Order aggressiveness of institutional and individual investors

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This paper investigates the determinants of the order aggressiveness of institutional and individual investors on the Australian Stock Exchange. Utilizing a proprietary data set that identifies institutional and individual order submissions, we document that the institutional and individual investors become more aggressive when the same-side (opposite-side) market depth increases (decreases). When the spread widens, both individual and institutional investors tend to become less aggressive. Institutional investors are more aggressive in the opening hour of the trading day, while individual investors are less aggressive initially and increase their order aggressiveness during the rest of the trading day.

1. Introduction

This study investigates the factors determining the order aggressiveness of institutional and individual investors on the Australian Stock Exchange (ASX). Utilizing a proprietary data set from the ASX that identifies institutional and individual order submissions, we examine the factors affecting the order aggressiveness of institutional and individual investors. We are particularly interested in the main differences between institutional and individual order placement strategies.

We classify orders into different levels of aggressiveness by comparing the order price and order size to the price and market depth of the best quote (Biais et al., 1995). The investigation of investors' order aggressiveness is important for various reasons. First, according to Harris (1998), understanding the factors that affect order submission strategies (order aggressiveness) allows traders to optimize their trading strategies, which, in turn, will result in lower transaction costs and higher portfolio returns.

Second, for the market as a whole, analyzing traders' order submission strategies will help determine the market conditions under which traders are willing to supply (submission of limit orders) and demand (placement of market orders) liquidity. This will improve our understanding of the price formation process (Ellul et al., 2007) and the fundamental issues of how order driven markets function (Bloomfield et al., 2005). The important role of limit order market as a form of security markets organization [1]provides further motivation for the research on order submission strategies of institutional and individual traders in the limit order market. The limit order book is also an important part of specialist and dealer markets such as the NYSE and the NASDAQ (see, among others, Harris and Hasbrouck, 1996; Chung et al., 1999; Bloomfield et al., 2005; Moulton, 2006; Hendershott and Moulton, 2008).

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[1] Glosten (1994) provides the theoretical background for the importance of order driven markets. Jain (2003) documents that at the end of 1999,26 of the 51 stock markets in his study, were limit order markets. Virtually all of the stock markets in Europe are also organized as limit order markets (Handa et al., 2003).

Prior literature often relies on the trade-off between the costs and benefits of using market and limit orders to explain the investors' order choice decision. The advantage of using market orders is the immediacy of the order execution, but it comes with the cost of paying higher execution prices. In contrast, limit orders provide price improvement over market orders, but are associated with the risk of non-execution.

Moreover, since the limit price is fixed over time and monitoring might be costly, limit orders can become mispriced and thus may be executed at an unfavorable price. This is often referred to in the literature as the risk of being "picked-off" or "picking-off' risk.[2] Developing a one-tick dynamic model of a limit order market without asymmetric information, Parlour (1998) highlights that the decision to submit a market order or a limit order depends critically on the market depth on either side of the order book. Since this is a one-tick model, traders can submit a market order, can place a limit order which has lower time priority than existing limit orders, or choose not to trade.

Therefore, execution probability of limit orders depends on the size of the book (market depth) and on the agent's belief about future order arrivals. Parlour (1998) shows that an increase in the buy-side (sell-side) market depth reduces the execution probability of buy (sell) limit orders and induces the incoming trader to submit a buy (sell) market order. Furthermore, sellers (buyers) also rationally anticipate the crowding out of limit orders on the buy (sell) side when the buy-side (sell-side) market depth increases. Thus, an increase in the buy-side (sell-side) market depth also makes limit sell (buy) orders more attractive than market sell (buy) orders. Consequently, there is a positive (negative) relation between same-side (opposite-side) market depth and order aggressiveness.[3]

Foucault (1999) presents a model of a dynamic limit order market where investors differ in their valuations but not in their private information. Foucault (1999) suggests that higher volatility implies a greater "picking-off" risk for limit order submitters. Thus, limit order traders will demand a larger compensation for the higher "picking-off" risk, which in turn results in a wider spread and a higher cost of trading with market orders. Hence, the model predicts that the proportion of limit orders in the order flow is positively related to the price volatility and the bid-ask spread in limit order markets.[4]

Empirical studies provide supportive evidence for the effect of spread and market depth on the investors' order aggressiveness in different markets and over different sample periods (see, for example, Biais et al., 1995; Griffiths et al., 2000; Ranaldo, 2004; Beber

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[2] Aitken et al. (2007a) suggest that "picking-off" risk has a different impact for different groups of investors. The authors argue that there are two types of institutional traders: active traders such as hedge funds and passive traders such as pension funds. Active traders expend resources monitoring the status of the order whereas passive traders do not. Hence, the "picking-off" risk is relevant to some of the institutional investors and to all the individual investors.

