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Macroeconomic news announcements and price discovery: Evidence from Canadian–U.S. cross-listed firms ☆

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ABSTRACT

This study employs macroeconomic news announcements as a proxy for new information arrivals and examines their impact on price discovery. We compare the price discovery of 38 Canadian companies listed on the Toronto Stock Exchange (TSX) and the New York Stock Exchange (NYSE) for the period 2004–2011. First, we observe that price discovery shifts significantly during macroeconomic news announcement days. Second, the NYSE becomes more important in terms of price discovery, regardless of the origin of the news. Third, we examine the relation between price discovery and market microstructure variables. After controlling for liquidity shocks, we find that the impact of news announcements persists. Intraday analyses of price discovery on periods surrounding news releases further support these findings. Overall, our findings suggest that there is a difference in information-processing capability of the two markets, with the U.S. market being better at processing information than the Canadian market during macroeconomic news announcements.

1. Introduction

In today's globalized financial markets, financial assets, such as stocks often trade in multiple markets. In the case of cross-listed stocks, intermarket arbitrage should keep the prices in the different markets from drifting apart. When new information arrives it affects the price of the asset in both markets. However, both markets may react to the new information in a different way. This leads to the concept of price discovery, which examines how well these markets process the information and incorporate them into prices. Price discovery becomes particularly important when new information arrives, because this is the time when the information processing capacity of a market is most relevant, and reflects the competitiveness of that particular market.

One important point in time when new information arrives to the market is the release of macro-economic news. These news announcements provide indications for the near-term policy changes that will subsequently be used by investors to price securities. Since macroeconomic news announcements are pre-scheduled, the timing of such releases is known, and investors may choose to trade on this information in one or another market. This may lead to a temporal shift in price discovery between markets which is related to the arrival of information from macroeconomic news announcements. Although the impact of news announcements on security prices has been studied extensively (see Andersen et al., 2007; Love and Payne, 2008; and Nowak et al., 2011), and studies on the price discovery of cross-listed securities are abundant (see Chen and Choi, 2012; Hupperets and

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Menkveld, 2002; Pascual et al., 2006), studies on the impact of news announcement on price discovery are rare, especially when considering a multi-market setting. However, we can expect a relationship between macroeconomic news announcements and price discovery, because when news gets released, they affect prices in one market which then leads to movement in prices in other markets. In addition, we may expect that the shift in price discovery is driven by the information processing capacity of a market and should not be affected by the origin of the news (i.e. whether this information is produced in the home market or in the foreign market).

In this paper, we investigate whether information released during scheduled news announcements in one market leads to a shift in price discovery from one market to another. We test this conjecture by comparing the Hasbrouck (1995) information share (IS) and Gonzalo and Granger (1995) permanent–transitory (PT) decomposition measures during days with scheduled macroeconomic news announcements with days with no announcements. In particular, we assess Canadian stocks traded in Canada and the U.S.[1] In doing so, we consider Canadian as well as U.S. macroeconomic news. Particularly, we examine the extent to which macroeconomic news announcements from either market contribute to the price discovery of Canadian stocks listed in these two markets.

Our work has a number of novel features compared with previous studies. First, our study is the first to analyse the impact of macroeconomic news on the price discovery of cross-listed stocks. Second, we assess both Canadian and U.S. macroeconomic news, compared with previous studies which only looked at the impact of announcements in a single market. Third, we examine the relation between price discovery and macroeconomic news announcements over a long period of time, from 2004 to 2011.

Our analysis leads to several interesting findings. First, we observe that price discovery shifts significantly during macroeconomic news announcements. Second, the U.S. market becomes more dominant in terms of price discovery, regardless of the news country of origin. Third, we also examine the relation between price discovery and market microstructure variables. After controlling for liquidity shocks, we find that the impact of news announcements still persists. Intraday analyses of price discovery on periods surrounding news releases further support these findings, particularly during Federal Funds Rate announcements. On the whole, our results suggest that the U.S. market is better at processing information from macroeconomic news announcements.

The remainder of this paper is as follows. Section 2 discusses some of the relevant literature on the price discovery of cross-listed stocks and its linkage with macroeconomic news announcements. Section 3 describes the framework in deriving the vector error correction model, as well as the Gonzalo and Granger (1995) permanent–transitory decomposition and Hasbrouck (1995) information share measures. Section 4 looks at the selection of sample companies, and macroeconomic news announcements. Section 5 reports the empirical findings. Finally, Section 6 concludes.

2. Literature review

The main objective of this study is to assess whether information from macroeconomic news releases contributes to the price discovery of stocks listed on multiple exchanges. As such, we connect two strands of literature; namely, the price discovery of cross-listed stocks and the impacts of macroeconomic news announcement on security prices. Whilst each of these topics has been studied separately in the literature, the connection between them has received little attention.

Extant studies on price discovery suggest that the home market tends to lead price discovery for cross-listed stocks, and this can be attributed to several market characteristics. For instance, Lieberman et al. (1999) investigate the dominant–satellite relation of stocks listed on two international markets, Tel-Aviv and New York. They find that arbitrage opportunities are generally not available and that usually, the domestic market emerges as the dominant one and the foreign market as the satellite one, particularly for international companies with large volume and stock-holding. Eun and Sabherwal (2003) examine price discovery for Canadian stocks that are also listed on the NYSE, AMEX, or NASDAQ in the U.S., and find that generally Canada leads in terms of price discovery. They further observe that the U.S. share of price discovery is directly related to the U.S. share of trading, and inversely related to the ratio of bid–ask spreads. Pascual et al. (2006) study the price discovery process of the Spanish stocks listed on the Spanish Stock Exchange and cross-listed on the NYSE. They find that the home market leads in terms of price discovery which is attributable to its own trading activity. Frijns et al. (2010) examine the price discovery of Australian and New Zealand bilaterally cross-listed stocks, and find that in both cases the home market is dominant in terms of price discovery. However, they also observe that as firms grow larger and their cost of trading in Australia declines, the Australian market becomes more informative.

It has further been documented that the arrival of information contributes to the price discovery process between markets. Using volatility as a proxy for information on the Bund futures contract, Martens (1998) shows that during volatile periods, the share of volume in the London International Financial Futures Exchange decreases whilst the share in price discovery process increases; whereas in quiet periods, the Deutsche Terminbourse share of price discovery increases. Amin and Lee (1997) document that the option market's share of price discovery increases relative to the equity market's share prior to quarterly

[1] The nature of cross-listings of Canadian stocks in the U.S. offers several advantages. First, Canada and the U.S. are highly integrated markets. This enables easy access for firms to list and also for investors to trade actively in both markets. Second, their trading hours are synchronised and overlap completely. Regular trading hours for both markets are from 9:30 AM to 4:00 PM (EST). This is important for conducting intraday analysis since we need prices observed at the same time in the two markets. Third, Canadian securities are listed in the U.S. as ordinary shares, unlike securities from other countries which are usually listed as American Depositary Receipts (ADRs). Canadian stocks trading in the U.S. and Canada are therefore fully fungible, and are likely to move more closely to each other than the prices of ADRs from other countries and their home-market securities.

earnings announcements. This is mainly due to the fact that option traders initiate a greater proportion of long and short positions immediately before the dissemination of earnings news.

In this study, we use macroeconomic news announcements as a proxy for information arrival. Macroeconomic news conveys price-relevant information and its release time is predetermined. Security prices are affected by adjustments in expectations to the changing economic conditions driven by macroeconomic news announcements, such as GDP output, employment and inflation surprises, amongst others. Studies have shown that macroeconomic news announcements are linked to changes in security prices. Andersen et al. (2003), for instance, list 25 important macroeconomic variables and demonstrate the asset pricing impact (instantaneous response) of macroeconomic announcements on exchange rates. They find that high-frequency exchange rate dynamics are linked to economic fundamentals. A similar reaction is observed by Bernanke and Kuttner (2005) and Boyd et al. (2005) who analyse the stock markets, whilst Balduzzi et al. (2001) and Fleming and Remolona (1999) analyze the bond market.

