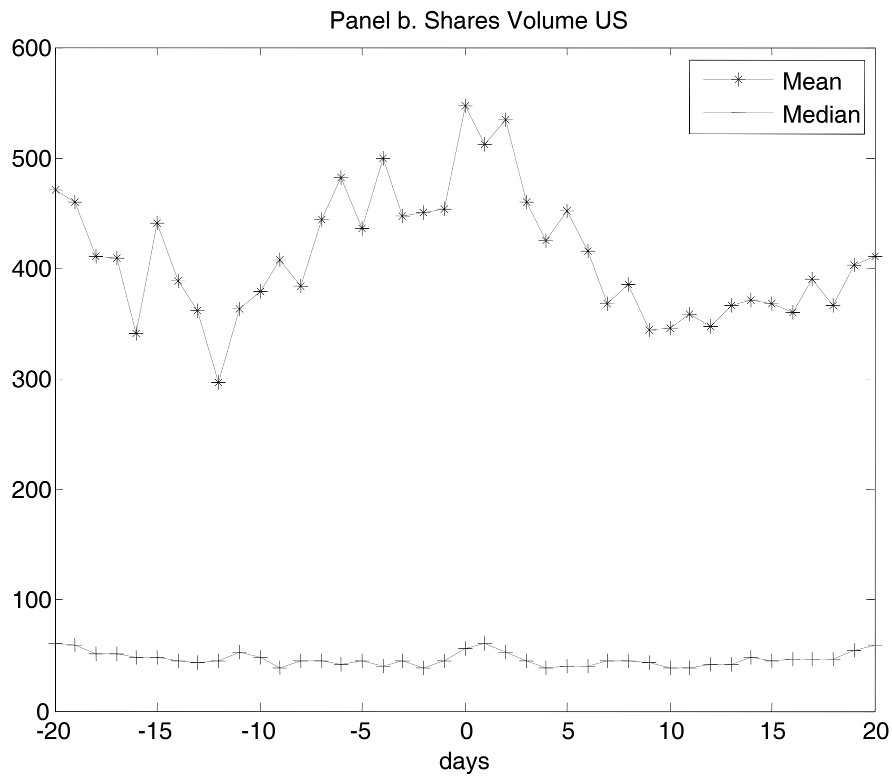
The number of lags is determined using the multivariate Schwarz criterion. Non-announcement periods contain stacked days [-20, -2] and [+2, +20], and announcement periods contain days [-1, +1] centered on the earnings announcement date [0]. Similar to Eun *et al.* (2003), $CanAdj$ is the feedback or contribution from the U.S. market to the domestic Canadian market. d_CanAdj is the difference between $CanAdj$ for regular non-announcement and earnings announcement periods. The sample size is 318. Bootstrapped p-values are used to test the null that the mean or median d_CanAdj is zero. [a, b] and [c] indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

	Non-announcement				Announcement				Difference
Statistic	α^{CAN}	β^{US}	α^{US}	$CanAdj$	α^{CAN}	β^{US}	α^{US}	$CanAdj$	d_CanAdj
5 perc	-0.341	-1.006	0.089	0.306	-0.300	-1.035	0.088	0.239	-0.294
25 perc	-0.201	-1.001	0.136	0.378	-0.185	-1.009	0.135	0.305	-0.105
median	-0.105	-1.000	0.192	0.433	-0.074	-0.999	0.186	0.387	-0.037
mean	-0.153	-1.000	0.204	0.427	-0.128	-0.998	0.203	0.362	-0.065
75 perc	-0.098	-0.998	0.256	0.458	-0.069	-0.988	0.258	0.426	0.002
95 perc	-0.081	-0.993	0.377	0.543	-0.048	-0.955	0.377	0.456	0.062
SD	0.086	0.004	0.093	0.083	0.090	0.023	0.092	0.083	0.113
t-stat									-10.219[c]
Wilcoxon									9.681[c]

Figure 1. Daily volume around earnings announcements for each market

In these figures, volume is measured as the number of traded shares in thousands. Day 0 represent the earnings announcement date. Daily cross-sectional means and medians are plotted for Canadian shares cross-listed in the U.S. based on trades in the Canadian market in panel A and in the U.S. market in panel B.




Panel b. Shares Volume US
Mean
Median
600
500
400
300
200
100
0
-20
-15
-10
-5
0
5
10
15
20
days