[3] Handa et al. (2003) also show that the larger the excess market depth of the buy (sell) side relative to the market depth of the sell (buy) side, the higher the execution risk to buyers (sellers). Therefore, the larger the imbalance between the buy (sell) side relative to the sell (buy) side, the more likely buyers (sellers) are to use market orders rather than limit orders.

[4] The prediction of a positive relation between limit order submissions and the bid-ask spread is also consistent with Cohen et al.'s (1981) theoretical model, in which limit orders become more attractive as the bid-ask spread increases.

and Caglio, 2005; Hall and Hautsch, 2006; Ellul et al., 2007; Aitken et al., 2007b; Cao et al., 2008). Past research on the effect of volatility on order aggressiveness is less conclusive. Bae et al. (2003), Ranaldo (2004) and Beber and Caglio (2005) document a positive relation between the placement of limit orders and volatility, as predicted by Foucault (1999).In contrast, Hasbrouck and Saar (2002), Wald and Horrigan (2005) and Aitken et al. (2007b) find that investors actually decrease the usage of limit orders relative to market orders when volatility increases.

Prior literature also highlights that the order aggressiveness of investors might exhibit an intraday pattern. Harris (1998) suggests that liquidity and informed traders become more aggressive as the trading progresses due to the daily trading targets of liquidity traders and the revelation of informed traders' "information" at the end of the trading day. In an experimental study, Bloomfield et al. (2005) provide evidence that informed traders are more (less) aggressive early in the trading day (towards the end of the trading day). In contrast, uninformed investors are less aggressive early in the trading day and become more aggressive as the trading day comes to a close. Beber and Caglio (2005) offer empirical evidence supporting the prediction of Harris (1998) while Anand et al. (2005) and Ellul et al. (2007) document evidence consistent with the experimental finding of Bloomfield et al. (2005).

Our paper contributes to the current literature by comparing the order aggressiveness of two different classes of investors, institutional and individual investors. While there are extensive empirical studies on the order choice or order aggressiveness of investors, few studies have made a distinction between institutional and individual investors' orders in their investigation of order aggressiveness. This distinction is important since these two classes of investors potentially differ in their possession of private information.[5] Moreover, individual investors are also an important investment group in Australia; with 55% of the adult Australian population owning shares. In terms of market value, individual investors possess at least 22% of the Australian equity market and their trading activities account for about 51% of the market turnover as measured by the number of transactions (D'Aloisio, 2005).

To the best of our knowledge, Aitken et al. (2007a) and Aitken et al. (2007b) are the only studies that distinguish between institutional and individual investors' orders while analyzing order aggressiveness. The main focus of Aitken et al. (2007a) is to highlight the simultaneous supply of liquidity at multiple prices in the limit order book and to compare the aggressiveness in liquidity supply of proprietary trading desks and hedge funds with mutual funds, index funds and insurance companies. In other words, Aitken et al. (2007a) examine the aggressiveness of limit orders after they have already been submitted to the order book. We differ from their study by analyzing the factors affecting the order aggressiveness of institutional and individual investors at the time of order submissions. This includes the choice of limit orders and market (marketable limit) orders of institutional and individual investors. We also distinguish our study from Aitken et al.'s (2007b) by not only analyzing the factors affecting investors' order aggressiveness but also by highlighting whether these factors affect institutional and

[5] Szewczyk et al. (1992), Alangar et al. (1999) and Dennis and Weston (2001) find evidence that institutional investors are better informed than individual investors. Chakravarty (2001) documents that institutional medium-size orders have a signiicantly greater cumulative stock price impact than individual orders. Moreover, Anand et al. (2005) also show that institutional limit orders outperform retail limit orders

individual investors' order aggressiveness in a similar fashion. The results of our study will enhance the understanding of the similarities as well as the differences in the supply and demand of liquidity of institutional and individual investors in order driven markets.