Since price discovery concerns the process of how information gets incorporated into prices, changes in prices during macronews announcements could affect the level of price discovery. Indeed, several papers have investigated this link between price discovery and macroeconomic news announcements. For instance, Mizrach and Neely (2008) test for information shares in the U.S. Treasury futures market using data at the one minute frequency during macroeconomic announcements in the period from 1997 to 2000. They find weak evidence on the impact of announcements on price discovery. Only in one out of four cases when news is released does the futures market gain information share. They conclude that macroeconomic announcements rarely explain information shares independently of liquidity. Stronger evidence is provided by Taylor (2011) who observes an increase in information asymmetry and price discovery around the release of key macroeconomic information. He assesses the level of price discovery for S&P 500 index constituents over the period January to December of 2002 at the one minute frequency, and finds that the E-mini futures market becomes more dominant during conditions of high liquidity and extreme information asymmetry, i.e. during macroeconomic news releases. Phylaktis and Chen (2010) investigate price discovery of the foreign exchange market during macroeconomic news announcements. They estimate price discovery over time for major trading banks in the U.K. and U.S. markets over the period January 1994 to December 1998. They find that the top 10 trading banks' information advantage becomes prevalent, and their information share expands during general scheduled macroeconomic news.

Existing studies are limited to several asset classes, such as foreign exchange rates, index funds, and Treasury futures. However, one can also expect a strong relationship between stock prices and macroeconomic news because businesses are concerned about inflation, industrial production, and the unemployment rate which is conveyed in macroeconomic variables (McQueen and Roley, 1993). Furthermore, the existing studies are limited to a single market context, whilst in reality, news affect prices of stocks listed in multiple markets. These points combined, provide an opportunity to investigate how macroeconomic news announcements contribute to price discovery of cross-listed stocks.

3. Methodology

In this Section, we first show how stock price dynamics of the same asset in two different markets can be modelled using an error-correction model. Subsequently, we compute Gonzalo and Granger (1995) permanent–transitory decomposition and Hasbrouck (1995) information share to measure price discovery.

3.1. Error-correction model

Market microstructure theory assumes that an asset has an efficient price. This unobserved efficient price represents the underlying value of an asset conditional on all available public information. Following Madhavan (2000), we assume that all investors share the same public information set, and prices are efficient in the sense that the current price reflects future price expectations conditional on the available information set. Consequently, the efficient (log) price, p_t, follows a random walk,

$$p_t = p_{t-1} + \eta_t, \tag{1}$$

where η_t is the innovation in public beliefs. The existence of market frictions (e.g. order processing costs, inventory holding costs, asymmetric information costs) leads to deviations from the efficient price, resulting in two different prices that market makers trade at. The observed transaction price, y_t, is equal to the efficient price and the friction component, ζ_t, which is positive (negative) for a buy (sell) transaction and zero for a transaction at the midpoint,

$$y_t = p_t + \zeta_t. \tag{2}$$

In the case of an asset trading in two different markets, the observed prices in both markets, share one common stochastic trend. Let $y_t = (y_{1,t}, y_{2,t})'$ be the price vector where $y_{1,t}$ and $y_{2,t}$ are the prices in the two markets. In a multivariate setting, this can be expressed as:

$$\begin{pmatrix} y_{1,t} \\ y_{2,t} \end{pmatrix} = \iota p_t + \begin{pmatrix} \zeta_{1,t} \\ \zeta_{2,t} \end{pmatrix}, \tag{3}$$

where ι is a (2×1) unit vector. This equation can be seen as the integrated process of random walk and news innovations plus the market frictions observed at time t. The study of price discovery relies on the assumption that when a single security trades in two different markets, prices in the two markets share a common efficient price, p_t. Since prices in both markets are driven by the same underlying fundamentals, the prices should be cointegrated. Therefore, the two $I(1)$ price series $y_{1,t}$ and $y_{2,t}$ are cointegrated with cointegrating vector, $\beta' = (1 \; -1)$. Subsequently, $\beta' y_t = y_{1,t} - y_{2,t}$, which is a stationary process will be the error correction term. The Engle–Granger Representation Theorem states that a cointegrated system can be expressed as an error-correction model of the following form,

$$\Delta y_t = c + \alpha\beta' y_{t-1} + \sum_{i=1}^{N} \Gamma_i \Delta y_{t-1} + \epsilon_t, \tag{4}$$

where Δy_t is the (2×1) vector of log returns, c is a vector of constants, α is a (2×1) vector that measures the speed of adjustment to the error-correction term (i.e. $\alpha = \begin{pmatrix} \alpha^{US} \\ \alpha^{CAN} \end{pmatrix}$), Γ_i are (2×2) matrices of AR coefficients, and ϵ_t is a (2×1) vector of innovations. The VECM has two parts: the first part, $\beta' y_{t-1}$, represents the long-run equilibrium between the price series. The second part, $\sum_{i=1}^{N} \Gamma_i \Delta y_{t-1}$, represents the short-term dynamics induced by market imperfections.

The VECM has been used extensively to study the price discovery of a security traded in multiple markets. For example, Hasbrouck (1995) uses the VECM to estimate price discovery of stocks traded on the NYSE and U.S. regional exchanges. Werner and Kleidon (1996) analyze the cointegration of British stocks cross-listed in the U.K. and U.S. markets. Huang (2002) studies the price discovery of quotes in NASDAQ market submitted by the electronic communication networks (ECNs) and by traditional market makers. Pascual et al. (2006) investigate the price discovery process of Spanish cross-listed stocks in the NYSE during the daily (two-hour) overlapping interval.

3.2. Price discovery measures

In this paper, we use the VECM to compute the price discovery measures of Canadian stocks cross-listed in the U.S. We follow two approaches: the Gonzalo and Granger (1995) permanent–transitory (PT) decomposition, and the Hasbrouck (1995) information share (IS) measures. They are directly related and the results of both models are primarily derived from the VECM.[2]

3.2.1. Gonzalo and Granger (1995) permanent–transitory decomposition (PT) measure

The PT measure is concerned with the permanent shocks that result in a disequilibrium as markets process news at different speeds. The PT measures each market's contribution to the common factor, where the contribution is defined to be a function of the market's error correction coefficients; in this case, the speed of adjustment coefficients, α. When a market dominates in terms of price discovery, its value of α will be small, indicating that this market does not correct in response to any differences in prices between markets. Conversely, when a market is a satellite market, its value of α will be large in absolute terms relative to the dominant market, indicating strong adjustment to price differences. If neither market is completely dominant, the magnitude of α will indicate the relative dominance between the two. The PT can be computed using the following measure,

$$PT^{US} = \frac{\alpha^{CAN}}{\alpha^{CAN} + |\alpha^{US}|}, \tag{5}$$

where α^{US} is negative, and α^{CAN} is positive given our β definition of $(1 \; -1)'$. This ratio gives an indication of the degree of dominance of one market over the other market. A higher value of this ratio reflects a greater feedback or contribution from the US. Therefore, a PT^{US} of zero would imply that the NYSE does not contribute to the price discovery of the stocks, whereas a PT^{US} greater than zero would imply feedback from the NYSE to the TSX.

