Belief Dispersion and Order Submission Strategies in the Foreign Exchange Market

Ingrid Lo and Stephen Sapp[1]

September 23, 2010

[1]Ingrid Lo is from the Financial Markets Department, Bank of Canada, Ottawa, Canada, Email: ingridlo@bankofcanada.ca. Stephen Sapp is from the Richard Ivey School of Business, University of Western Ontario, London, Canada, Email: ssapp@ivey.uwo.ca.

Belief Dispersion and Order Submission Strategies in the Foreign Exchange Market

Abstract

This paper empirically examines how dispersions across investors beliefs influence traders order submission decisions in the foreign exchange market. Previous research has found that dispersion in traders beliefs regarding future macroeconomic announcements has a significant impact on both price dynamics and trading volume before the announcements in the foreign exchange and other financial markets. However, little is known about how this dispersion impacts traders choice in submitting different types of orders and thus to supply and demand liquidity either before or after such announcements. Since the types of orders submitted by traders at these times are the building blocks of the observed price and trading dynamics, it is important to understand how differences in investors' information sets before and after important macroeconomic announcements affect their order submission decisions. We find that (i) belief dispersion affects the size and aggressiveness of orders both before and after macroeconomic announcements, (ii) the magnitude of the impact of factors known to affect order choice depends on the level of belief dispersion, and (iii) the influence of information shocks (the revelation of unexpected information) on order choices depends on the level of belief dispersion.

Key Words: market microstructure, limit order book, belief dispersion, information flows.

I. Introduction

Existing research has confirmed that there are significant differences in economic agents expectations (for example, Frankel and Froot (1990), Mankiw, Reis and Wolfers (2003), Swanson (2006)) and that this heterogeneity in expectations has a significant impact on observed price dynamics and trading volume (e.g. Shalen (1993), Berger et al. (2008), Jongen et al. (2008), Yan and Xiong (2009)). To help us understand how the differences in traders information influences their trading behavior, market microstructure researchers have proposed various models of trading behavior which explicitly relate trading to various measures of public and private information (for surveys see OHara (1995) and Madhavan (2000)). Despite the evidence that differences in traders expectations influence prices, little empirical work has examined the process by which the heterogeneity in expectations (or belief dispersions) affects the traders' choice to supply and demand liquidity [1]. Since the choice of which types of orders traders submit plays an important role in understanding the dynamics in prices and volumes, this is an important question for researchers in both the areas of market microstructure and asset pricing. This question also has broader implications as the quantity of information being processed by traders and the number of financial markets using electronic (order driven) trading platforms both continue to increase.

In this paper we examine how the dispersion of investors' beliefs before macroeconomic announcements influences traders' order submission decisions in the foreign exchange market before and after significant macroeconomic announcements. Because of the importance of these announcements, surveys are regularly performed of the professional analysts before the forecasts to estimate the dispersion in their forecasts (i.e., the dispersion in their beliefs and market expectations) before the announcement as well as the magnitude of the surprise contained in the announcement (i.e., how significant was the difference between the expected and actual announcements?). We can therefore examine how changes in the type and level of information available to traders impacts their order submission decisions [2].

[1] Liquidity refers to the quantity of orders standing in the limit order book against which an incoming order can be executed. Supplying (demanding) liquidity therefore increases (decreases) the depth of orders standing in the limit order book.

[2] When talking about traders order submission decisions, we are concentrating on the two key characteristics of each order. The first is the type of order. Traders can either submit market orders which are executed immediately against the

Formally, the heterogeneity in investors expectations (belief dispersion) is captured by the second moment of professional analysts' forecasts preceding each macroeconomic announcement. Our measure of the information shock from the announcement is defined as the difference between the median investors forecast and the actual announcement. We can therefore estimate how traders order submission decisions depend on the heterogeneity in expectations regarding future economic conditions before the announcement and the magnitude of changes in the information used by investors afterwards. These are two of the most important factors in market microstructure models of order choice but they have been rarely tested empirically. We are therefore examining whether less consensus among market participants before an announcement leads to traders supplying (demanding) more or less liquidity? And how this dispersion and any associated changes in liquidity may influence traders reactions to new, unexpected information contained in the announcements? Despite the importance of these questions and the number of mechanisms which have been proposed to explain how this information will influence order submissions in the theoretical microstructure literature, there is little agreement in the literature and even less empirical insight into these questions.

Because information and uncertainty both play key roles in our analysis, it is important to clearly define what we mean by these terms. As noted in Llambros and Zarnowitz (1987), belief dispersion (or the heterogeneity across investors expectations) is related to, but conceptually different, from uncertainty: belief dispersion is the second moment of analysts forecasts but uncertainty is the second moment of the value of the underlying fundamentals, which is unobservable. Thus exactly what belief dispersion is capturing remains an open question. There are two potential interpretations for belief dispersion. First, belief dispersion may be capturing the differences in investors' expectations regarding an upcoming announcement. In this case, once the announcement is made, the uncertainty should be resolved and belief dispersion should no longer have an effect on order submission strategies. Second, belief dispersion may be correlated with market participants uncertainty regarding fundamental

best quote standing in the order book or limit orders which are executed at a specific price. Since limit orders designate a price for execution, they are subject to execution risk if no order is submitted on the other side of the market at that price or better. Market orders are, however, subject to price risk as it is unknown the price at which the market order will execute but it is not to subject to execution risk. Consequently, market orders are considered more aggressive as they are submitted to ensure rapid order execution with the potential risk that it may be at a less advantageous price. The second is the size of the order.

information on the value of the asset. As Kim and Verrechia (1994) point out, if this is the case, the announcement itself may not remove the heterogeneity in market participants understanding of the fundamentals. The latter is a commonly adopted assumption in the microstructure literature as it provides a motivation for trade both before and after announcements (e.g. Green (2004) and Pasquariello and Vega (2007)). Recent literature also suggests that heterogeneous expectations affect the side on which traders want to submit orders (e.g. Sarkar and Schwartz (2009)). Our study offers a unique opportunity to explore these issues.

The order submission data we examine in this paper comes from the Reuters electronic limit order market in the Canadian dollar - US dollar currency pair during 2005. For our announcements, we focus on the order submission information around major regularly scheduled macroeconomic announcements in Canada and the United States. We use data from the foreign exchange market for several reasons. Beyond the obvious advantages that foreign exchange trading data is based on a very large and liquid market, there are also other advantages for our study. For example, the foreign exchange market has continuous trading by a large number of sophisticated traders. Not having specific opening and closing hours limits concerns related to liquidity changes during the day related to the opening and closing of markets. This is especially relevant when trying to study the impact of news announcements which are frequently scheduled before local financial markets open because of the significant information contained in the announcements. In a related fashion, the foreign exchange market is also especially useful because we can easily identify the announcements of relevance and measure investors' expectations regarding these announcements and subsequently determine how the uncertainty regarding the announcement was resolved.

In our analysis, we model traders order submission choices by formally recognizing that the order submission decision involves both the choice of order type (e.g., market or limit order) and order size. We capture this by employing a simultaneous equation framework including standard variables found to influence traders order submission decisions in previous research. We divide our analysis into three parts. In the first stage of analysis, we examine the order submission decision across the periods with and without announcements. We find that orders tends to be of smaller size and traders are more sensitive to changes in the state of the limit order book on announcement days. Traders submit smaller orders and tends to submit less aggressive orders than non-announcement days when price risk increase and more aggressive orders than non-announcement days when execution risk increases.

In the second part of the analysis, we examine how belief dispersion affect order submission strategies before and after announcement. Before announcement, order aggressiveness decreases with dispersion i.e. traders tends to submit limit orders when belief dispersion is large. As the magnitude of belief dispersion increases, we find that the information content of independent variables decreases and thus their impact on traders order submissions decreases. This suggests that traders are extracting information from other sources or not trusting the information from orders standing in the limit order book or standard market characteristics at times of increased uncertainty.

After announcement, we examine whether belief dispersion is capturing only uncertainty about the outcome of announcement or if it is capturing a more broad measure of uncertainty, by examining whether belief dispersion still has an influence on order submission strategies after the announcement. We find that it does still influence traders order submissions after the announcement, but its role changes over time. In the 15 minute interval immediately following the announcement, order aggressiveness continues to decrease with dispersion. This suggests that traders react to dispersion before and immediately after the announcement by continuing to submit limit orders to protect themselves from price uncertainty after the announcement. In the second 15-minute interval after the announcement, order aggressiveness starts to increase but the effect is still attenuated when the dispersion before the announcement is wide. This result suggests that traders switch to more aggressive orders less quickly if the belief dispersion before the announcement had been wide.

In the last part of the analysis, we examine how the magnitude of information shocks (i.e., the surprise component of the announcement) affects order submission decisions and whether traders reaction to information shocks conditions on belief dispersion. There is very little literature in this area. Most of the recent studies focus on the impact of information shocks from announcement days on price discovery (for example, Pasquariello and Vega (2007)) or how quickly new information is incorporated into prices (e.g. Green (2004)). We consider how both belief dispersion and information shocks influence traders actual order submission decisions. Consistent with our expectations, we find that traders tend to submit less aggressive orders as the magnitude of the information shock increases. By separating orders into those during high and low dispersion, we find that there is only a minor role played by information shocks in traders order submission decisions in periods when belief dispersion was low. This suggests that traders tend to avoid the price risk associated with market orders following large information shocks but the size of the relationship between order submission strategies and information shocks depends on the overall information environment as captured by the belief dispersion.