Another contribution of our study is the examination of order aggressiveness of stocks based on firm size. We examine order placement strategies of institutional and individual traders for large, medium (mid) and small capitalization (cap) stocks. Order placement strategies of investors in small and mid cap stocks as compared to large cap stocks are likely to take into account two significant differences in their respective trading environments. First, sophisticated investors, such as hedge funds, have incentives to expend more effort in monitoring large cap stocks as compared to mid and small cap stocks (Aitken et al. 2007a). Thus, the "picking-off" risk is exacerbated for large stocks as compared to mid and small cap stocks. Second, the non-execution risk is larger for mid cap and small cap stocks as compared to large stocks due to a lower rate of arrival of market orders. These factors will tend to alter the order placement behavior of institutional and individual investors. Our motivation in focusing on firm size is to enhance the cross-sectional generalizability of our results.

We examine the order aggressiveness of institutional and individual investors for 30 large cap, 30 mid cap and 30 small cap stocks traded on the ASX between 1 August 2005 and 25 November 2005. Consistent with prior literature, we find the order aggressiveness of institutional and individual investors to be positively (negatively) related to the same-side (opposite-side) market depth. We conclude that both institutional and individual investors take execution probability into account while placing orders. In addition, we also document a negative relation between order aggressiveness and the bid-ask spread, especially in large cap stocks. Furthermore, we provide evidence indicating that institutional traders place more aggressive orders in highly volatile markets ostensibly to "pick-off" stale limit orders. Since monitoring is lower and transaction costs are higher for mid cap and small cap stocks, investors become less aggressive in trading these stocks when volatility increases.

We also observe an intraday pattern for order aggressiveness with institutional investors being more aggressive during the first trading hour, and individual investors being less aggressive early in the day and tending to increase their order aggressiveness as the end of the trading day approaches. In addition, institutional and individual investors are more aggressive when submitting large orders, with the exception of institutional investors for small cap stocks. Institutional (individual) investors are also more (less) aggressive in their selling activities than in their buying activities in large and mid cap stocks. Both groups of investors are more aggressive in their selling activities in small cap stocks. We also document different responses of individual buyers and sellers to the changes in spread in mid cap stocks.

The rest of the paper is organized as follows. Section 2 describes the data to be used in the study and Section 3 explains the research methodology. Section 4 discusses the results and implications while Section 5 concludes the paper.

2. Data

We investigate the determinants of order aggressiveness for 30 large cap, 30 mid cap and 30 small cap stocks traded on the ASX between 1 August 2005 and 25 November 2005. The sample ends on 25 November 2005 to avoid the impact of anonymous trading on the ASX, which starts from 28 November 2005.[6]

The selection criteria for the stocks under investigation include both the stock market capitalization and trading activity. First, we consider only seasoned common stocks so all the unit trusts, preference shares and stocks with less than 3 years of trading history are excluded from the sample. Second, we require that all the stocks under investigation must be included in the S&P/ASX 200 index on 29 July 2005 (the day before our sample period) and 25 November 2005 (the end of the sample period). The choice of the S&P/ASX 200 index ensures the representation of large cap, mid cap and small cap stocks as well as the institutional trading interest and the liquidity of the stocks under investigation. Consistent with the classification of the ASX, large cap stocks are defined as the stocks included in the S&P/ASX 50 index. The mid cap stocks are defined as the stocks included in the S&P/ASX 100 index but not in the S&P/ASX 50 index while the stocks included in S&P/ASX 200 index but not in the S&P/ASX 100 index represent our universe of small cap stocks. Third, we rank all large cap, mid cap and small cap stocks based on the daily average number of trades for the three-month period (May to July 2005) before our sample period. The chosen 30 large cap stocks and 30 small cap stocks are the 30 most traded large cap stocks and the 30 least traded small cap stocks, based on the daily average number of trades between May and July 2005, respectively. We choose 30 mid cap stocks by drawing 15 stocks above and 15 stocks below the stock with the median daily average number of trades for the period between May and July 2005.

We obtain two different datasets from the Securities Industry Research Centre of Asia-Pacific (SIRCA) for the investigation of the order aggressiveness of institutional and individual investors. The first dataset is the proprietary Order Book Dataset which records details on each order, including the order type (order submission, order revision, order cancellation and execution), the date and time to the nearest hundredth of a second, stock code, order price, order volume and order direction (buy or sell order). Each new order is assigned a unique identification number (ID) so that we can track the order from its submission through to any revision, cancellation or execution. A unique feature of this dataset is the provision of the confidential dummy variable, which indicates whether the order is submitted by an institutional or individual investor. The second dataset is the Market Depth Dataset, also provided by SIRCA, which contains information on the market depth of a particular stock. Specifically, it details the 10 best limit prices on the bid and ask side, in association with the total volume (number of shares) and the total number of orders at each price level.