3.2.2. Hasbrouck (1995) information share

Hasbrouck proposes an alternative measure for price discovery — the information share (IS). It measures the proportion of variance contributed by one market with respect to the variance of the innovations in the common efficient price. To assess this, note that we can rewrite Eq. (4) as a vector moving average (Wold representation):

$$\Delta y_t = \Psi(L) e_t, \tag{6}$$

[2] Baillie et al. (2002) explain that PT and IS provide similar results if the VECM residuals are uncorrelated. However, if substantial correlation exists, the two measures usually yield different results. Whilst the PT measure is not affected by contemporaneous correlation in the residuals, the IS model is. Therefore it needs to be handled using Cholesky factorization, which requires that the prices be ordered. This makes the IS results variable order dependent and Hasbrouck (1995) suggests that different orders be used in order to calculate the upper and lower IS bounds before they are averaged to arrive at a final IS result.

where $\Psi(L)$ is a matrix polynomial in the lag operator ($\Psi(L) = 1 + \psi_1 L + \psi_2 L^2 + \psi_3 L^3 + \ldots$). Following the Beveridge and Nelson (1981) decomposition, which states that every (matrix) polynomial has permanent and transitory structure, we can write Eq. (6) in its integrated form as:

$$y_t = \Psi(1)\sum_{s=1}^{t} e_s + \Psi^*(L)e_t. \tag{7}$$

where $\Psi(1)$ is the sum of all moving average coefficients, and measures the long-run impact of an innovation to the level of prices. Since prices are cointegrated, $\beta' y_t$ is a stationary process, this implies that $\beta'\Psi(1) = 0$, i.e. the long-run impact is the same for all prices. If we denote $\psi = (\psi_1 \psi_2)$ as the common row vector in $\Psi(1)$, Eq. (7) becomes:

$$y_t = \iota\psi\left(\sum_{s=1}^{t} e_s\right) + \Psi*(L)e_t. \tag{8}$$

Hasbrouck (1995) states that the increment ψe_t in Eq. (8) is the component of price change that is permanently impounded into the price and is presumably due to new information and decomposes the variance of the common factor innovations, i.e., $var(\psi e_t) = \psi\Omega\psi'$. The information share of a market is defined as the proportion of variance in the common factor that is attributable to innovations in that market. Since Hasbrouck (1995) uses the Cholesky factorization of $\Omega = MM'$ to handle contemporaneous correlation, where M is a lower triangular matrix, the information share of market i is represented as:

$$S_i = \frac{([\psi M]_i)^2}{\psi\Omega\psi'}. \tag{9}$$

We compute $\Psi(1)$ in Eq. (8) by calculating the product of the orthogonal matrices of $\beta_\perp$ and $\alpha_\perp$ (see Baillie et al., 2002),

$$\begin{aligned} &\Psi(1) = \beta_\perp \prod a'_\perp, \\ &\prod = \left(a'_\perp\left(I - \sum_{j=1}^{k} A_j\right)\beta_\perp\right)^{-1}, \end{aligned} \tag{10}$$

where I is a (2×2) identity matrix, and Π is a scalar if there is only one common factor in the system. Since $\beta = (1\ -\ 1)'$, we know that $\beta_\perp = (1 \cdot 1)'$. Therefore,

$$\Psi(1) = \begin{bmatrix}\psi \\ \psi\end{bmatrix} = \Pi\begin{bmatrix}\gamma_1 & \gamma_2 \\ \gamma_1 & \gamma_2\end{bmatrix} \tag{11}$$

where γ_1 and γ_2 are the elements of $\alpha_\perp'$. The lower triangular matrix, M given by Cholesky factorization of Ω in Eq. (9) can be expressed as:

$$M = \begin{bmatrix}m_{11} & 0 \\ m_{12} & m_{22}\end{bmatrix} = \begin{bmatrix}\sigma_1 & 0 \\ \rho\sigma_2 & \sigma_2\left(1-\rho^2\right)^{1/2}\end{bmatrix}. \tag{12}$$

Using Eqs. (8), (11), and (12) we can rewrite the information share as:

$$\begin{aligned} S_1 &= \frac{(\gamma_1 m_{11} + \gamma_2 m_{12})^2}{(\gamma_1 m_{11} + \gamma_2 m_{12})^2 + (\gamma_2 m_{22})^2}, \\ S_2 &= \frac{(\gamma_2 m_{22})^2}{(\gamma_1 m_{11} + \gamma_2 m_{12})^2 + (\gamma_2 m_{22})^2} \end{aligned} \tag{13}$$

where S_1 denotes the upper bound of the information share of market 1 and S_2 the lower bound of market 2. In order to get the lower bound for market 1 and upper bound for market 2, we reverse the order of $\Psi(1)$ as well as M and recompute Eq. (13). Subsequently, we compute the midpoints to obtain the IS value.

4. Data sources

4.1. Intraday stock returns data

We collect data for 38 Canadian stocks which are traded on the TSX and the NYSE for the period January 1, 2004 to January 31, 2011 (1727 trading days). For the U.S. market, we use the national best bid and ask quotes for stocks with the NYSE as primary listings and for the Canadian market, we use quotes posted at the TSX. The end of the sample is chosen to avoid confounding effects from the new Order Protection Rule in Canada which became effective on February 1, 2011 (see Clark, 2011). The stocks in

our sample are simultaneously traded cross-listed pairs through the sample period. Data are collected from the Thomson Reuters Tick History (TRTH) database maintained by SIRCA.[3] We obtain intraday quotes sampled at a one-second frequency.[4] Since sometimes trading in one of the markets starts later than 9:30:00, we risk having non-synchronous data. Therefore, we omit the first 5 min of the trading day. This leaves us to 23,100 observations per trading day per company. Following Grammig et al. (2005), we use midpoints of quotes to study price discovery as these are less affected by the bid-ask bounce that is normally observed in transaction prices. We also obtain intraday Canadian–U.S. Dollar exchange rate quotes from TRTH and use the midpoint to convert prices into a common currency to facilitate the specification of the error-term and ensure the comparability of prices between the two markets, similar to Eun and Sabherwal (2003) and Chen and Choi (2012). Hence, our analyses in this paper are based on the quote price series for each firm in the same currency, the U.S. dollar.[5]

Table 1 contains descriptive statistics for our sample consisting of 38 firms. We report the market capitalization, average daily trade, and average percentage bid-ask spread for each stock in both the U.S. and Canada. We also include the trading and spread ratio of the U.S. market relative to the Canadian market. Our sample covers a broad set of firms with market capitalization ranging from a minimum of $558 million to a maximum of $66 billion. It covers the less liquid stock such as Kingsway Financial Services with average daily U.S. trades of 158 trades to a more liquid stock such as Barrick Gold with average daily trades of 33,331 trades, with a sample average of 7110 trades. In Canada, the daily number of trades ranges from a minimum of 108 trades for MI Developments Inc. to a maximum of 10,213 trades for Suncor Energy, with a sample average of 4179 trades. The trading ratio suggests that trading intensity is higher in the U.S. than in Canada as shown by a ratio of 63%. The highest trading ratio in the U.S. is Brookfield Office with 84% whilst the minimum is reported by TransAlta Corp with 11%. The average daily percentage spread in both markets is 0.12%, and the average spread ratio for the U.S. market as a proportion to the Canadian market is 50%, suggesting that the cost of trading, on average, is about the same in the U.S. and Canada.

We conduct the usual procedures of unit root and cointegration tests before estimating the PT and IS measures. To test for non-stationarity, we perform Augmented Dickey–Fuller tests using the Akaike Information Criterion (AIC) to select optimal lag length. For all stocks, we cannot reject the presence of a unit root. Subsequently, we conduct Johansen (1988) test for cointegration. In all tests, we reject the null of no cointegration in favour of the alternative of one cointegrating vector. Since the price series in our sample satisfy both conditions, we conclude that each pair of our sample stocks is cointegrated.

4.2. Macroeconomic news announcements

Table 2 lists the names, sources, time of release and the frequency of all the macroeconomic news announcements considered in this study. We obtain the date, time and the actual figures for the macroeconomic news announcements from their respective websites as listed at the bottom of Table 2. For the Canadian market, we select 10 Canadian macroeconomic news releases (in line with studies such as Gravelle and Moessner, 2001; Doukas and Switzer, 2004). Real GDP, Capacity Utilization Rate, and Current Account Balance are announced quarterly, Interest Rates are released every 6 weeks, whilst the rest are released monthly. As for the U.S. announcements, given the large number of data releases, we restrict our sample to the most relevant 22 items. This is in line with the literature in this area (see e.g. Balduzzi et al., 2001; Andersen et al., 2003, 2007). From these major announcements, the GDP related announcements are released quarterly, Fed Funds Rate is released every 6 weeks, and all the remaining announcements are released monthly.