The rest of the paper develops with the next section discussing literature in this area and how we extend it. Section three presents our data. The presentation and motivation for our models as well as the discussions of the results follow in the fourth section. The final section concludes.

II. Literature Review

Our paper complements the growing literature at the intersection of market microstructure and asset pricing. Under the Efficient Markets Hypothesis which forms the heart of much of modern asset pricing, all price relevant information will be quickly and accurately incorporated into prices. The market microstructure literature examines the channels through which this information is incorporated into prices. The theoretical microstructure literature suggests that market participants are asymmetrically informed and this asymmetry of beliefs regarding the future value of an asset influences how traders submit orders and thus how prices are ultimately set in the market (for surveys see O'Hara (1995), and Parlour and Seppi (2008)).

The most important factor influencing traders order submission decisions is information. In one of the first microstructure models explaining the role of trade in setting prices, the Kyle (1985) model, equilibrium prices are derived under the assumption that traders are asymmetrically informed. The asymmetry of information and liquidity of the market are two of the key factors in this model and form the core of much of the subsequent literature and our empirical tests.

Moving beyond the Kyle model, other papers have more carefully examined the factors influencing liquidity such as order type (e.g., whether traders submit market or limit orders). Starting with the seminal works of Demsetz (1968), Cohen et al. (1981) and Glosten (1994), a core assumption in this research has been that informed traders submit market orders to take advantage of their information before it is fully reflected in the market. As Copeland and Galai (1983) point out, the commitment to trade at a set price associated with a limit order provides liquidity to the market but puts these orders at an informational disadvantage as they can be picked off by traders arriving later with more up-to-date information. Subsequent studies endogenize informed traders' order choice decisions and consider the role of market characteristics such as market volatility, the state of the limit order book and the rate of order arrival (for a recent survey see Parlour and Seppi (2008)). To simplify these models, the size of orders is generally assumed to be a constant (e.g., one unit). As a result, there are few studies explaining the role of size in the order submission decision. Though not a focus of the papers, Goettler, Parlour and Rajan (2009) and Rosu (2010) mention the role quantity can play in the order submission decision - traders may choose to submit more aggressive orders if they are smaller in size.

Because of difficulties in measuring many of the features included in the theoretical models, the empirical literature predominantly examines how changing market conditions affect the order submission decision. The empirically observable changes in market conditions considered are indirect proxies for the level of information and uncertainty in the market [3]. For example, Biais, Hillion and Spatt (1995) consider spread as a measure of uncertainty and find that wider spreads lead to more limit than market orders. Ahn, Bae and Chan (2001) and Ranaldo (2004) find that the order submission decision depends on volatility and market depth. Handa, Schwartz and Tiwari (2003) extend this to examine the importance of the relative depth on the two-sides of market. Tkatch and Kandel (2006) find that traders' order submission decisions are based on how long they expect it to take for an order to be executed. Cao, Hansch and Wang (2004) find that the quantity of orders standing behind the best price influences price discovery process.

Our paper builds directly on these results but differs in two important aspects. First, we empirically examine the effect of direct measures of the heterogeneity of expectations on the order submission decision. Specifically, we examine the impact of the degree of information heterogeneity between mar-

[3] A notable exception is the experimental study of Bloomfield, OHara and Saar (2005) in which they are able to artificially generate specific information environments and examine their influence on order submission choices.

ket participants on the order submissions of foreign exchange traders before major macroeconomic announcements as well as the influence of information shocks after the announcements (and their potential interactions). This allows us to more precisely measure the influence of changes in the markets perception of current and future fundamental values on asset prices and trading strategies than in past studies. Second, we use a simultaneous equations framework to capture the joint nature of the order aggressiveness and order size decision in order submissions. Previous studies have focused solely on the type of order (order aggressiveness) decision neglecting the potential trade-offs between aggressiveness and size.

We focus on the periods surrounding major macroeconomic announcements because regularly scheduled macroeconomic announcements represent one of the major sources of information in the foreign exchange market. Theoretically, Harris and Raviv (1993) and Kim and Verrechia (1994) propose that a greater dispersion of beliefs leads to higher trading volume. Previous studies such as Mankiw, Ries and Wolfers (2004) and Swanson (2006) document significant belief dispersions among traders before macroeconomic announcements and that the degree of dispersion varies across macroeconomic announcements. Examining the effect of belief dispersion, studies have documented that the degree of heterogeneity of expectations affects the dynamics of asset prices and trading volume (e.g. Shalen (1993), Berger et al. (2008), Jongen et al. (2008), Yan and Xiong (2009)). Studies such as Green (2004) and Pasquariello and Vega (2007) use the dispersion in beliefs before announcements as a proxy for the dispersion in private beliefs among traders in the Treasury market. They found that the degree of belief dispersion significantly affects how trading incorporates new information into the market price. Sarkar and Schwartz (2009) suggests that the heterogeneity of expectations affects the side of trades as well. We extend these studies by examining whether and how belief dispersion affects traders order choice decisions in a limit order market. Similar to Green (2004), we focus on the one hour window around these announcements.

In addition to belief dispersion before the announcements, we also consider the effect of information surprises (i.e. the effect of differences between the actual announcement and the expected announcement). Thus our paper is also related to studies such as Evans and Lyons (2008), Osler et al. (2007), Rime et al. (2008) and Tham (2007). These studies find empirical evidence that order flow (the net volume of buy and sell transactions) conveys more private information subsequent to announcements. Kim and Verrechia (1994 and 1997) show that the release of public information can lead to the endogenous creation of private information. Consequently, we also examine the role of information shocks on the order submission decision. Our empirical models examine the role of information shocks and belief dispersion with other factors which are known to influence traders order submission decisions.

Because very few studies directly examine the effect of changes in the information environment on order submission strategies, our study provides useful new insights into this important area. Two exceptions are the empirical study of Carlson and Lo (2006) and the experimental study of Bloomfield, OHara and Saar (2005). Carlson and Lo (2006) examine changes in traders order submission strategies around a single unanticipated macroeconomic announcement. They find significant changes in the order submission strategies before and after the announcement. Bloomfield, OHara and Saar (2005) examine the order submission decisions of informed and uninformed traders in an experimental setting to document how changes in the information environment impact the types of orders trader submit. We extend these studies by examining changes in traders order submission decisions around a series of regularly scheduled macroeconomic announcements. The use of scheduled announcements allows us to quantify the differences in market participants beliefs before the announcement to fully explore the effect of differences in the heterogeneity of expectations on traders order submission strategies. We can also study the impact of differences in the magnitude of the information shocks on order submission decisions after the event. Thus our study is able to more clearly examine the effects of changes in market conditions on the order submission decision before and after these announcements. By using a larger number of real-world events compared to previous studies, we can more easily generalize our findings.

III. Data

We utilize two datasets in the paper. The first data set contains the data on the electronic order submissions of the majority of traders in the Canadian dollar - U.S. dollar currency pair. The second data set consists of the forecasts provided by analysts in advance of the most important macroeconomic announcements as well as the results from the actual announcements in Canada and the U.S.. Below we discuss each data set in more detail.

A. Foreign Exchange Market Data

The first data set contains all of the orders submitted to Reuters, one of the worlds largest electronic foreign exchange broker systems, for the Canadian dollar-U.S. dollar currency pair over the period from January 1st, 2005 to December 31st, 2005. The system is an electronic order book to which foreign exchange dealers can submit market and limit orders of any size US $1 million and greater [4]. Dealers using the system observe the five most recent transactions as well as the most recent best quoted bid and ask prices and the corresponding depth on the bid and ask side of the market. In our data set, we not only have this information but we also have information on every order submitted to the market (not just those standing in the limit order book at the best bid and ask prices). The data we have on each order includes the: order type, quoted price for limit orders, order size, time the order was submitted and when the order was either executed or cancelled. Consequently, we have both the information that is publicly available to all traders as well as measures related to private information.

Using order submission data from the foreign exchange market has several advantages over similar equity data. For example, the electronic platform operates 24-hours a day, 7-days a week with no specific opening and closing hours. This allows our analysis to cover the periods both before and after all of our macroeconomic announcements without having to worry about the effects of special market clearing mechanisms around these times (e.g., at the opening or closing of markets as documented in Hamao and Hasbrouck (1995) and Davies (2003)). Further, the electronic platform is a purely order-driven market so there is no need to worry about the potential role of players such as the market maker whose role is to provide liquidity and price stability which may therefore impact observed market behavior. Finally, for the foreign exchange market there are a large number of significant information announcements for which the timing is known in advance and therefore analysts' provide forecasts. This allows us to cleanly estimate the belief dispersion before the announcement as well as the level

[4]Traders may also cancel outstanding limit orders which have not yet been executed.

of the surprise contained in the announcement. Thus, our data set allows us to clearly investigate how traders order submission decisions influence the supply and demand for an asset (the Canadian dollar US dollar) around significant information announcements.