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[6] From 28 November 2005, brokers can no longer observe the identiication (IDs) of other brokers submitting orders in the ASX. Prior to this change, brokers have been able to identify, in real-time the broker number associated with every order (the broker IDs) in the central limit order book for each security traded on the ASX (Australian Stock Exchange, 2005). Australian Stock Exchange (2003,2005) discusses the reasons behind the removal of broker IDs on the ASX. Empirical findings on the impact of anonymity on market quality are documented in Comerton-Forde et al. (2005), Foucault et al. (2007) and Comerton-Forde and Tang (2009).

This dataset is updated whenever there is a change to the price and/or volume to any of these 10 best limit prices. We remove all the observations in the Market Depth Dataset whenever the bid price is greater than the ask price at any of the 10 limit price levels. We also exclude all observations where the bid (ask) prices are not in strict descending (ascending) order from the first to the tenth best prices.

For our purpose of comparing the order aggressiveness of institutional and individual investors, we match the Order Book Dataset to the Market Depth Dataset. Thus, we arrive at a final dataset that contains detailed information on every institutional or individual order submitted, revised or cancelled together with the market depth information at the time of order submission, revision or cancellation. In this study, only the orders submitted in the continuous trading session (from 10:10 to 16:00)[7]are included. In addition, we only analyze standard orders, so that crossing orders, All or Nothing orders and Fill and Kill orders are excluded.[8]

In the current study, the confidential classification of institutional and individual orders is provided on an aggregated basis by SIRCA, after the approval to release confidential data from the ASX. For robustness check, we also perform an independent test for the ASX's classification of institutional and individual orders based on a trade-by-trade data from IRESS. This dataset identifies the transaction date and time, transaction price, trading volume, trade direction (whether the transaction is initiated by a buyer or seller) and most importantly the identity of the buying and selling brokers involved in the transactions. During our sample period, there are 89 brokers identified by the IRESS data, with 79 brokers participating in trading activity of the stocks considered in this robustness test. We classify the brokers into brokers dealing with institutional investors, with individual investors and with both groups of investors.[9] From the IRESS data, we focus only on the transactions that have the buying broker or selling broker classified as doing business with either institutional or individual investors. From the Order Book Dataset provided by the ASX, we can identify for every transaction, whether the buyer and seller is an institution or an individual, as classified by the ASX. We then compare the ASX classification of institutions and individuals with our classification based on brokers' identities provided by IRESS. For the five randomly chosen large cap stocks, five randomly chosen mid cap stocks and five randomly chosen small cap stocks, we obtain a consistency of at least 98.62% in the institutional/individual orders classification.[10]

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[7] [7] Since the ASX's staggered opening procedure takes up to 10 minutes to complete, the data for the first 10 minutes of each day are excluded from our sample, to avoid any potential bias.

[8] If an investor submits an All or Nothing order, he/she instructs the order to be filled in full, otherwise the order is cancelled. In contrast, if an investor places a Fill and Kill order, his/her intention is to fill the order as much as possible and the unexecuted part will be cancelled.

[9] This classification is based on the brokers' names as well as on the description of the brokers' activities, services and products, provided on their websites and through telephone interviews.

[10] The results of this robustness check and the classification of brokers, where the brokers are identified based on the IRESS code, are available upon request.

3. Research methodology

Consistent with Biais et al. (1995), we classify orders into six levels of order aggressiveness. Category 1, the most aggressive orders, are buy (sell) orders with prices greater (less) than the best ask (bid) quote and the size of the orders exceeds the market depth at the best ask (bid) quote. These orders are executed against the volume at the ask (bid) and in part against the market depth available higher (lower) in the book up to the order price. The unfilled portion of the order enters as a limit order in the order book. Category 2 orders are buy (sell) orders with prices equal to the best ask (bid) quote and demand more volume than the market depth at the best ask (bid) quote. These orders are executed immediately and the unfilled portion of the order becomes a limit order at that price in the limit order book. Category 3 orders are orders with price equal to the opposite best quote and demand less volume than the market depth at the opposite best quote. These orders are executed immediately and in full. Category 4 and 5 orders are limit orders within and at the prevailing quotes, respectively. Category 6 orders are the least aggressive, in the sense that they are buy (sell) orders with prices less (greater) than the best bid (ask) quotes. Based on this classification, Categories 1, 2 and 3 can be classified as market orders, since they result in immediate execution,[11] while Category 4, 5 and 6 orders are limit orders as they are not executed immediately. These orders stand in the limit orders book, waiting for execution.