5. Results

In this Section, we present the results for the models proposed in Section 3. We divide our analyses into two subsections. The first subsection concerns the change in daily level of price discovery caused by macroeconomic news announcements. Specifically, we compute the IS and PT for stocks during announcement and non-announcement days over the sample periods. Then, we measure the difference between the two sets. We examine the absolute changes in price discovery as well as the directional changes. We further conduct a regression analysis and control for the possible impact of liquidity during announcement times. The second subsection concerns the change in intraday price discovery during announcement times. Using smaller intraday event windows on periods surrounding the announcements, we implement similar tests to the ones in Section 1. These tests assess the impact of macroeconomic news announcements on price discovery, the direction of the news impact, the types of news (domestic vs foreign news), as well as the accuracy of the time and model specifications.

5.1. Daily price discovery during announcement and non-announcement days

To illustrate the importance of macroeconomic announcements in understanding the price discovery mechanism, we consider the relation between announcement vs non-announcement days and the price discovery measures of the stocks. We compute IS

[3] Securities Industry Research Centre of Asia-Pacific.

[4] Fleming and Remolona (1999) indicate that more powerful tests of market efficiency can be carried out only by using intraday observations of financial asset prices. Eun and Sabherwal (2003) use quotes at a 10-minute interval to assess price discovery in their study from February to July 1998, whilst a 1-minute interval is employed in Chen and Choi (2012) in their study from January 1998 to December 2000. Riordan and Storkenmaier (2012) uses millisecond frequency to capture price discovery in their 2007 study, albeit their sample are the most actively traded companies making up the German main indexes. With these considerations, we postulate 1-second interval as the optimal sampling frequency.

[5] We also conducted the analysis in Canadian dollars and found no significant difference in results.

Table 1
Sample of Canadian firms listed in Canada and the U.S.
Table 1 provides a summary statistics of the 38 stocks in our sample. It reports the Market capitalization, the average daily trade, and the average percentage spread in the U.S. and Canada. Also reported are the trading ratio and the spread ratio of the U.S. market relative to the Canadian market.

	January 2004–January 2011		Market Cap	Average Daily Trade			Average % Spread		
No.	Company	Symbol	($mil)	US	CAN	US/(US + CAN)	US	CAN	US/(US + CAN)
1	Agnico-Eagle Mines Limited	AEM	7122	12,197	3543	77%	0.07%	0.10%	41%
2	Agrium Inc.	AGU	8784	11,923	4180	74%	0.07%	0.10%	43%
3	Bank of Montreal	BMO	31,497	2195	5578	28%	0.09%	0.05%	63%
4	Bank of Nova Scotia	BNS	49,846	1886	6456	23%	0.09%	0.05%	65%
5	Barrick Gold	ABX	34,904	33,331	9,682	77%	0.04%	0.06%	43%
6	BCE Inc.	BCE	27,213	3,347	5823	36%	0.07%	0.05%	56%
7	Brookfield Office	BPO	7793	7738	1470	84%	0.10%	0.14%	41%
8	Cameco Corp.	CCJ	11,372	9971	4703	68%	0.08%	0.09%	49%
9	Canadian Imperial Bank Communication	CM	27,844	1679	4637	27%	0.10%	0.05%	65%
10	Canadian National Railway Company	CNI	27,396	6165	4264	59%	0.06%	0.06%	49%
11	Canadian Natural Resources Ltd.	CNQ	34,037	11,492	7157	62%	0.06%	0.06%	49%
12	Canadian Pacific	CP	9,967	3115	2594	55%	0.08%	0.08%	50%
13	Celestica Inc.	CLS	1826	3734	1588	70%	0.14%	0.16%	47%
14	CGI Group	GIB	3738	581	1479	28%	0.25%	0.17%	59%
15	COTT Corp.	COT	889	1737	679	72%	0.28%	0.37%	43%
16	Enbridge Inc.	ENB	19,012	1405	2599	35%	0.10%	0.08%	55%
17	Encana Corp.	ECA	31,810	13,930	8092	63%	0.05%	0.05%	48%
18	Enerplus Corp.	ERF	4834	2640	1380	66%	0.11%	0.13%	45%
19	Gildan Activewear Inc.	GIL	3060	2987	1436	68%	0.14%	0.16%	47%
20	Goldcorp Inc.	GG	24,539	30,137	9517	76%	0.05%	0.07%	42%
21	Kingsway Financial Services Inc.	KFS	558	158	409	28%	0.49%	0.36%	58%
22	Kinross Gold Corp.	KGC	10,759	19,549	7,345	73%	0.11%	0.11%	50%
23	Manulife Financial Corp.	MFC	40,305	7,026	7590	48%	0.06%	0.06%	52%
24	MI Developments Inc.	MIM	1385	317	108	75%	0.21%	0.36%	37%
25	Nexen Inc.	NXY	12,615	8974	5645	61%	0.09%	0.09%	51%
26	Pengrowth Energy Corp.	PGH	3156	3081	1250	71%	0.13%	0.17%	43%
27	Potash Corporation of Saskatchewan Inc.	POT	28,774	26,273	5374	83%	0.05%	0.07%	42%
28	Precision Drilling Trust	PDS	2307	3980	1936	67%	0.13%	0.13%	49%
29	Ritchie Brothers Auctioneers	RBA	2262	1252	281	82%	0.16%	0.36%	30%
30	Rogers Communication Inc.	RCI	16,220	2016	3980	34%	0.12%	0.09%	57%
31	Royal Bank of Canada	RY	66,555	3849	8094	32%	0.07%	0.05%	60%
32	Shaw Communications Inc.	SJR	7803	945	2011	32%	0.14%	0.12%	54%
33	Sun Life Financial	SLF	20,867	2074	3958	34%	0.10%	0.07%	57%
34	Suncor Energy Incorporated	SU	42,305	22,901	10,213	69%	0.05%	0.06%	48%
35	Talisman Energy Inc.	TLM	17,131	12,566	6478	66%	0.08%	0.08%	49%
36	Toronto-Dominion Bank	TD	52,833	4437	7027	39%	0.07%	0.05%	59%
37	TransAlta Corp.	TAC	4865	205	1654	11%	0.20%	0.11%	64%
38	TransCanada Corp.	TRP	23,358	1449	3615	29%	0.08%	0.06%	58%
	Mean			7454	4311	63%	0.12%	0.12%	49%

and PT daily. The VECM of Eq. (4) is estimated by Ordinary Least Squares with optimal lag length suggested by AIC. We differentiate between the IS and PT on non-announcement days and specific announcement days. The difference in IS and PT indicates market reactions to price discovery imposed by news releases. We report percentage change in IS and PT. Significance tests are based on t-statistics which are computed using paired-difference test, and controlled for possible heteroskedasticity using Newey–West correction.

5.1.1. Absolute difference test

Price discovery may shift in either direction for stocks listed in multiple markets, especially when news may originate from either market. Therefore, the relative impact of news on price discovery is not obvious. As discussed in Eun and Sabherwal (2003), the TSX, as the home market stock exchange, is likely to contribute substantially to price discovery as it is in the security's home market where substantial information is expected to be produced. However, the dominance of the U.S. stock exchanges as amongst the largest and most liquid exchanges in the world also suggests that they are likely to contribute significantly to price discovery. Such conflicting arguments do not provide us with a clear prior hypothesis on the directional impact of news announcements. Therefore, we may observe price discovery shifts in either direction.