The dataset also has a distinct advantage over many of the commonly used data sets for the foreign exchange market. It is one of the few data sets available with a long period of complete tick-by-tick information on the limit order book in the inter-dealer foreign exchange market. Other studies such as Evans and Lyons (2002a and 2002b), Osler, Mende and Menkhoff (2007) and Bjonnes, Osler and Rimes (2008) use similar but more limited information (e.g., from a single dealer or for completed transactions but not for the complete order book). Our study therefore provides a valuable complement to these others. The complete data set consists of 1,358,614 quotes for the Canadian dollar-U.S. dollar over the sample period, but we focus on a subset of these quotes as we focus on the order submission activities in the one-hour window around the announcements.

B. Announcement Data

The second dataset we use allows us to characterize the information environment traders are experiencing. We have all of the major regularly scheduled macroeconomic announcements in both the U.S. and Canada in 2005. This data set allows us to study the evolution of the information environment in the foreign exchange market. To be consistent with previous research, we use the announcements found to have the largest impact in these studies. The full list of announcements we consider can be found in Table 1.

The data we use includes measures obtained from surveys performed by Bloomberg in which they ask market participants what they are expecting in the upcoming macroeconomic announcement. We measure market belief dispersion as the standard deviation of the individual forecasts from the market participants survey as in Green (2004) and Pasquariello and Vega (2007). The belief dispersion of announcement k to be released at time t is therefore given by:

$$dis_t^k = \sqrt{\frac{\sum_{j=1}^{J}(forecast_{j,t}^k - \overline{forecast_t^k})^2/\hat{\sigma}^{dis,k}}{J}}$$

where j is the j-th analyst forecast for announcement k to be released at time t, and $\hat{\sigma}^{dis,k}$ is the standard deviation of $(forecast_{j,t}^{k} - \overline{forecast_{t}^{k}})^2, t = 1, 2, \cdots, T$.

The measure for the surprise component of the actual announcement is defined as:

$$SUR_t^k = \frac{A_t^k - E_t^k}{\sigma^{\hat{SUR},k}}$$

where A_t^k is the level of the actual announcement k at time t, E_t^k is the median forecast from the J-analysts for the announcement k on day t, and $\sigma^{\hat{SUR},k}$ is the standard deviation of $(A_t^k - E_t^k), t = 1, 2, \cdots, T$.

In Table 1, we can see that there is a significant variation in the level of belief dispersion and surprises across events. This ensures that our analysis should include a wide variety of information environments to allow us to provide general insights into the role played by differences in traders expectations and uncertainty on their order submission decisions.

C. Descriptive Statistics

To limit the impact of intraday seasonalities on our results, we focus our analysis on order submission activities in the one-hour window around our set of macroeconomic announcements. The announcements occur at either 7:00 EST, 8:30 EST or 10:00 EST depending on the announcement. The statistics in Table 2 describe the state of the order book during these time periods. The data includes all of the days in our sample and this data is then subdivided to include only days with major announcements before and after the announcements. Looking at the depth at the best prices, we find that the depth is lowest before the announcements and highest after the announcements. Assuming that traders are more hesitant to trade before an announcement and are more eager to trade after the resolution of uncertainty following an announcement, this result is as one may have expected. It is interesting to note that the overall depth in the order book (the depth at both the best and behind the best prices) is larger on announcement days. Given that our measure of the depth at prices behind the best price is not observable by traders, the statistics suggest that traders hide their positions as information unfolds, especially before the announcements. For our other measures of market conditions, we find that the average spreads are widest and trading volumes are highest around announcements with the spreads being wider before and volumes after the announcements. These results suggest that there are differences between the announcement and non-announcement days and there are also differences before and after the announcements.

IV. Empirical Model and Results

In this section, we present the simultaneous equations models we use to study the relationship between traders information, market conditions and traders order submission choices. We first estimate this model to compare the trading behavior between announcement and non-announcement days. Since we find differences between announcement and non-announcement days, we focus our analysis on announcement days to better understand the sources of these differences. Within our set of announcement days, we compare the trading behavior before and after our announcements.

A. Framework

When submitting an order in a limit order market, traders have to make two key decisions: the aggressiveness and the size of the order. Order aggressiveness is determined by the execution priority of the order. In this sense, market orders are the most aggressive - they are executed immediately. Limit orders at prices at the best or better than the best price standing in the market get executed next and are therefore next in order aggressiveness. The limit orders submitted at prices further behind the best price have correspondingly lower execution priorities and may not even be executed. Consequently, we classify order aggressiveness as highest for market orders followed by limit orders at the best price and limit orders submitted at prices behind the best price. Order size is another key dimension of the order submission decision. Though it gets less attention, recent studies such as Goettler, Parlour and Rajan (2005 and 2009) and Rosu (2010)) find that there are strategic trade-offs with respect to traders decisions on order aggressiveness and quantity.

To completely model the order submission decision, we set up a simultaneous equations model to capture the joint order aggressiveness and quantity decisions made by traders (similar to Lo and

Sapp (2010)). For the order aggressiveness, we use an ordered probit model to capture the discrete nature of order aggressiveness. More specifically, we create a vector of the discrete choices of order aggressiveness at time t, I_t, which depends on the latent order aggressiveness variable, I_t^*, which is assumed to be continuous. The values range from 4 for the most aggressive orders (market orders) to 1 for the least aggressive orders (limit orders that were submitted at prices behind the best price). The latent order aggressiveness is related to the choice of order type as follows:

$$
\begin{aligned}
I_t &= 4 \text{ if } -\infty < I_t^* \leq \mu_1 \text{ (market order)} \\
& \quad 3 \text{ if } \mu_1 < I_t^* \leq \mu_2 \text{ (limit orders improving the best quote)} \\
& \quad 2 \text{ if } \mu_2 < I_t^* \leq \mu_3 \text{ (limit orders at the best quote)} \\
& \quad 1 \text{ if } \mu_4 < I_t^* \leq \infty \text{ (limit orders behind the best quote)}
\end{aligned}
$$

To model order size, we use a censored regression framework. A censored regression is employed because there is a minimum order size of US\$1 million in the Reuters electronic brokerage system used in the foreign exchange market. This means that our model may have orders that would ideally have been less than US\$1 million but had to be submitted at US \$1 million. Therefore the observed quantity at time t, qn_t, depends on the latent quantity, qn_t^*, such that

$$
\begin{aligned}
qn_t &= 1 \text{ if } qn_t^* \leq 1 \\
&= qn_t^* \text{ if } qn_t^* > 1
\end{aligned}
$$

The basic framework that we examine is the following simultaneous equations system:

$$
\begin{aligned}
I_t^* &= \beta_{qn} qn^* + \beta_x x_t + \varepsilon_t \\
qn_t^* &= a + b_I I^* + b_x x_t + e_t
\end{aligned} \tag{1}
$$

The vector x_t contain our set of independent variables defined below found to influence traders order submission decisions with previous studies. We use two-stage least square in estimating the model. In the first stage of regression, we include two sets of instruments in addition to x_t to aid in the identification. Specifically, in the qn_t^* equation, we use number of orders submitted behind the best quotes on the same side of the market during the past 5-minute interval,z_t^I, as instrument. In the I^* equation, the quantity submitted behind the best quotes on the same side of the market during the past 5-minute interval, z_t^{qn}, is used as instrument. They are valid instruments for identification in our model for two main reasons. First, since order submission activities behind the best quotes are not observable to market participants, these measures should not be correlated with the error term, theoretically speaking. Furthermore, these variables are significantly correlated with endogenous explanatory variables. Thus our instruments should lead to consistent estimation.

We estimate our models of traders order submission strategies in the half-hour interval before the announcement and in the half-hour interval after the announcements. However, we exclude observations in the two minute intervals immediately before and after the announcements to allow for potential errors (such as recording errors) in the announcement time.

B. Independent Variables

The variables which we include in our models, x_t, were chosen because of their documented impact on order submission strategies in previous research. We list and define these variables below.

$Spread = p_0^a - p_0^b$ is the difference between the best ask price, p_0^a, and the best bid price, p_0^b, standing in the market at the end of each interval. An increasing spread is generally through an increase in market uncertainty and an increase in the asymmetry of information across market participants (e.g., Foucault, Moinas and Theissen (2007)). Both market uncertainty and an increase in asymmetric information increase the price risk for market orders and therefore increase the likelihood of traders submitting less aggressive orders (e.g., Foucault (1999) and Ahn, Bae and Chan (2001)). Thus we expect that dealers would submit fewer market orders as the spread increases. Similarly, we expect a decrease in the quantity for orders submitted as the spread increases because dealers will put less at risk with each order.

$Volatility = \sum_{i=1}^{15}(log(p_{i+1}^{mid}) - log(p_i^{mid}))^2$ is the realized volatility of returns in the previous 15-minute period. This is estimated as the volatility of the mid-point of the best bid and ask prices, $log(p_{i+1}^{mid})$, standing in the market at the end of each minute during the past 15 minutes. As suggested by Foucault (1999) and Foucault, Kadan and Kandel (2005), among others, if increasing volatility is a signal of an increase in uncertainty regarding the future value of the asset, we should see an increase in the number of limit orders posted as volatility increases (i.e., more orders are submitted at less aggressive prices). On the other hand, Cohen et al. (1981) point out that as price uncertainty increases risk-averse dealers place a premium on ensuring the execution of their trades. As a consequence, their model suggests we should see an increase in market orders (more aggressive orders) as volatility increases. This leaves the role of volatility on order aggressiveness an empirical question and therefore an important factor to control for. With respect to the quantity decision, previous studies suggest that liquidity is inversely related to volatility (e.g., Ahn, Bae and Chan (2001), Bae, Jang and Park (2003), Ranaldo (2004) and Foucault, Moinas and Theissen (2007)), so we expect to see a decrease in the size of the orders submitted as the level of volatility increases.