Building on Griffiths et al. (2000) and Ranaldo (2004), the determinants of institutional and individual investors' order aggressiveness are investigated based on the ordered probit model. Consistent with Biais et al. (1995), the dependent variable - the order aggressiveness - is classified into one of the six levels. The explanatory variables include the same-side market depth, the opposite-side market depth, the relative bid-ask spread, volatility, the order size and two dummy variables, one for the first trading hour and one for sell orders. The same-side (opposite-side) market depth is defined as the natural logarithm of the same-side (opposite-side) market depth, in terms of the number of shares, at the time of order submission. The relative bid-ask spread is the percentage of the bid-ask spread over the bid-ask mid-point, at the time of the order submission. Following Ranaldo (2004), volatility is defined as the standard deviation of the 20 most recent mid-quote returns multiplied by 100. The order size is the natural logarithm of the number of shares in a particular order.

Besides spread, market depth and volatility, we include a dummy variable for the first trading hour to examine the potential differences in the order aggressiveness of institutional and individual investors in the early part of the trading day, as suggested by Bloomfield et al. (2005) and Anand et al. (2005). The dummy variable for sell orders is included to control for potential asymmetry between buy and sell orders, as documented by Ranaldo (2004). Order size is also incorporated in the ordered probit regression to examine the relation between order size and its aggressiveness. In order to highlight the potentially different impact that an explanatory variable might have on the order aggressiveness of institutional and individual investors, the ordered probit model is estimated separately for institutional and individual orders. We also perform the analysis of the institutional and individual investors' order aggressiveness for the

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[11] Since all orders on the ASX are priced, Category 1, 2 and 3 orders should be classified as marketable limit orders. In the current paper, we refer to them as market orders for brevity.

buy orders and sell orders separately to highlight the potential differences in the determinants of the order aggressiveness of buyers and sellers.

In this study, we investigate the determinants of institutional and individual order aggressiveness based on new order submissions and order revisions. Ranaldo (2004) investigates order aggressiveness with order cancellations classified as the least aggressive type of orders. Pascual and Veredas (2004) and Hall and Hautsch (2006) provide discussion for the need to model order submissions and order cancellations differently. In our sample period, 25.70% of all orders are subsequently cancelled and order cancellation accounts for 16.11% of all new order submissions, order revisions and order cancellations. We examine order aggressiveness without order cancellations and with order cancellations classified as the least aggressive orders, as in Ranaldo (2004). The results in both cases are qualitatively the same. Therefore, we only report the results without order cancellations in this study.[12]

4. Empirical results

4.1. Statistics of order submissions

Table 1 provides summary statistics for the orders submitted for the 90 stocks under investigation. In total, we investigate 7,210,868 orders, including 3,079,243 orders submitted by institutional investors and 4,131,625 orders submitted by individual investors. Similar to Aitken et al. (2007b), Category 5 orders are the most common order type for institutional investors, while the most common order type for individual investors is Category 6 orders. In addition, consistent with Parlour (1998) and Handa et al. (2003), both institutional and individual investors tend to submit aggressive (market) orders when the same-side market depth is higher than the opposite-side market depth. For both institutional and individual investors, the relative bid-ask spread is also higher at the time of limit order submissions than at the time of market order submissions. These observations present early support for the effect of the spread and market depth on order aggressiveness.

4.2. The distribution of order aggressiveness levels

Table 2 provides information regarding the distribution of order aggressiveness levels over the course of the trading day. In the current study, we partition the trading day into six intervals: 10:10-11:00, 11:0012:00,12:00-13:00,13:00-14:00,14:00-15:00 and 15:00-16:00.

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[12] The results with order cancellations can be provided upon request. For more discussion on order cancellations on the ASX, see Liu (2009).

Table 1
Descriptive statistics of order submissions.