Table 3 reports the difference in price discovery between non-announcement and announcement days for the period January 2004 to January 2011. The figures reported are the absolute percentage differences in IS and PT, $\frac{|(IS(PT)_{Announcement} - IS(PT)_{Non-Announcement})|}{IS(PT)_{Non-Announcement}}$, and their corresponding t-statistics. It also reports the number of firms which significantly cause shifts in IS and PT.[6] On aggregate,

[6] We use Li and Maddala's (1997) stationary bootstrap method to resample the residuals. We first estimate the VECM model of Eq. (4). The estimated parameters and residuals are stored. The resampled residuals are then inserted back into the VECM. The VECM is-re-estimated and the new IS and PT recalculated. We repeat the process 200 times.

Table 2
Macroeconomic news releases (January 2004–January 2011).
Table 2 provides a summary of the macroeconomic news announcements used in the study, the total number of releases (Obs.), sources, the time of release using Eastern Standard Time (EST), and the frequency of releases. * indicates that U.S. Personal Income and U.S. Personal Consumption Expenditures have the same release dates. ** indicates that U.S. Business Inventories release times varies from 8:30 am and 10:00 am. *** indicates that U.S. Industrial Production and U.S. Capacity Utilization have the same release dates. Total U.S. and Canada announcements are adjusted for overlapping days.

No	Macroeconomic Announcement	Obs	Source	EST	Frequency
CAN Announcements					
1	Real GDP	28	CANSIM	8:30	Quarterly
2	Capacity Utilization Rate	28	CANSIM	8:30	Quarterly
3	Current Account Balance	28	CANSIM	8:30	Quarterly
4	CPI	85	CANSIM	7:00	Monthly
5	Industrial Product Price	86	CANSIM	8:30	Monthly
6	Unemployment Rate	85	CANSIM	7:00	Monthly
7	Retail Sales	85	CANSIM	8:30	Monthly
8	Leading Indicators Index	85	CANSIM	8:30	Monthly
9	Housing Starts	57	CMHC	8:15	Monthly
10	Interest Rate	85	BoC	9:00	6-Week
US Announcements					
11	GDP Advance	29	BEA	8:30	Quarterly
12	GDP Preliminary	28	BEA	8:30	Quarterly
13	GDP Final	28	BEA	8:30	Quarterly
14	Personal Income, Personal Consumption Expenditures*	85	BEA	8:30	Monthly
15	Trade Balance	85	BEA	8:30	Monthly
16	Nonfarm Payroll Employment	85	BLS	8:30	Monthly
17	PPI	85	BLS	8:30	Monthly
18	CPI	85	BLS	8:30	Monthly
19	Retail Sales	85	BC	8:30	Monthly
20	New Home Sales	85	BC	10:00	Monthly
21	Durable Goods Orders	85	BC	8:30	Monthly
22	Factory Orders	85	BC	10:00	Monthly
23	Business Inventories**	85	BC	8:30/10:00	Monthly
24	Construction Spending	85	BC	10:00	Monthly
25	Housing Starts	85	BC	8:30	Monthly
26	Consumer Confidence Index	85	CB	10:00	Monthly
27	Chicago PMI	85	CB	9:45	Monthly
28	Leading Indicators Index	85	CB	10:00	Monthly
29	Industrial Production, Capacity Utilization***	85	FRB	9:15	Monthly
30	Consumer Credit	85	FRB	15:00	Monthly
31	Government Budget	86	FMS	14:00	Monthly
32	Federal Funds Rate	57	FRB	14:15	6-Week
	Total US and Canada Announcements (adjusted)	1297			
	Total Non-Announcement Days	430			
	Total Sample Days	1727			

CANSIM = Statistics Canada
CMHC = Canada Mortgage and Housing Corporation
BoC = Bank of Canada
BES = Bureau of Economic Analysis
BLS = Bureau of Labour Statistics
BC = Bureau of the Census
CB = Conference Board
FRB = Federal Reserve Bank
FMS = Financial Management Service.

macroeconomic news announcements cause a 3.1% shift in IS, and a 2.6% shift in PT, respectively. Canadian announcements contribute to 3.4% (2.8%) shifts in IS (PT), whilst U.S. announcements lead to 3.0% (2.5%) shifts. On average, more than 95% from a total of 38 firms in our sample react significantly to macroeconomic news announcements, causing significant shifts in both IS and PT.

Looking at individual announcements, we find significant shifts in price discovery during all announcements. The number of firms which show significant reactions is also very high. These results strongly suggest that macroeconomic news announcements affect the level of price discovery between Canada and the U.S.

5.1.2. Directional difference test

We examine the directional impact of news announcements on price discovery by computing the percentage difference in IS and PT during days with a specific announcement and non-announcement days. Table 4 reports the differences in price discovery during various announcement days and their corresponding t-statistics. It also reports the number of firms with significant reduction and increase in the IS and PT measures.

Table 3
Absolute change in Price Discovery during announcement days.
Table 3 provides the change in IS and PT for 38 Canadian cross-listed stocks during announcement days. The IS and PT are computed of daily averages, reported as the absolute percentage difference between IS and PT during announcement and non-announcement days $\left(\frac{|IS(PT)_{Announcement} - IS(PT)_{Non-Announcement}|}{IS(PT)_{Non-Announcement}}\right)$. The figures under "Total" denote the number of firms (out of 38 firms) showing significant shift in Price Discovery during announcement times at the 5% significance level obtained using the bootstrap procedure. Figures in parentheses are the t-statistics. *** denotes significance at the 1% level.

January 2004–January 2011		Panel A: Information Share (IS)			Panel B: Component Share (PT)		
Price Discovery	Time	Diff	t-stat	Total	Diff	t-stat	Total
ALL Announcements		3.1%***	(17.1)	36.7	2.6%***	(18.73)	36.8
CAN Announcements		3.4%***	(8.94)	36.7	2.8%***	(9.87)	36.7
US Announcements		3.0%***	(14.91)	36.7	2.5%***	(16.15)	36.8
CAN Announcement							
CPI	7:00	2.9%***	(8.59)	35	2.5%***	(8.6)	36
Labour Force Survey	7:00	3.2%***	(12.76)	36	2.3%***	(11.25)	38
Housing Starts	8:15	2.2%***	(7.34)	35	1.8%***	(8.63)	36
Real GDP	8:30	4.5%***	(8.95)	38	3.6%***	(7.98)	36
Capacity Utilization Rate	8:30	6.0%***	(9.6)	38	4.4%***	(10.57)	38
Current Account Balance	8:30	4.2%***	(7.14)	36	3.6%***	(6.46)	37
Industrial Price Index	8:30	2.0%***	(10.54)	37	1.7%***	(8.63)	37
Retail Sales	8:30	3.7%***	(10.49)	38	3.4%***	(10.93)	36
Leading Indicators Index	8:30	2.8%***	(10.45)	37	2.3%***	(9.1)	36
Interest Rate	9:00	2.7%***	(6.44)	37	2.3%***	(6.88)	37
US Announcement							
GDP Advance	8:30	5.7%***	(8.09)	38	4.1%***	(7.09)	36
GDP Preliminary	8:30	3.9%***	(6.47)	34	3.4%***	(7.33)	38
GDP Final	8:30	3.7%***	(7.66)	37	3.4%***	(7.86)	36
Personal Income	8:30	2.6%***	(7.51)	38	1.7%***	(7.31)	37
Trade Balance	8:30	2.7%***	(8.48)	36	2.4%***	(8.96)	37
Nonfarm Payroll Employment	8:30	2.0%***	(7.13)	36	2.0%***	(8.44)	38
PPI	8:30	1.8%***	(6.62)	36	1.6%***	(7.17)	36
CPI	8:30	3.2%***	(7.17)	38	2.5%***	(7.58)	37
Retail Sales	8:30	1.8%***	(8.12)	36	1.6%***	(8.67)	37
Durable Goods Orders	8:30	2.8%***	(8.25)	36	2.1%***	(9.15)	36
Housing Starts	8:30	3.7%***	(9.54)	37	3.0%***	(11.94)	37
Industrial Production	9:15	3.7%***	(8.47)	38	2.9%***	(8.52)	37
Chicago PMI	9:45	2.5%***	(6.86)	38	2.0%***	(6.39)	34
New Home Sales	10:00	2.9%***	(8.35)	36	2.4%***	(7.58)	37
Factory Orders	10:00	2.2%***	(7.23)	38	1.8%***	(6.75)	35
Business Inventories	10:00	1.8%***	(10.2)	35	1.6%***	(8.39)	37
Construction Spending	10:00	4.3%***	(10.62)	38	3.8%***	(11.43)	38
Consumer Confidence Index	10:00	2.8%***	(6.33)	36	2.2%***	(6.72)	38
Leading Indicators Index	10:00	2.7%***	(8.04)	37	2.6%***	(9.84)	37
Government Budget	14:00	3.2%***	(7.82)	37	2.8%***	(9.16)	37
Federal Funds Rate	14:15	2.9%***	(9.52)	36	2.3%***	(9.01)	36
Consumer Credit	15:00	2.41%***	(9.82)	36	2.0%***	(9.75)	38