$Dpth^{bst}_{same}$ is the accumulated depth at the best quote on the same side of the market as the submitted order. For example, if an ask order is submitted, $Dpth^{bst}_{same}$ is the depth accumulated at the best price on the ask side of the market, p^a_0. An increase in the depth on the same side of the market would indicate an increase in the competition for order execution resulting in dealers wanting to submit smaller, more aggressive orders to try to increase their likelihood of timely execution (e.g. Parlour (1998), Biais, Hillion and Spatt (1995) and Hall and Hautsch (2006 and 2007)).

$Dpth^{bhd}_{same}$ is the cumulative depth at prices behind the best quote on the same side of the market. For example, if an ask order is submitted, $Dpth^{bhd}_{same}$ is the depth accumulated at prices behind (worse than) the best ask price, p^a_0. This part of the book is not observable to market participants. Thus if traders react to changes in behind best depth, it indicates a presence of private information. One possible source is clients order flow base. Recent studies such as Bloomfield, OHara and Saar (2005), Kaniel and Liu (2006) and Goettler, Parlour and Rajan (2005 and 2009) suggest that informed traders optimally submit limit orders so the depth behind the best price represents bets backed up by real money on the future direction of price changes. As a result, we could expect traders viewing this increase in depth will submit smaller, less aggressive orders when the behind best depth increases.

$Dpth^{bst}_{opp}$ is the accumulated depth at the best quote on the opposite side of the market. An increase in the depth available at the best price on the opposite side of the market implies market orders are less costly because they are less likely to have to walk up/down the order book to be executed. Consequently more depth on the opposite side of the market should encourage market orders.

$Dpth_{opp}^{bhd}$ is the accumulated depth behind the best quote on the opposite side of the market. The arguments with respect to the influence of this information on order submission strategies are similar to those for the depth behind the best price.

$PrImpt$ is the price impact of order flow. It is estimated using the following regression based on data from the 15 minute interval before an order is submitted

$$(log(p_{i+1}^{mid}) - log(p_i^{mid})) = \alpha + PrImptOF_i + \varepsilon_i \quad (2)$$

where i is the time interval, $i = 1, 2, ..., 15$, and order flow is defined as OF = number of buy trades − number of sell trades. Building on the work of Evans and Lyons (2002a), a growing literature has documented a strong relationship between order flow and information flows. The basic argument is that an increased willingness for traders to buy (or sell) as reflected in the order flow measure, indicates an asymmetry of information in the market. Consequently, an increase in the price impact of order flow may signal an asymmetry of information which would provide traders with an incentive to submit smaller limit orders at these times.

C. Empirical Estimation: Announcement days vs Non-announcement days

We start by testing for differences in dealers order submission strategies on announcement versus non-announcement days. We use the same one hour intervals for both announcement and non-announcement days to control for the potential influence of intraday seasonalities. In each case the analysis is divided into two parts: the half-hour interval before and the half-hour after the announcement. Specifically, we estimate the following model:

$$\begin{aligned} I_t^* &= D^{news} + \beta_{qn} qn^* + \beta_{qn}^{news} qn^* D^{news} + \beta_x x_t + \beta_x^{news} x_t D^{news} + \varepsilon_t \\ qn_t^* &= a + D^{news} + b_I I^* + b_I^{news} I^* D^{news} + b_x x_t + b_x^{news} x_t D^{news} + e_t \end{aligned} \quad (3)$$

The variable D^{news} is a dummy variable with a value of 1 if the day includes a news announcement and 0 otherwise. The variables β_x^{news} and b_x^{news} measure the marginal impact of announcements on order submission strategies.

The results from the estimation of Equation (3) are presented in Table 3. The first set of columns reports the estimates and p-values in the period before the announcements and the second set of columns contains the values after the announcements. Although the results are similar in the time periods before and after the announcements, there are significant differences between the announcement and non-announcement days. The estimated coefficients on the D^{news} dummy variable are statistically significant after the announcements in the aggressiveness and quantity equations. This suggests that after the announcement there are less aggressive, larger orders than usual. These findings are consistent with our belief that the resolution of uncertainty around announcements influences order submission choices and further they indicate a role for both aggressiveness and size in order submission strategies.

To investigate the trade-off between aggressiveness and quantity, we consider the role of each in our models and how it changes on announcement days. We find that order aggressiveness increases as size increases, but the effect is smaller on announcement days. That is, larger orders tends to be associated with less aggressive orders on announcement days. On days with announcements the relationship is no longer statistically significant. These results confirm that order aggressiveness (order type) and quantity are jointly determined, and the relationship changes around announcement times when uncertainty is increasing.

Next we examine the differences in the roles played by our independent variables in the order submission decision on announcement versus non-announcement days. The interaction of the news dummy variable and each of our independent variables allows us to determine how the impact of these factors may be influenced by the different information environments on announcement versus non-announcement days. In virtually every case the D^{news} interaction accentuates the influence of the control variables on the order aggressiveness and quantity choices.

The price impact of order flow, $PrImpt$, is related to less aggressive yet larger orders. Traders observe an increase in the impact of executed orders on prices to signal an increase in price risk, which may come from a thin market. So they submit less aggressive limit orders to avoid price risk. With the interaction of D^{news} with $PrImpt$ we find that the interaction accentuates this relationship – it is significantly negative. Consequently, the uncertainty regarding announcements highlights any already existing concerns about price risk.

An increase in the depth at the best quote on the same side of the market, $Dpth_{same}^{bst}$ is associated with more aggressive, larger orders on days with announcements. This suggests that market participants are less willing to wait and join the already existing queue around announcements. The coefficient on the best depth on the opposite side of the market indicates that an increase in depth at the best price on the opposite side of the market is associated with less aggressive, larger orders (more so on days with announcements). This is not consistent with our hypothesis that increasing opposite side depth at the best price being associated with market orders. One possible reason is that deepening depth on the opposite side of the market indicates more traders ”vote” on existing price. Thus traders more confidently join existing quote on the same side of the market. The interaction between D^{news} and the depth behind the best quote is significantly negative when the depth is on the same side of the market but positive on the opposite side of the market. This suggests that market participants take increases in the behind best depth as a signal of future price movements around announcements. For example, upon seeing an increasing behind best depth on the ask side of market, traders on the bid side of market may interpret that as a signal of future increase in price and so submit a more aggressive bid order before the price change is realized.

The estimated coefficient on the interaction of D^{news} with our indirect measures of market uncertainty (spread and volatility) are in the hypothesized directions. Specifically, as spread increases we find that order aggressiveness decreases but only significantly so after announcements. For order size, we find that orders are smaller as the spread increases before announcement. The result suggests that traders tend to avoid price risk before announcement by posting smaller orders and posting limit orders after announcement.

Increases in price uncertainty signalled by an increase in volatility are related to an increase in order aggressiveness and smaller orders. The added uncertainty of a major announcement accentuates this effect for order aggressiveness with traders submitting even more aggressive orders but, surprisingly, larger orders after the announcements. The results confirm with Cohen et al.(1981) that risk averse traders place a premium on execution of orders when uncertainty increases.

Overall, these results suggest that there are significant differences in how traders interpret information and react to market conditions around announcements. In the next section we examine the role of differences in belief dispersions before the announcements and the news component from the revelation of information after the announcement on traders order submission strategies.

D. Empirical Estimation: Role of Belief Dispersion Before Announcements

Focusing on just the days with announcements, we start by exploring how the dispersion of beliefs before the announcements affects traders order submission strategies. Since there are occasionally days with multiple announcements, we use only days with a single announcement in our analysis to ensure that we more cleanly capture the information environment on that day. Belief dispersion at time t is captured using the belief dispersions, DIS, for the upcoming announcements measured as discussed earlier. To capture the influence of belief dispersion on its own or through the interaction with other factors, we estimate the following system of simultaneous equations:

$$\begin{aligned} I_t^* &= \alpha_0 DIS + \beta_{qn} qn^* + \beta_{qn}^{DIS} qn^* DIS + \beta_x x_t + \beta_x^{DIS} x_t DIS + \varepsilon_t \\ qn_t^* &= a + a_0 DIS_t + b_I I^* + b_I^{DIS} I^* DIS + b_x x_t + b_x^{DIS} x_t DIS + e_t \end{aligned} \quad (4)$$

Table 4 presents the results from the estimation of Equation (4). The first three columns contain the results for the order aggressiveness equation, I^*, and the second set of three columns are for the quantity equation, qn^*.