Aggressiveness level	Frequency	% of all orders	Order size	Depth at best same	Depth at best opposite	Depth at same	Depth at opposite	Relative spread	Volatility
Panel A: Institutional orders									
1	47,037	1.53%	7033	8095	1686	68,662	62,151	0.2595	0.0208
2	243,815	7.92%	17,961	30,124	7951	201,484	194,312	0.1199	0.0377
3	733,943	23.84%	4653	52,373	40,130	355,296	347,854	0.1800	0.0352
4	342,900	11.14%	3024	10,417	9965	78,629	78,838	0.3217	0.0458
5	1,177,779	38.24%	5312	37,791	47,993	343,663	343,093	0.1623	0.0378
6	533,769	17.33%	6000	20,323	26,668	207,379	207,004	0.1914	0.0297
Panel B: Individual orders									
1	76,386	1.85%	6254	10,120	1733	88,131	81,768	0.2418	0.0270
2	251,393	6.08%	12,537	29,184	5724	205,386	187,803	0.1404	0.0432
3	1,053,617	25.50%	4267	113,143	93,429	808,353	776,996	0.1796	0.0322
4	365,992	8.86%	3244	12,664	11,356	92,595	91,114	0.3727	0.0509
5	1,150,572	27.85%	5909	70,820	89,287	638,467	639,789	0.2184	0.0438
6	1,233,665	29.86%	5575	63,416	73,925	589,755	579,842	0.2040	0.0357

This table presents summary statistics of the order submissions of institutional and individual investors in this study. The sample period is between 1 August 2005 and 25 November 2005. Following Biais et al. (1995), orders are classified into six aggressiveness levels. Category 1 orders are buy (sell) orders with the prices greater (less) than the best ask (bid) quote and the order size exceeds the market depth at the best ask (bid) quote. Category 2 orders are buy (sell) orders with prices equal to the best ask (bid) quote and demand more volume than the market depth at the best ask (bid) quote. Category 3 orders are orders with price equal to the opposite best quote and demand less volume than the market depth at the opposite best quote. Category 4 and 5 orders are limit orders within and at the prevailing quotes, respectively. Category 6 orders are buy (sell) orders with prices less (greater) than the best bid (ask) quotes. "Frequency" is the number of orders submitted at a particular aggressiveness level."% of all orders" is the percentage of the number of orders in a particular order aggressiveness level over all orders. "Order size" is the average number of shares submitted in an order. "Depth at best same (opposite) " is the average number of shares at the best same-side (opposite-site) quote at the time of order submission. "Depth at same (opposite)" is the average number of shares at the 10 best same-side (opposite-side) quote at the time of order submission. "Relative spread" is the average relative spread, which is calculated as the percentage of the bid-ask spread over the bid-ask midpoint, at the time of the order submission. "Volatility" is the average volatility, which is calculated as the standard deviation of the most recent 20 mid-quote returns at the time of order submission multiplied by 100.

Table 2
The distribution of order aggressiveness levels over the trading day.

Interval	Levels of order aggressiveness						MO	LO	Total	% MO	% LO
	1	2	3	4	5	6					
Panel A: Institutional orders											
10:10–11:00	12,955	51,123	144,235	81,655	198,976	96,660	208,313	377,291	585,604	35.57%	64.43%
11:00–12:00	10,280	41,848	127,019	61,479	191,401	103,751	179,147	356,631	535,778	33.44%	66.56%
12:00–13:00	4914	26,148	86,249	37,984	144,762	71,835	117,311	254,581	371,892	31.54%	68.46%
13:00–14:00	2840	15,617	62,071	26,601	123,026	54,654	80,528	204,281	284,809	28.27%	71.73%
14:00–15:00	6318	43,049	122,911	57,459	224,649	90,832	172,278	372,931	545,218	31.60%	68.40%
15:00–16:00	9730	66,030	191,458	77,722	294,965	116,037	267,218	488,724	755,942	35.35%	64.65%
Panel B: Individual orders											
10:10–11:00	22,231	54,307	217,667	91,953	232,615	300,296	294,205	624,864	919,069	32.01%	67.99%
11:00–12:00	15,407	43,654	189,305	64,488	200,780	243,210	248,366	508,478	756,844	32.82%	67.18%
12:00–13:00	9061	29,735	140,570	47,565	156,889	173,395	179,366	377,849	557,215	32.19%	67.81%
13:00–14:00	7255	20,102	104,481	33,275	118,844	126,954	131,838	279,073	410,911	32.08%	67.92%
14:00–15:00	8839	40,907	163,405	53,052	186,018	171,438	213,151	410,508	623,659	34.18%	65.82%
15:00–16:00	13,593	62,688	238,189	75,659	255,426	218,372	314,470	549,457	863,927	36.40%	63.60%