Panel A in Table 4 presents the changes in U.S. IS during the different announcement days. We observe that price discovery mainly shifts to the U.S. during days with macroeconomic news announcements. On average, macroeconomic news announcements cause a significant 1.1% increase in the U.S. IS, at 1% level significance, with an average of 24.3 firms significantly showing increases in IS and 12.3 firms show decreases. Canadian announcements contribute to a significant 1.5% increase in IS, and the U.S. announcements contribute to a 0.9% increase.

When we break down the different Canadian announcements, we find that five macroeconomic announcements: Consumer Price Index, Labour Force Survey, Capacity Utilization Rate, Retail Sales and Leading Indicator Index significantly increase the U.S. IS (decrease Canada IS). This is reflected in the number of firms which significantly increase the U.S. IS as opposed to those which reduce it, as reported in the third and fourth columns of Panel A. For example, the increase in IS during Consumer Price Index announcements is caused by 30 of the firms in our sample showing a significant increase in IS whereas only 5 firms show a significant decrease. Some of the largest increases in IS are during Canada Capacity Utilization Rate announcements with 4.7%, followed by Retail Sales announcements with 3.7%, and Labour Force Survey with 2.8%. This may indicate that these announcements lead to more concentrated and intensive reaction from U.S. market players. Canada Interest Rates announcement does not appear to be significant. One possible explanation may be the relative ease of predictability of the statistics by the market players, since there has not been a sufficient degree of divergence between Canadian and U.S. business cycles after the Bank of Canada began efforts to improve its monetary policy transparency in the early to mid-1990s.

As for the U.S. announcements, we observe that a large number of announcements significantly increase the U.S. IS. The Fed Funds Rate announcements, as one of the key macroeconomic variables, appear to lead to a significant increase in IS. Forward looking macroeconomic announcements such as Consumer Confidence Index, Chicago PMI, and Leading Indicator Index also

Table 4
Change in Price Discovery during announcement days.
Table 4 provides the change in U.S. IS and PT for 38 Canadian cross-listed stocks during announcement days. The IS and PT are computed of daily averages, reported as the percentage difference between IS and PT during announcement and non-announcement days $\left(\frac{|IS(PT)_{Announcement} - IS(PT)_{Non-Announcement}|}{IS(PT)_{Non-Announcement}}\right)$. The figures under "−" ("+") denote the number of firms (out of 38 firms) showing a decrease (increase) in U.S. Price Discovery during announcement times at the 5% significance level obtained using the bootstrap procedure. Figures in parentheses are the t-statistics. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

January 2004–January 2011		Panel A: Information Share (IS)				Panel B: Component Share (PT)			
US Price Discovery	Time	Diff	t-stat	−	+	Diff	t-stat	−	+
ALL Announcements		1.1%***	(3.45)	12.3	24.3	1.0%***	(3.73)	11.5	25.2
CAN Announcements		1.5%***	(2.39)	11.4	25.3	1.1%**	(2.16)	10.9	25.8
US Announcements		0.9%***	(2.49)	12.8	23.9	0.9%***	(2.97)	11.8	25.0
CAN Announcement									
CPI	7:00	2.4%***	(5.53)	5	30	1.9%***	(5.05)	6	30
Labour Force Survey	7:00	2.8%***	(7.78)	2	34	2.1%***	(7.86)	4	34
Housing Starts	8:15	0.5%	(1.17)	14	21	0.6%*	(1.66)	14	22
Real GDP	8:30	0.3%	(0.31)	17	21	0.0%	(−0.05)	16	20
Capacity Utilization Rate	8:30	4.7%***	(5.37)	6	32	3.6%***	(6.07)	4	34
Current Account Balance	8:30	−1.6%*	(−1.91)	22	14	−1.8%***	(−2.45)	21	16
Industrial Price Index	8:30	−0.3%	(−0.86)	21	16	0.0%	(−0.06)	20	17
Retail Sales	8:30	3.7%***	(10.11)	2	36	3.3%***	(9.92)	1	35
Leading Indicators Index	8:30	1.7%***	(3.92)	9	28	1.6%***	(4.31)	9	27
Interest Rate	9:00	0.5%	(0.87)	16	21	0.2%	(0.5)	14	23
US Announcement									
GDP Advance	8:30	−1.8%	(−1.56)	24	14	−1.6%*	(−1.83)	21	15
GDP Preliminary	8:30	0.4%	(0.48)	14	20	0.3%	(0.44)	18	20
GDP Final	8:30	1.0%	(1.33)	11	26	1.8%***	(2.76)	8	28
Personal Income	8:30	−2.2%***	(−5.26)	28	10	−1.3%***	(−4.68)	29	8
Trade Balance	8:30	1.7%***	(3.58)	6	30	1.8%***	(4.83)	4	33
Nonfarm Payroll Employment	8:30	1.4%***	(3.69)	8	28	1.7%***	(5.8)	7	31
PPI	8:30	0.5%	(1.23)	13	23	1.0%***	(3.31)	9	27
CPI	8:30	2.8%***	(5.33)	4	34	2.0%***	(4.89)	6	31
Retail Sales	8:30	0.4%	(1.06)	17	19	0.6%*	(1.95)	14	23
Durable Goods Orders	8:30	−1.0%*	(−1.76)	24	12	−0.8%**	(−2.12)	22	14
Housing Starts	8:30	3.2%***	(6.31)	3	34	2.6%***	(7.29)	4	33
Industrial Production	9:15	2.8%***	(4.8)	6	32	2.5%***	(5.9)	5	32
Chicago PMI	9:45	2.0%***	(4.63)	6	32	1.7%***	(4.68)	4	30
New Home Sales	10:00	2.0%***	(4.24)	6	30	2.0%***	(5.23)	6	31
Factory Orders	10:00	0.4%	(0.88)	18	20	0.4%	(0.92)	16	19
Business Inventories	10:00	0.5%	(1.64)	14	21	0.8%***	(2.75)	12	25
Construction Spending	10:00	−3.4%***	(−5.73)	32	6	−3.1%***	(−6.45)	33	5
Consumer Confidence Index	10:00	1.4%***	(2.42)	12	24	1.2%***	(2.63)	13	25
Leading Indicators Index	10:00	2.3%***	(5.74)	6	31	2.3%***	(6.85)	4	33
Government Budget	14:00	2.7%***	(5.43)	9	28	2.6%***	(7.28)	5	32
Federal Funds Rate	14:15	1.5%***	(2.81)	10	26	1.3%***	(3.32)	9	27
Consumer Credit	15:00	1.3%***	(3.19)	10	26	0.9%***	(2.56)	11	27

report significant increase in IS. Housing Starts reports, which are used by analysts to help create estimates for other consumer-based indicators, is also significant. Another important macroeconomic variable is the Trade Balance. It has been documented that small open economies are affected by international economic developments, especially by large countries with which they have important relationships in international trade.[7] Therefore, it is not surprising if an open economy like Canada with a strong trade and capital market links with the United States is expected to be affected by developments in the U.S. economy.