Looking at the first column of the order aggressiveness equation, we find that increased dispersion is related to the submission of less aggressive orders. There is a positive correlation between quantity and order aggressiveness in all specifications at 1% significance level but it reverses as dispersion increases with $qn^* \times DIS$ significantly negative. But overall more aggressive orders tends to be of larger size. For the quantity equations, we find that orders are significantly larger as order aggressiveness increases. Overall the results suggest that traders respond to the uncertainty before the announcement, but the impact on size is less consistent.

We next examine whether other independent variables affect the order submission decision and how they interact with the level of belief dispersion. The estimate of the price impact of orders, $PrImpt$, provides insight into how price risk influences order submission decisions under different levels of belief dispersion. An increase in $PrImpt$ indicates that the same size order will have a larger price impact at these times and traders protect themselves by submitting less aggressive orders at these times, but it is really a result of increasing levels of belief dispersion. For quantity, we find an increase in quantity as the price impact increases, but this is also mainly when belief dispersion is increasing. The results suggest that the major influence of our price impact measure is when belief dispersion is high.

The impact of depth on order aggressiveness tends to be weakened and order size drops when belief dispersion widens. For example, when uncertainty on upcoming announcement increases, market participants tends to place more (less) aggressive orders when the behind best depth on the opposite (same) side of market deepens than the control group. This suggest that traders tend less to infer price direction from behind best depth, which is their private information. These results suggest that market participants tend to infer less information from the depth in the limit order book as belief dispersion increases.

Considering the spread, we find that the spread coefficient is negative and significant at the 1% level in the order aggressiveness equation in Model (3) so a wider spread is associated with less aggressive orders. This is consistent with Foucault (1999). The impact of spread is, however, sensitive to the level of dispersion – its interaction with DIS is significantly positive in the order aggressiveness equation. The impact of spread is only significant for order size in the model without DIS. These results suggest that orders become more aggressive when spread widens as belief dispersion increases. Assuming that an increasing spread is indicative of decreasing market liquidity or an increase in asymmetric information in the market, traders become more sensitive to execution risk when the level of belief dispersion is wide.

Considering the role of volatility, we find that increasing volatility is related to a significant increase in the aggressiveness of orders but does not significantly impact order size. This suggests that traders become more concerned about execution risk as volatility increases. The effect of volatility on aggressiveness tends to attenuate when belief dispersion is wide. The coefficient of $Vlty \times DIS$ is significantly negative. Thus when uncertainty about upcoming announcement is wide, traders tend to be more reluctant to submit aggressive orders even when price movement is volatile.

E. Empirical Estimation: Role of Belief Dispersion After Announcements

The final stage of our analysis examines the changes in order submission strategies after the revelation of information from the announcement. The analysis focuses on two issues. First, we examine whether belief dispersion continues to play a role in order submission decisions after the announcements. Second, we examine whether the order submission decision is affected by the interaction between belief dispersion and the magnitude of information shocks.

To examine the first question regarding whether belief dispersion still influences the order submission decision after the announcement, we estimate the following system of equations in each of the two 15-minute horizons after the announcement:

$$\begin{aligned} I_t^* &= \alpha_0 DIS_t + \beta_{qn} qn_t^* + \beta_{qn}^{DIS} qn_t^* DIS_t + \beta_x x_t + \beta_x^{DIS} x_t DIS_t + \varepsilon_t \\ qn_t^* &= a + a_0 DIS_t + b_I I_t^* + b_I^{DIS} I_t^* DIS_t + b_x x_t + b_x^{DIS} x_t DIS_t + e_t \end{aligned} \quad (5)$$

The analysis is performed separately on the period from 3 minutes until 15 minutes immediately after the announcement and the subsequent 15-minute interval. This allows us to investigate how belief dispersion affects order submission strategies immediately after the announcement as well as after the market has had some time to digest the information. If our measure of belief dispersion reflects only the uncertainty regarding the information contained in the announcement, we should not see an impact by dispersion on order submissions after the announcement, especially in the second 15-minute interval. Studies such as Andersen et al. (2003) suggest that most of the information from an announcement is incorporated into prices (and thus into trading behavior) within the first fifteen minutes. Alternatively, belief dispersion may be an indicator of uncertainty regarding overall market fundamentals which can remain after the announcement.

Our results in Table 5 demonstrate that belief dispersion continues to significantly affect order submission strategies after announcements. In both the first and second 15 minute interval after announcement, the term DIS is significantly negative. This suggests that traders react to belief dispersion (or allow it to influence the order submission choices) before the announcement and they continue to submit limit orders to protect themselves from price uncertainty after the announcement. However, the interaction term of quantity with belief dispersion, $qn \times DIS$ is significantly positive. This suggests that larger order size tends to be more aggressive when belief dispersion is higher before announcement. The result suggest that traders are more confident to submit market orders after release of announcement.

The results with the rest of the independent variables and the relative levels of significance are similar to the case before the announcement for the first 15-minute interval after the announcement. The impact of independent variables tend to attenuate when dispersion before announcement is wide. Thus the effect of our independent variables still depend on belief dispersion immediately after the announcement. However, the dependence on the level of belief dispersion changes in the second 15-minute interval after the announcements. Dispersion before announcement still weakens the effect of price impact and best depth on the opposite side of market on order aggressiveness. But the impact is not significant any more for the rest of independent variables. Similar results hold for the order size equation. With the exception of the interaction terms of depth on the opposite side of the market, dispersion does not have an impact on order size in the second 15-minute interval after announcement

Next, we examine whether and how the level of belief dispersion interacts with the magnitude of the information shocks from the announcements. Table 6 characterizes how both belief dispersion and information shocks affect order submission. Panel A highlights the role of just information shock, measured by the absolute standardized announcement surprise, whereas the potential interactions of both information shock and belief dispersion is presented in Panel B. We divide the orders into terciles based on the absolute value of the size of the surprise. Panel A shows that there are more and larger orders submitted after the largest surprises. These results suggest possible changes in traders order submissions after surprises.

In Table 6B, we examine if the traders reaction to the information shock is influenced by the level of dispersion in analysts expectations before the announcement. We find that as the dispersion before the announcement increases, there are more orders of all types for the same level of surprise. This increase is even stronger when the surprise is higher. For the quantity of the orders, we find that the quantities are larger as dispersion increases for all order aggressiveness levels. These results indicate a clear role for both dispersion and surprise in how traders make their order submission decisions.

To formally examine how order submission decisions depend on the interaction of belief dispersion and information shocks, we divide the sample into two sub-sample based on median dispersion and we examine how order submission decision depends on the size of information shocks measured by $|SUR|$. More specifically, we estimate the following equations using the two samples

$$
\begin{aligned}
I_t^* &= \alpha_0|SUR|_t + \beta_{qn} qn_t^* + \beta_{qn}^{SUR} qn_t^* |SUR|_t + \beta_x x_t + \beta_x^{SUR} x_t |SUR|_t + \varepsilon_t \\
qn_t^* &= a + a_0|SUR|_t + b_I I_t^* + b_I^{SUR} I_t^* |SUR|_t + b_x x_t + b_x^{SUR} x_t |SUR|_t + e_t
\end{aligned} \tag{6}
$$

Table 7 shows the results of estimating Equation (6). The size of absolute surprise significantly affect order aggressiveness and order size when belief dispersion is low in the first 15-minute interval. The effect on order aggressiveness remains significant in the second 15-minute interval. On the other hand, absolute surprise does not affect order submission decision when belief dispersion is high. The result suggests that when before announcement uncertainty is low but information shock turns out to be large, traders tends to submit less aggressive orders.

Considering the effect of endogenous variables, we find that a larger information shock tends to lower the impact of order size when belief dispersion is wide in the first 15-minute interval. The opposite holds true in the second 15-minute interval when belief dispersion is low. Larger order size tends to be more aggressive when belief dispersion is low. This suggests market participants trade off order aggressiveness and order size differently. They become more confident to submit larger and more aggressive orders as information shock from announcement is incorporated into prices, especially when belief dispersion is low.

When belief dispersion is wide before announcement, traders tend to care less about price risk by posting aggressive orders when information shock is large. The coefficient of $PrImp \times |SUR|$ under high belief dispersion is significantly positive in the first 3 to 15 interval after announcement. The effect is not significant in the second 15-minute interval. Thus traders seems to care more about certain execution when announcement outcome is far from expectation. On the other hand, when belief dispersion is low, especially in the second 15 minute interval, traders tends to post more aggressive orders with $PrImp$ being significantly positive at 10% interval. This suggests that traders care less about price risk after incorporation of information into market price. The effect on aggressiveness is offset though when announcement surprise is large, which seems to suggests a slower incorporation of information after large surprise.

High belief dispersion in general intensifies the effect of depth variables on order aggressiveness especially during immediately after announcement. For example, the interaction terms of best depth and behind best depth on the same side of market with $|SUR|$ significantly accentuate the impact of the control group. However the effect is mostly significant during the first 15-minute interval. The results confirm with Andersen et al. (2003) and Green (2004) that the effect of announcement surprise is fully incorporated into prices within the first 15 minutes of announcement.

Spread significantly affects order size but its impact on order aggressiveness is significant at 10% only when belief dispersion is wide. This is especially so when spread widens under large information shock. Order size is significantly smaller with larger information shock. This suggests that traders tends to post more aggressive but smaller orders in response to wider spread when information shock is large.