This table presents the distribution of the order aggressiveness level over the trading day. Following Biais et al. (1995), orders are classified into six aggressiveness levels. Category 1 orders are buy (sell) orders with the prices greater (less) than the best ask (bid) quote and the order size exceeds the market depth at the best ask (bid) quote. Category 2 orders are buy (sell) orders with prices equal to the best ask (bid) quote and demand more volume than the market depth at the best ask (bid) quote. Category 3 orders are orders with price equal to the opposite best quote and demand less volume than the market depth at the opposite best quote. Category 4 and 5 orders are limit orders within and at the prevailing quotes, respectively. Category 6 orders are buy (sell) orders with prices less (greater) than the best bid (ask) quotes. Orders with aggressiveness levels from 1 to 3 are market orders and orders with

aggressiveness levels from 4 to 6 are limit orders. The trading day is divided into six intervals: 10:10-11:00,11:00-12:00,12:00-13:00, 13:00-14:00,14:00-15:00 and 15:00-16:00. "MO" ("LO") refers to the total number of market (limit) orders in a particular interval. "Total" is the total number of orders submitted in a particular interval. "%MO" ("%LO") is the percentage of market(limit) orders out of all orders submitted in a particular interval.

From Table 2, we observe that the order aggressiveness of institutional investors has a U-shaped pattern. Institutional investors are more aggressive and demand more liquidity (place more market orders) early on in the trading day than in other intervals. As the trading day progresses, institutional investors become less aggressive and submit fewer market orders and more limit orders. However, towards the end of the trading day, institutional investors increase their order aggressiveness, but their order aggressiveness at the end of the trading day is not as high as it is at the beginning of the trading day. Individual investors behave in an opposite fashion; they are less aggressive early on in the day and become more aggressive as the end of the trading day approaches.

4.3. The order aggressiveness of institutional and individual investors
Table 3 presents the results of investigating the determinants of order aggressiveness for institutional and individual investors. Since the aggressiveness levels are ranked from 1 (the most aggressive) to 6 (the least aggressive), a negative coefficient indicates a positive relation between the explanatory variable and investors' order aggressiveness.

Table 3
The determinants of institutional and individual order aggressiveness.

	Large cap stocks			Mid cap stocks			Small cap stocks		
	Coeff	% t-stat> 1.96	% t-stat< −1.96	Coeff	% t-stat> 1.96	% t-stat< −1.96	Coeff	% t-stat> 1.96	% t-stat< −1.96
Panel A: Institutional orders									
Depth$_{same}$	−0.0481	10.00%	66.67%	−0.0373	26.67%	46.67%	−0.1090	13.33%	56.67%
Depth$_{opposite}$	0.1002	96.67%	0%	0.0995	66.67%	3.33%	0.0782	63.33%	3.33%
Spread	0.6383	83.33%	6.67%	0.1615	60.00%	20.00%	0.1203	80.00%	10.00%
Volatility	−0.6394	23.33%	70.00%	0.0065	40.00%	23.33%	−0.0881	10.00%	26.67%
FirstInt	−0.1046	0%	90.00%	−0.0429	13.33%	66.67%	0.0173	23.33%	13.33%
Size	−0.1301	0%	100.00%	−0.0509	6.67%	90.00%	0.0282	53.33%	26.67%
Direction	−0.0113	26.67%	60.00%	−0.0129	33.33%	50.00%	−0.0083	23.33%	43.33%
Panel B: Individual orders									
Depth$_{same}$	−0.0788	0%	93.33%	−0.0766	10.00%	76.67%	−0.1340	6.67%	73.33%
Depth$_{opposite}$	0.0614	86.67%	6.67%	0.0550	60.00%	6.67%	0.1147	66.67%	10.00%
Spread	0.9082	90.00%	6.67%	−0.0003	30.00%	40.00%	0.0061	40.00%	33.33%
Volatility	−0.9172	20.00%	36.67%	0.0805	46.67%	16.67%	−0.0562	16.67%	30.00%
FirstInt	0.0387	60.00%	0%	0.0073	36.67%	33.33%	0.0218	33.33%	6.67%
Size	−0.0373	16.67%	80.00%	−0.0469	13.33%	76.67%	−0.0205	26.67%	60.00%
Direction	0.0118	50.00%	30.00%	0.0339	60.00%	30.00%	−0.0286	33.33%	53.33%