Panel B of Table 4 reports the PT results. They are very similar to those of the IS results in Panel A. The correlation coefficient between the IS and PT measures is 0.978, which confirms our earlier finding. On average, macroeconomic announcements cause a significant 1.0% increase in PT, with a 1.1% increase contributed by the Canadian announcements and 0.9% increase by the U.S. announcements. Overall, price discovery shifts to the U.S. during macroeconomic news announcements. To further assess the robustness of our results, we conduct a regression analysis, controlling for possible exogenous variables as discussed in the next section.

5.1.3. Daily regression analysis

Jiang et al. (2011) suggest that liquidity shocks, such as changes in the bid–ask spread and market depth during macroeconomic news announcements have significant predictive power for changes in security prices. Moreover, Mizrach and

[7] Campbell and Lewis (1998) show that Australian fixed-income markets are significantly affected by U.S. macroeconomic news.

Table 5
Regression on daily Price Discovery.
Table 5 reports the estimates of Eq. (14). The dependent variable is the Ratio IS (PT) which is the daily log ratio of U.S. share of IS (PT) relative to Canada. *Time* denotes a linear time trend, *Ratio Trade* and *Ratio Spread* denote the log ratio of U.S. trades relative to Canada, and the log ratio of percentage spread in the U.S. relative to Canada, respectively. *All Announcements* denotes a dummy variable for days with macroeconomic news releases. *US Announcements* and *CAN Announcements* each represents a dummy variable for U.S. and Canadian macroeconomic news, respectively. Figures in parentheses are heteroscedasticity-consistent t-statistics controlled using clustered standard error. *** denotes significance at the 1% level.

	Panel A: Ratio IS		Panel B: Ratio PT	
	(1)	(2)	(1)	(2)
Constant	−1.30***	−1.30***	−1.19***	−1.19***
	(−3.19)	(−3.19)	(−3.31)	(−3.31)
Time	0.00084***	0.00084***	0.00083***	0.00083***
	(9.02)	(9.02)	(10.9)	(10.9)
Ratio Trade	0.75***	0.75***	0.33***	0.33***
	(5.4)	(5.4)	(3.16)	(3.16)
Ratio Spread	−1.10***	−1.10***	−1.03***	−1.03***
	(−3.07)	(−3.07)	(−3.1)	(−3.1)
All Announcements	0.036***		0.031***	
	(4.82)		(4.84)	
US Announcements		0.036***		0.031***
		(4.42)		(4.65)
CAN Announcements		0.035***		0.032***
		(4.35)		(4.03)
R sq (Adj)	0.491	0.491	0.447	0.447

Neely (2008) find that market liquidity contributes significantly to the level of IS and PT during announcement times. With these considerations, we construct a model using dummy variables as a proxy for announcement days to test for the impact of announcements, controlling for liquidity effect. In doing so, we first construct series using daily IS and PT, and estimate the following model:

$$ln\left(\frac{PD_t^{US}}{1-PD_t^{US}}\right) = c + \beta_1\left[\ln\left(\frac{N_t^{US}}{N_t^{US}+N_t^{CAN}}\right)\right] + \beta_2\left[\ln\left(\frac{S_t^{US}}{S_t^{US}+S_t^{CAN}}\right)\right] + \beta_3 Time + \beta_4 D_t + \varepsilon_t \quad (14)$$

where PD_t^{US} represents the daily U.S. IS or PT, N_t^{US} and N_t^{CAN} are the daily number of trades in the U.S. and Canada, S_t^{US} and S_t^{CAN} are the daily average percentage spreads in both markets, *Time* is a simple linear trend, and D_t is the announcement day dummy which takes on a value of 1 during an announcement day, or 0 during non-announcement day. We estimate the coefficients using firm fixed effects estimator with clustered standard errors.

Table 5 illustrates the linkage between microstructure variables and the price discovery estimates. For both the IS and PT, the announcement day dummy variable strongly explains the increase in price discovery. Even after separating the Canadian and U.S. announcements as shown in the second column of each panel, the result still holds strongly. This suggests that the U.S. market becomes more informative not only during days with Canadian macroeconomic news announcements, but also during days with U.S. news announcements. There also appears to be a strong time trend effect as captured by the *Time* variable. *Ratio Trade* is positive and highly significant, implying that an increase in relative number of trades in the U.S. increases the U.S. portion of price discovery. This is consistent with Engle and Lange (2001) who find that a large price adjustment is normally driven by trades. *Ratio Spread* is negative and also highly significant which suggests price premium in the U.S. (represented by the increase in relative spread in the U.S.) lowers the U.S. portion of price discovery. This is in line with Fleming et al. (1996) who indicate that informed traders will transact in the market with the lowest transaction costs in order to maximise profits generated from trading on their information. The $R^2(adj)$ from Eq. (14) range from 49.1% for the IS model to 44.7% for the PT model. We conclude that macroeconomic news announcements and standard liquidity measures strongly capture the daily fluctuations in price discovery between Canada and the U.S.

5.2. Intraday price discovery

We also test the impact of announcements using smaller event windows, particularly on periods surrounding news releases. Several studies show that prices adjust within minutes of the announcement (see Fleming and Remolona, 1999; Nowak et al., 2011; Scholtus et al., 2014). Such an immediate and short-lived effect would not be picked up in a daily estimation. We therefore investigate the news effect using a 20-minute time window (10 min pre and post) surrounding a specific announcement. We select this window to enable us to capture the impact of news which occur earlier than the officially scheduled time.[8] This may

[8] Scholtus et al. (2014) point out that although, on average, macroeconomic news arrivals are reasonably punctual, substantial differences can be found across the different announcements.

cause prices and therefore price discovery measures to adjust before the announcements and then continue to affect the news interpretation.

We focus on U.S. announcements (10 in total) which occur after the stock market opens at 9:30 AM in both markets. There are no Canadian announcements after the opening time. We first construct a price series by selecting the 20-minute data (1200 observations) surrounding the news release on a particular announcement day. Based on this series, the VECM model is estimated on a daily basis and the IS and PT computed.

Table 6 presents the absolute difference in price discovery during non-announcement and various announcement days. Panel A and B in Table 5 present the IS and PT over the different announcement days, respectively. On average, macroeconomic news announcements cause a 4.9% shift in IS and a 3.6% shift in PT. These numbers, as expected, are larger than those of the daily coefficients. Looking at the number of firms, the IS (PT) measure reports 35.7 (34.8) firms with significant shifts in price discovery. For the individual announcements, we find significant shifts in the IS and PT during all ten announcements. Fed Funds Rate announcement in particular, leads to a very large shift in both IS and PT.

As for the directional impact of announcements, the results are reported in Table 7. For the information share, Panel A shows that, on average, the announcements lead to a 2.4% increase in IS. For 7 out of 10 announcements, the information share shifts to the U.S. The magnitudes of the figures are higher than the figures for daily estimation as reported in Table 3. For example, Chicago PMI reports an increase in IS by 3.5% at the intraday level as compared to 2.0% at the daily level. New Home Sales announcement leads to an increase in IS by 2.7% as opposed to 2.0%, whilst Construction Spending leads to an increase in IS by 2.3% as opposed to −3.4%. These results suggest that the smaller event window allows us to pick up a stronger price formation process as well as a more precise reaction which may not be captured accurately in daily estimation. Another interesting finding is that U.S. IS increases by 11.6% during Fed Funds Rate announcements. This indicates a strong reaction from market players in the U.S. towards interest rates releases. As for the PT, the average increase is 1.4%, with only 5 out of 10 announcements showing a significant increase. The Fed Funds Rate shows a consistent and significant increase of 6.3%.