The effect of volatility concentrates on the second 15 minute interval. Similar to order book depth, information shock tends to attenuate the effect of volatility on order aggressiveness and order size. Market participants tend to post less aggressive and larger orders with more volatile prices when information shock is large. Thus when information shock is large, traders tend to be more reluctant to submit aggressive orders even when price movement is volatile

V. Conclusion

In this paper we examine the role of belief dispersion in traders' order submission decisions. Going back to the foundational work on the role of information in asset prices and market efficiency, we know that information plays a significant role in investors decisions. Traders decide when to buy and sell their assets based on their current information set and their expectations about the future value of the asset. More recent work argues that in efficient markets, all price relevant information is quickly and accurately incorporated into prices. Consequently, market microstructure theorists have developed models which provide mechanisms through which this may happen but few studies have empirically examined how this occurs in practice.

In this study we use a novel data set including detailed information on the market's expectations regarding macroeconomic announcements (belief dispersion before the announcement) and information on how the actual announcement differed from the expected announcement to determine the level of surprise after the announcement. These two pieces of information allow us to more completely characterize the information environment surrounding these announcements than previous studies. Studying the relationship between these two important types of information before and after the announcements we are able to examine the impact of this information on traders' order submission decisions.

Combining this information with traders order submission decisions in the liquid foreign exchange market, we are able to empirically characterize the role of this information on the order submission process. In the first stage of the analysis we confirm that there are, in fact, differences in traders order submission decisions in days with major macroeconomic announcements relative to the days with no announcements. These results confirm many of the hypotheses regarding what factors influence traders order submission decisions (i.e., our set of independent variables). We also find that many of these relationships are actually stronger on days with announcements than without.

Focusing on the days with announcements, we investigate how belief dispersion before announcements influences traders order submission strategies. We find that increasing belief dispersion reduces the influence of many factors on traders order submission decision. Traders therefore are impacted by the level of uncertainty before the announcement. The role of the information in the limit order book and other market characteristics is lower at these times. When we consider the role of the level of the surprise in the announcement, we find that the surprise plays a larger role in the order submission decision when the level of belief dispersion had been high before the announcement. However, the role of surprises is relatively minor in general.

Our results provide interesting insights into the role of information in traders order aggressiveness and size decisions. Depending on the source of the uncertainty and the ability to extract private information from the limit order book, we find traders are willing to change the aggressiveness of the orders they submit to ensure execution and this may also be reflected in the order size. Consequently, our analysis demonstrates how price and execution risk influence order submissions in general, but the impact of the different factors measuring market conditions and the state of the limit order book change depending on the level of uncertainty in the market.

References

Ahn, H., K. Bae and K. Chan, 2001, Limit Orders, Depth, and Volatility: Evidence from the Stock Exchange of Hong Kong, Journal of Finance 56, 769-790.

Anderson, Torben, Tim Bollerslev, Francis Diebold, Francis and Clara Vega, 2003, Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange. American Economic Review 93(1), pages 38-62.

Bae K.-H., H. Jang and K. Park, 2003, Traders Choice between Limit and Market Orders: Evidence from the NYSE Stocks. Journal of Financial Markets 6, pages 517538.

Berger, David W., Alain P. Chaboud, Sergey V. Chernenko, Edward Howorka, and Jonathan H. Wright, 2008, Order flow and exchange rate dynamics in Electronic Brokerage System data. Journal of International Economics 75(1), pages 93109.

Biais, B., P. Hillion, and C. Spatt, 1995, An Empirical Analysis of the Limit Order Book and the Order flow in the Paris Bourse, Journal of Finance 50, pages 1655-1689.

Bjnnes, Geir H., Carol L. Osler, and Dagfinn Rime, 2008, Asymmetric information in the foreign exchange market. Working Paper , Norges Bank, 2008.

Bloomfield, R., M. OHara and G. Saar, 2005, The Make or Take Decision in an Electronic Market: Evidence on the Evolution of Liquidity, Journal of Financial Economics 75, pages 165199.

Carlson, John A. and Melody Lo, 2006, One minute in the life of the DM/US$: Public news in an electronic market. Journal of International Money and Finance 25(7), pages 10901102.

Cao, C., O. Hansch and X. Wang, 2004, The Informational Content of an Open Limit Order Book,

Cohen, K., S. Maier, R. Schwartz, and D. Whitcomb, 1981, Transaction Costs, Order Placement Strategy, and Existence of the Bid-Ask Spread, Journal of Political Economy 89, 287305.

Copeland, T. and D. Galai, 1983, Information Effects on the Bid-Ask Spreads, Journal of Finance 38, 14571469.

Davies, R.J., 2003, The Toronto Stock Exchange preopening session, Journal of Financial Markets 6(4), 491-516.

Demsetz, H., 1968, The Cost of Transacting, Quarterly Journal of Economics 82, 3353.

Evans, Martin D. D., 2002, FX trading and exchange rate dynamics. Journal of Finance, 57(6):24052447.

Evans, Martin and Richard K. Lyons, 2002a, Order flow and Exchange Rate Dynamics, Journal of Political Economy 110(1), pages 170-180.

Evans, Martin D. D. and Richard K. Lyons, 2002b, Time-varying liquidity in foreign exchange. Journal of Monetary Economics, 49(5):10251051.

Evans, Martin D. D. and Richard K. Lyons, 2008, How is macro news transmitted to exchange rates? Journal of Financial Economics, 88(1):2650.

Foucault, T., 1999, Order flow Composition and Trading Costs in a Dynamic Limit Order Market, Journal of Financial Markets 2, pages 99134.

Foucault, T., O. Kadan and E. Kandel, 2005, The Limit Order Book as a Market for Liquidity, Review of Financial Studies 18, pages 11711217.

Foucault, T., S. Moinas, E. Theissen, 2007, Does Anonymity Matter in Electronic Limit Orders Markets?, Review of Financial Studies 20, pages 1707-1747.

Frankel, J., and K. A. Froot, 1990, Chartists, Fundamentalists, and Trading in the Foreign Exchange Market. American Economic Review 80, no. 2, pages 181-185

Glosten, L., 1994, Is the Electronic Open Limit Order Book Inevitable? Journal of Finance 49, pages 1127-1161.

Goettler, R., C. Parlour and U. Rajan, 2005, Equilibrium in a Dynamic Limit Order Market, Journal of Finance 60, pages 21492192.

Goettler, R., C. Parlour and U. Rajan, 2009, Informed Traders and Limit Order Markets," Journal of Financial Economics 93(1): 67-87.

Green C., 2004, Economic news and the impact of trading on bond prices. Journal of Finance 59: 12011234.

Hall A. D. and Hautsch N., 2006, Order Aggressiveness and Order Book Dynamics. Empirical Economics 30, pages 9731005.

Hall A. D. and Hautsch N., 2007, Modelling the Buy and Sell Intensity in a Limit Order Book. Market. Journal of Financial Markets 10(3), 249-286.

Hamao,Y, and J. Hasbrouck, 1995, "Securities trading in the absence of dealers: Trades and quotes on the Tokyo Stock Exchange", Review of Financial Studies, Vol. 8 pp.849 - 878.

Handa, P., R. Schwartz, and A. Tiwari, 2003, Quote Setting and Price Formation in an Order Driven Market, Journal of Financial Markets 6, 461489.

Harris, L., 1998, Optimal Dynamic Order Submission Strategies in Some Stylized Trading Problems, Financial Markets, Institutions & Instruments 7, 176.

Harris, M., and A. Raviv, 1993, Differences of Opinion Make a Horse Race. Review of Financial Studies, 6 , 473506.

Jongen, Ron, Verschoor, Willem F. C. and Wolff, Christian C. P., 2008,Foreign Exchange Rate Expectations: Survey and Synthesis. Journal of Economic Surveys, Vol. 22, No. 1, pp. 140-165.

Kaniel, R., and H. Liu, 2006, What Orders do Informed Traders Used, Journal of Business 79, 18671913.

Kim, O., and Verrecchia, R., 1994, Market liquidity and volume around earnings announcements. Journal of Accounting and Economics 17, 4167.

Kim, O., and Verrecchia, R., 1997, Pre-announcement and event period private Information, Journal of Accounting and Economics 24, pp.395 - 419.

Llambros, Louis and Victor Zarnowitz 1987, Consensus and Uncertainty in Economic Prediction, Journal of Political Economy 95 (3), pp. 591-62.

Lo, Ingrid and Stephen G. Sapp, 2006, The submission of limit orders or market orders: The role of timing and information in the Reuters D2000-2 system. Journal of International Money and Finance, 27(7), pages 10561073.

Lo, Ingrid and Stephen Sapp ,2009. Order submission: The choice between limit and market orders. Journal of International Financial Markets, Institutions and Money forthcoming.

Madhavan, Ananth, 2000, Market Microstructure: A Survey. Journal of Financial Markets 3, 205-258.

Mankiw, N. Gregory, Ricardo Ries, and Justin Wolfers , 2003, Disagreement About Inflation Expectations, in NBER Macroeconomics Annual 2003

Osler, Carol, Alexander Mende and Lukas Menkhoff, 2007, Price discovery in currency markets. Working paper, Brandeis

OHara, M., 1995, Market Microstructure Theory, Blackwell.

Parlour, C. and D. Seppi, 2008, Limit Order Markets: A Survey, in Handbook of Financial Intermediation and Banking, eds. Thakor, A. and A.W. de Boot, North-Holland Press, pages 61-96.

Pasquariello, Paolo and Clara Vega, 2007, Informed and Strategic Order Flow in the Bond Markets Rev. Financ. Stud. 20: 1975-2019.

Ranaldo, A., 2004, Order Aggressiveness in Limit Order Book Markets, Journal of Financial Markets 7, 5374

Rime, D., Sarno, L. and Sojli, 2010, Exchange Rate Forecasting, Order Flow and Macroeconomic Information, Journal of International Economics, 80, pages 72-88.

Rosu, I. , 2009, A Dynamic Model of the Limit Order Book, Review of Financial Studies 22, 46014641.

Rosu, I., 2010, Liquidity and Information in Order Driven Markets, Working Paper

Sarkar, A. and Swartz, R., 2009, Market Sidedness: Insights into Motives for Trade Initiation, Journal of Finance, 64(1), pages 375-423

Seppi, D., 1997, Liquidity Provision with Limit Orders and a Strategic Specialist, Review of Financial Studies 10, 103150.

Shalen, C., 1993, Volume, volatility, and the dispersion of beliefs. Review of Financial Studies 6: 405-434.

Tham, W., 2007, Information Asymmetry and Macroeconomic News in Foreign Exchange Market. Working Paper

Tkatch, I., and E. Kandel, 2006, Demand for the Immediacy of Execution: Time is Money, working paper Georgia State University.

Yan, Hongjun and Xiong, Wei, 2009, Heterogeneous Expectations and Bond Markets. Review of Financial Studies, Forthcoming.

Zarnowitz, V. and L.A. Llambros, 1987, Consensus and uncertainty in economic prediction, Journal of Political Economy 95, 591-621

Table 1. Macro Announcement

This table reports the list of macroeconomic news announcements we consider in our analysis. N denotes the total number of announcements during the period from 1/1/2005 to 12/31/2005. Time denotes the time, in Eastern Standard Time (EST), of the announcement. Mean(Dis) denotes the sample mean dispersion between the analysts forecasts obtained from Bloomberg surveys, Mean(Sur) denotes the sample mean of the standardized surprise, $N_{dis>mean(dis)+std(dis)}$ denotes the number of dispersion measures that were one standard deviation or more above the mean, $N_{abs(sur)>1}$ denotes the number of announcements where the surprise contained in the announcement was more than 1 standard deviation away from the mean.

Event	time	N	Mean(Dis)	Mean(Sur)	$N_{dis>mean(dis)+std(dis)}$	$N_{abs(sur)>1}$
CPI (Canada)	7:00:00	12	1.38	-0.33	0	1
Employment Rate (Canada)	7:00:00	12	1.78	0.14	0	1
GDP (Canada)	8:30:00	12	1.93	-0.18	0	4
Retail Sales (Canada)	8:30:00	12	1.42	0.10	1	5
Trade balance (Canada)	8:30:00	12	2.59	0.23	1	2
Consumer Confidence	10:00:00	12	3.61	0.16	3	3
CPI	8:30:00	12	2.63	0.11	2	4
Durable Goods	8:30:00	12	2.87	0.20	2	5
GDP	8:30:00	4	0.95	-0.30	0	0
Initial Unemployment Claims	8:30:00	52	1.29	0.03	6	14
ISM index	10:00:00	12	3.79	0.26	1	4
New Home Sales	10:00:00	12	3.17	0.37	5	5
Change in Nonfarm Payroll	8:30:00	12	2.97	-0.14	2	4
PPI	8:30:00	12	2.03	0.09	1	3
Retail Sales	8:30:00	12	2.19	-0.01	2	4

Table 2. Summary Statistics

This table reports the summary statistics of our set of variables characterizing the Canadian dollar-US dollar currency market around major macroeconomic announcements. The order submission data was obtained from Reuters and covers the period from 1/1/2005 to 12/31/2005. For our announcement days, the aggregated trading volume ($ billions) and return volatility (%) are based on the mid point of the best bid-ask quotes in the half hour interval before the announcements and in the half hour interval right after announcements. The relative spread ($\times 10,000$), depth at the best bid and ask ($ millions), and depth in the entire order book ($ millions) are averaged over 5-minute intervals in the corresponding interval. On days without any major announcements, we calculated the same measures in the one-hour window centered at 7:00 a.m., 8:30 a.m. and 10:00 a.m., the times at which our announcements take place.

	mean	median	std	max	min	skew	kurt
Non-Announcement							
Depth at best quotes	6.20	5.92	1.09	9.31	4.35	0.74	3.05
Overall Depth	31.96	25.43	18.16	140.66	11.65	2.82	15.17
Spread $\times$ 100	0.0570	0.0554	0.0180	0.1098	0.0302	1.16	4.26
Trading Volume	161.19	133.00	125.56	675.00	8.00	1.27	4.58
Volatility	1.65	1.49	0.82	4.92	0.43	1.31	4.92
Before Announcement							
Depth at best quotes	6.03	5.86	1.61	11.33	2.97	0.83	4.04
Overall Depth	33.13	28.58	17.71	117.37	7.24	1.63	6.85
Spread $\times$ 100	0.0607	0.0544	0.0232	0.1461	0.0302	1.31	4.52
Trading Volume	172.18	151.00	109.64	628.00	21.00	1.40	5.50
Volatility	1.64	1.42	0.87	5.45	0.44	1.55	5.93
After Announcement							
Depth at best quotes	6.50	6.39	1.51	11.81	3.72	0.65	3.52
Overall Depth	35.31	31.01	18.28	112.38	9.82	1.46	5.53
Spread $\times$ 100	0.0583	0.0523	0.0208	0.1406	0.0299	1.65	6.01
Trading Volume	302.82	267.50	171.82	994.00	52.00	1.11	4.46
Volatility	1.89	1.72	0.95	7.18	0.49	1.51	6.49

Table 3. Order Submission around Announcement Days versus Non-announcement Days

This table reports the results from the estimation of Equation (2) for order submission strategies. We examine the effects of our set of independent variables and how they change on days with and without announcements. The first column and the second column present results during the half hour interval before the announcements and the corresponding time period on days without announcements. The third and fourth columns present results during the half hour interval after the announcement versus the same time on non-announcement days. * indicates significance at the 10% level, ** indicates significance at the 5% level and *** indicates significance at 1% level.

	Before		After	
	I^*	qn^*	I^*	qn^*
	I^*	qn^*	I^*	qn^*
α		-0.223***		-0.205***
D^{news}	0.007	-0.057	-0.011*	0.157*
$\hat{qn}^*$	0.144***		0.179***	
$\hat{I}^*$		0.536***		0.509***
$\hat{qn}^* \times D^{news}$	-0.027***		-0.051***	
$\hat{I}^* \times D^{news}$		0.107		0.048
$PriceImpact$	-0.034***	0.081***	-0.005	0.021
$PriceImpact \times D^{news}$	-0.029***	0.091***	-0.020***	0.056***
$Dpth^{bst}_{same}$	0.018***	0.091***	0.021***	0.050***
$Dpth^{bst}_{same} \times D^{news}$	0.024***	0.055***	0.023***	0.044***
$Dpth^{bhd}_{same}$	-0.102***	0.154***	-0.101***	0.146***
$Dpth^{bhd}_{same} \times D^{news}$	-0.081***	0.151***	-0.087***	0.093***
$Dpth^{bst}_{opp}$	-0.050***	0.765***	-0.064***	0.656***
$Dpth^{bst}_{opp} \times D^{news}$	-0.027***	0.665***	-0.017***	0.573***
$Dpth^{bhd}_{opp}$	0.028***	0.116***	0.031***	0.130***
$Dpth^{bhd}_{opp} \times D^{news}$	0.043***	0.080***	0.061***	0.128***
$Spread$	-0.006	-0.072***	-0.013***	-0.064***
$Spread \times D^{news}$	-0.002	-0.082***	-0.010***	-0.002
$Volatility$	0.013***	-0.033*	0.012***	-0.007
$Volatility \times D^{news}$	0.022***	0.027	0.007*	0.062***
Likelihood	-135537	-199100	-187297	-281598

Table 4. Effect of Belief Dispersion on Order Submission Strategies: before Announcement

This table reports the estimation results of Equation (4). This model examines the relationship between order submission strategies, our set of independent variables and belief dispersion. The first model only considers the effect of belief dispersion on order submissions. The subsequent models consider the role of our set of independent variables and belief dispersion. * indicates significance at the 10% level, ** indicates significance at the 5% level and *** indicates significance at 1% level.