We re-estimate Eq. (14) at the intraday level on a 20-minute period window and report the results in Table 8. Similar to our previous finding, the Announcement time dummy is positive and significant at the 10% level for both the IS and PT models. This suggests that the impact of macroeconomic news announcements is not only observable at the daily, but also intraday level. This result further confirms our previous findings that the U.S. market becomes more informative during the release of macroeconomic news announcements. Time trends and liquidity shocks contribute significantly to the level of IS and PT during announcement times. An increase in relative trade in the U.S. increases the IS and PT whilst an increase in relative spread in the U.S. decreases them. The R^2 (adj) range from 27.3% for the IS model to 27.2% for the PT model. Overall, we can conclude that price discovery shifts to the U.S. during macroeconomic news announcements, and our findings are robust to model and time specifications.

6. Conclusion

In this paper, we examine the impact of macroeconomic news announcements on the price discovery of Canadian stocks listed in Canada and in the U.S. Using a sample of 38 Canadian stocks listed on the TSX that are also listed in the U.S. market with the NYSE as primary listing, we measure price discovery over the period January 2004 to January 2011. We assess the contribution of macroeconomic news by comparing the level of price discovery during days with and without announcements. We also assess when the news originates either from Canada or the U.S.

Table 6
Absolute change in Price Discovery surrounding news release (20-minute window).
Table 6 provides the change in IS and PT for 38 Canadian cross-listed stocks during announcement days. The IS and PT are computed on 20 min surrounding the announcement times; 10 min prior and 10 min after. The figures reported are the absolute percentage differences in 20 min IS and PT during announcement and non-announcement days $\left(\frac{|IS(PT)_{Announcement} - IS(PT)_{Non-Announcement}|}{IS(PT)_{Non-Announcement}}\right)$. The figures under "Total" denote the number of firms (out of 38 firms) showing significant shift in Price Discovery during announcement times at 5% significance level obtained using the bootstrap procedure. Figures in parentheses are the t-statistics. *** denotes significance at 1% level.

January 2004–January 2011		Panel A: Information Share (IS)			Panel B: Component Share (PT)		
Price Discovery	Time	Diff	t-stat	Total	Diff	t-stat	Total
All Announcements		4.9%***	(6.34)	35.7	3.6%***	(8.15)	34.8
Chicago PMI	9:45	4.3%***	(6.38)	35	3.6%***	(7.36)	36
US New Home Sales	10:00	4.0%***	(6.35)	36	3.1%***	(7.9)	37
US Factory Orders	10:00	3.4%***	(7.72)	35	2.5%***	(8.14)	36
US Business Inventories	10:00	4.0%***	(7.47)	35	3.0%***	(8.64)	35
US Construction Spending	10:00	5.2%***	(6.46)	37	3.3%***	(5.4)	34
US Consumer Confidence Index	10:00	4.7%***	(8.14)	36	3.1%***	(8.1)	36
US Leading Indicators Index	10:00	3.5%***	(9.7)	36	2.6%***	(8.78)	33
US Government Budget	14:00	4.6%***	(9.99)	36	3.4%***	(8.47)	32
Federal Funds Rate	14:15	11.8%***	(9.68)	37	7.3%***	(10.65)	35
US Consumer Credit	15:00	4.1%***	(6.76)	34	3.6%***	(7.84)	34

Table 7
Change in Price Discovery surrounding news release (20-minute window).
Table 7 provides the change in U.S. IS and PT for 38 Canadian cross-listed stocks during announcement days. The IS and PT are computed on 20 min surrounding the announcement times; 10 min prior and 10 min after. The figures reported are the percentage differences in 20 min IS and PT during announcement and non-announcement days $\left(\frac{IS(PT)_{Announcement}-IS(PT)_{Non-Announcement}}{IS(PT)_{Non-Announcement}}\right)$. The figures under "−" ("+") denote the number of firms (out of 38 firms) showing a decrease (increase) in U.S. Price Discovery during announcement times at 5% significance level obtained using the bootstrap procedure. Figures in parentheses are the t-statistics. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

		Panel A: Information Share (IS)				Panel B: Component Share (PT)			
US Price Discovery	Time	Diff	t-stat	−	+	Diff	t-stat	−	+
All Announcements		2.4%**	(2.18)	11.9	23.8	1.4%**	(2.2)	13.5	21.3
Chicago PMI	9:45	3.5%***	(4.45)	5	30	2.1%***	(3.05)	10	26
US New Home Sales	10:00	2.7%***	(3.37)	8	28	1.8%***	(3.22)	7	30
US Factory Orders	10:00	0.4%	(0.61)	15	20	−0.1%	(−0.17)	18	18
US Business Inventories	10:00	−0.4%	(−0.46)	21	14	−0.3%	(−0.42)	20	15
US Construction Spending	10:00	2.3%**	(2.11)	12	25	1.5%*	(1.89)	13	21
US Consumer Confidence Index	10:00	2.1%**	(2.35)	14	22	0.8%	(1.26)	18	18
US Leading Indicators Index	10:00	1.1%*	(1.75)	12	24	0.6%	(1.22)	17	16
US Government Budget	14:00	−1.0%	(−1.17)	22	14	−0.5%	(−0.68)	17	15
Federal Funds Rate	14:15	11.6%***	(9.12)	1	36	6.3%***	(6.78)	5	30
US Consumer Credit	15:00	1.8%**	(2.14)	9	25	1.2%*	(1.73)	10	24

Our analyses yield several important findings. First, we observe that price discovery shifts for most of the firms in our sample during news announcement days. Second, both Canadian and U.S. macroeconomic news announcements lead to price discovery shifts towards the U.S. as represented by significant increase in U.S. IS and PT. Third, the impact of news announcements remains strong even after controlling for time trends and liquidity shocks. These findings are further supported by intraday analyses of price discovery on periods surrounding news releases. On the whole, we find that the U.S. market sees an increase in price discovery relative to the Canadian market during announcement times, thus implying the difference in information processing capability between the two markets, particularly with regard to the processing of market-wide information.

Our results have several important implications. First, for financial markets, our findings suggest a decline in the importance of the Canadian market during macroeconomic news announcements time. The U.S. market seems to be better at processing information from macroeconomic news. Second, the fact that Canadian announcements lead to the same price discovery shift to the U.S. as the U.S. announcements indicates that Canadian market participants actually put less emphasis on domestic macroeconomic news releases than the U.S. market participants. Finally, the significant increase in the trading ratio and the decrease in the spread ratio of the U.S. markets relative to the Canadian markets suggest that the U.S. markets, as the larger and the more liquid exchange of the two, is the preferred destination for traders who seek liquidity and cheaper trading options.

Table 8
Regression on intraday Price Discovery.
Table 8 reports the estimates of Eq. (14). The dependent variable is the Ratio IS (PT) which is the daily log ratio of U.S. share of IS (PT) relative to Canada. The IS and PT are computed on 20 min surrounding the announcement times. *Time* denotes a linear time trend, *Ratio Trade* and *Ratio Spread* denote the log ratio of U.S. trades relative to Canada, and the log ratio of percentage spread in the U.S. relative to Canada, respectively. *All Announcements* denotes a dummy variable for days with macroeconomic news which are released after 9:30 AM. Figures in parentheses are heteroscedasticity-consistent t-statistics controlled using clustered standard error. *, and *** denote significance at the 10% and 1% levels, respectively.

	Panel A: Ratio IS	Panel B: Ratio PT
Constant	−2.04***	−1.71***
	(−16.37)	(−16)
Time	0.0037***	0.0037***
	(10.23)	(11.75)
Ratio Trade	0.32***	0.076***
	(7.92)	(2.42)
Ratio Spread	−1.66***	−1.57***
	(−30.33)	(−31.23)
All Announcements	0.079*	0.054*
	(1.83)	(1.77)
R sq (Adj)	0.273	0.272

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