	I^* Equation			qn^* Equation		
	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
α				-0.244	-0.356***	-0.067
DIS	-0.013***		-0.018***	-0.07		-0.038
$\hat{qn}^*$	0.149***	0.107***	0.155***			
$\hat{qn}^* \times DIS$	-0.018***		-0.018***			
$\hat{I}^*$				0.322	0.594***	0.229
$\hat{I}^* \times DIS$				0.132**		0.099*
$PrImp$		-0.038***	0.001		0.100***	-0.033
$PrImp \times DIS$			-0.020***			0.065***
$Dpth^{bst}_{same}$		0.021***	0.009		0.093***	0.079
$Dpth^{bst}_{same} \times DIS$			0.007			0.005
$Dpth^{bhd}_{same}$		-0.077***	-0.218***		0.144***	0.353***
$Dpth^{bhd}_{same} \times DIS$			0.052***			-0.088***
$Dpth^{bst}_{opp}$		-0.015**	-0.064***		0.657***	0.789***
$Dpth^{bst}_{opp} \times DIS$			0.020***			-0.056**
$Dpth^{bhd}_{opp}$		0.047***	0.095***		0.091***	0.135*
$Dpth^{bhd}_{opp} \times DIS$			-0.014**			-0.022
$Spread$		0	-0.037***		-0.077***	0.009
$Spread \times DIS$			0.014**			-0.033
$Vlty$		0.030***	0.088***		0.022	-0.12
$Vlty \times DIS$			-0.017***			0.041
Likelihood	-39136	-38962	-38860	-59006	-58607	-58594

Table 5. Effect of Private Belief Dispersion on Order Submission Strategies after Announcement

This table reports the estimation results of Equations (4). These models relate order submission strategies to the effects of belief dispersion (defined as earlier) but in the periods following the announcement. The first four columns report results of different specifications during the interval between 2 and 15 minutes immediately following the announcement. The last four columns report results of different specifications during the period 15-minute to 30-minutes after the announcement. * indicates significance at the 10% level, ** indicates significance at the 5% level and *** indicates significance at 1% level.

	$(3,15]min$						$(15,30]min$					
	I^* eqn			qn^* eqn			I^* eqn			qn^* eqn		
α				0.293	0.193	0.467*				-0.317	-0.350***	-0.306
DIS	-0.040***		-0.041***	0.000		-0.066	-0.036***		-0.041***	0.016		0.044
$\hat{qn}^*$	0.076***	0.118***	0.081***				0.069***	0.126***	0.077***			
$\hat{qn}^* \times DIS$	0.015***		0.016***				0.023***		0.020***			
$\hat{I}^*$				0.038	0.378***	0.026				0.453***	0.755***	0.511***
$\hat{I}^* \times DIS$				0.116		0.115				0.113*		0.067
$PrImp$		-0.008	0.027		0.025	-0.138*		-0.034***	0.025		0.104***	0.007
$PrImp \times DIS$			-0.016**			0.071**			-0.025***			0.042
$Dpth^{bst}_{same}$		0.035***	-0.029		0.064**	0.304***		0.018***	-0.003		0.052*	0.066
$Dpth^{bst}_{same} \times DIS$			0.025***			-0.091***			0.008			-0.009
$Dpth^{bhd}_{same}$		-0.080***	-0.125***		0.104***	-0.122		-0.093***	-0.100***		0.097***	0.166**
$Dpth^{bhd}_{same} \times DIS$			0.017***			0.078***			0.004			-0.041
$Dpth^{bst}_{opp}$		-0.023***	0.022		0.684***	1.220***		-0.016**	0.032*		0.507***	0.820***
$Dpth^{bst}_{opp} \times DIS$			-0.015**			-0.210***			-0.018***			-0.125***
$Dpth^{bhd}_{opp}$		0.050***	0.163***		0.099***	-0.08		0.074***	0.092***		0.143***	0.261***
$Dpth^{bhd}_{opp} \times DIS$			-0.041***			0.068***			-0.006			-0.052*
$Spread$		-0.003	-0.021		-0.026	-0.115*		-0.023***	-0.018		0.039	-0.061
$Spread \times DIS$			0.007			0.031			-0.003			0.04
$Vlty$		0.004	-0.040*		0.077***	0.220**		0.017*	0.066**		0.044	-0.047
$Vlty \times DIS$			0.016*			-0.053			-0.017*			0.026
Likelihood	-33674	-33476	-33397	-50048	-49735	-49683	-32539	-32329	-32294	-49630	-49371	-49346

Table 6. Information Shocks, Belief Dispersion and Order Submission Activities

In Panel A, we sort the absolute announcement surprise $|sur|$ into 3 equal groups (terciles) and report the proportion of orders submitted and the average order size in each group. In Panel B, we compare the proportion and size of orders based on our measures of surprise and dispersion. For each surprise tercile we consider high and low belief dispersions. We first sort the absolute announcement surprise $|sur|$ into terciles. Within each tercile, we sort the belief dispersion into high and low groups relative to the median dispersion and report the proportion of orders submitted and the average order size in each group. The belief dispersion is based on the surveys of analysts by Bloomberg and the surprise is the actual announcement compared to the median forecast provided by analysts. The order submission data is for the Canadian dollar-US dollar currency pair on the Reuters electronic brokerage system from 1/1/2005 to 12/31/2005.

		Proportion of Orders				Average Order Size			
$\|sur\|$	dis	mkt	lmt1	lmt2	lmt3	mkt	lmt1	lmt2	lmt3
Panel A: Information Shocks and Order Submission Activities									
T1		0.074	0.146	0.032	0.036	2.48	2.20	1.80	2.51
T2		0.081	0.159	0.038	0.048	2.45	2.17	1.82	2.48
T3		0.095	0.190	0.048	0.052	2.60	2.31	1.90	2.61
Panel B: Information Shocks, Belief Dispersion and Order Submission Activities									
T1	1.01	0.033	0.065	0.014	0.016	2.36	2.16	1.77	2.30
	2.78	0.041	0.081	0.018	0.021	2.58	2.24	1.83	2.71
T2	1.25	0.028	0.059	0.013	0.015	2.27	2.05	1.65	2.16
	2.58	0.053	0.100	0.025	0.033	2.64	2.29	1.99	2.78
T3	1.40	0.043	0.087	0.020	0.025	2.51	2.28	1.97	2.68
	3.68	0.052	0.103	0.027	0.027	2.69	2.34	1.83	2.55

Table 7. Effect of Information Shocks and Private Belief Dispersion on Order Submission Strategies

This table reports the estimation results of Equations (5). These models relate order submission strategies to the effects of information shocks and belief dispersion (defined as earlier). The first four columns report results between the 3- to 15-minute interval right after announcement. The last four columns report results during the 15-minute to 30-minute interval after announcement. In each period, the models are estimated for high and low dispersion relative to the median dispersion. * indicates significance at the 10% level, ** indicates significance at the 5% level and *** indicates significance at 1% level.

	$(3,15]min$				$(15,30]min$			
	I^* eqn		qn^* eqn		I^* eqn		qn^* eqn	
	$HighDIS$	$LowDIS$	$HighDIS$	$LowDIS$	$HighDIS$	$LowDIS$	$HighDIS$	$LowDIS$
α			0.577*	-0.151			-0.303	-0.02
$\|SUR\|$	-0.023	-0.095***	-0.101	0.789**	-0.012	-0.136***	0.140	-0.014
$\hat{qn}^*$	0.139***	0.122***			0.144***	0.085***		
$\hat{qn}^* \times \|SUR\|$	-0.020***	0.014			-0.002	0.044***		
$\hat{I}^*$			-0.022	0.529***			0.734***	0.439*
$\hat{I}^* \times \|SUR\|$			0.260	-0.509*			-0.071	0.126
$PrImp$	-0.029*	0.001	0.139**	-0.055	-0.076***	0.043*	0.093	-0.106
$PrImp \times \|SUR\|$	0.012*	-0.040	-0.048	0.157	0.017	-0.063*	0.034	0.297**
$Dpth^{bst}_{same}$	0.026***	0.045**	0.072*	0.189**	0.000	0.024	0.105*	0.084
$Dpth^{bst}_{same} \times \|SUR\|$	0.038**	-0.040	-0.132**	0.038	0.028*	-0.010	-0.048	-0.125
$Dpth^{bhd}_{same}$	-0.056***	-0.121***	0.148***	0.122	-0.097***	-0.079***	-0.117	-0.023
$Dpth^{bhd}_{same} \times \|SUR\|$	-0.029**	0.035	-0.026	-0.354**	0.012	-0.017	0.279***	0.000
$Dpth^{bst}_{opp}$	-0.027**	-0.091***	0.349***	1.117***	-0.031**	0.010	0.505***	1.394***
$Dpth^{bst}_{opp} \times \|SUR\|$	0.029	0.096	0.466	-0.150	0.013	-0.010	-0.159***	-0.659***
$Dpth^{bhd}_{opp}$	-0.004	0.122***	0.190***	0.062	0.106***	0.135***	0.049	0.079
$Dpth^{bhd}_{opp} \times \|SUR\|$	0.070***	0.019	-0.057	-0.138	-0.066*	-0.032	0.117	-0.033
$Spread$	-0.011	-0.030	0.106**	0.034	-0.010	0.032	0.057	-0.161
$Spread \times \|SUR\|$	0.032*	0.018	-0.230***	-0.399***	-0.036	-0.066	0.054	-0.014
$Vlty$	0.006	-0.026	0.048	0.066	0.041**	0.008	-0.072	-0.067
$Vlty \times \|SUR\|$	0.008	0.053	0.053	-0.289	-0.098***	0.065	0.358**	-0.072
Likelihood	-17074	-16253	-26472	-23080	-15913	-16294	-25723	-23463