This table presents results from the investigation of the determinants of institutional and individual investors' order aggressiveness. We estimate the following ordered probit model for institutional and individual orders: $Z_i = \beta_1 Depth_{same,i} + \beta_2 Depth_{opposite,i} + \beta_3 Spread_i + \beta_4 Vola_i + \beta_5 FirstInt_i + \beta_6 Size_i + \beta_7 Direction_i + \varepsilon_i$, where Z_i is the latent order aggressiveness, $Depth_{same,i}$ ($Depth_{opposite,i}$) is the natural logarithm of the same-side (opposite-side) market depth, in terms of the number of shares, at the time of order submission. $Spread_i$ is the relative bid-ask spread at the time of the order submission. $Vola_i$ is defined as the standard deviation of the 20 most recent mid-quote returns multiplied by 100. $FirstInt_i$ is the dummy variable for the first trading hour of the trading day and $Direction_i$ is the dummy variable for sell orders. $Size_i$ is the natural logarithm of the number of shares in the particular order. "Coeff" refers to the average of the estimated coefficients. % t-stat> 1.96 (% t-stat<− 1.96) refers to the percentage of coefficients that is positive (negative) and significant at the 5% level.

From Table 3, we observe a positive (negative) and significant relation between the same-side (opposite-side) market depth and order aggressiveness in the majority of

stocks. These results are consistent for both institutional and individual investors' orders and provide support for the effect of market depth on order aggressiveness. Both institutional and individual investors tend to submit more aggressive orders when the same-side market depth increases or when the opposite-side market depth decreases. In contrast, investors tend to submit less aggressive orders when the same-side market depth decreases or when the opposite-side market depth increases.

We also find that the majority of the coefficients for the bid-ask spread are positive and significant for institutional investors' orders. This evidence supports a negative relation between the order aggressiveness of institutional investors and the bid-ask spread. The order aggressiveness of individual investors is also negatively related to the bid-ask spread, especially in large cap stocks. In mid cap stocks, individual investors tend to submit more aggressive orders when the spread widens. This finding indicates that the execution risk is a significant factor for mid cap stocks. Thus, individual investors place more aggressive orders when the spread widens while trading mid cap stocks as compared to large cap stocks.

The finding for the effect of volatility on institutional and individual investors' order aggressiveness varies across stocks. We observe a negative relation between the order aggressiveness of institutional and individual investors and volatility in mid cap stocks. In contrast, a positive relation between institutional investors' order aggressiveness and volatility is documented in large cap stocks. The relation between order aggressiveness and volatility is insignificant in the majority of small cap stocks for both institutional and individual investors.[13]   Since higher volatility implies greater a "picking-off risk (Foucault, 1999) and institutions often monitor the limit order book more closely (AAHM), we can expect greater "picking-off" activity by institutions when volatility increases. Because monitoring is lower for mid and small cap stocks (Liu, 2009), the increase in "picking-off" activity by institutions should be more prevalent in large cap stocks. This argument is supported by our finding that institutions become more aggressive when volatility increases in large cap stocks.

We also document that institutional and individual investors adopt different order submission strategies in the first hour of the trading day. For institutional investors, negative and significant coefficient estimates for the dummy variable for the first trading hour are observed for the majority of large and mid cap stocks under investigation. This implies that institutional investors are more aggressive and demand liquidity in the first hour of the trading day. In contrast, for individual orders, the coefficient estimates for the dummy variable for the first trading hour tend to be positive and significant, especially in large cap stocks. This result indicates that individual investors are less aggressive and use more limit orders during the first trading hour.

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[13] Consistent with Ranaldo (2004), we also examine volatility in a separate regression, or calculate volatility based on the standard deviation of the most recent 10 and 30 mid-quote returns. The results of these investigations are qualitatively similar to those reported in the current study.

With regard to the relation between order size and order aggressiveness, the results in Table 3 indicate that institutional and individual investors tend to increase their order aggressiveness when submitting large orders for large and mid cap stocks. For small cap stocks, institutional (individual) investors are less (more) aggressive when they submit a large order.

Finally, the results in Table 3 show that institutional investors' sell orders are more aggressive than their buy orders in large cap, mid cap and small cap stocks. In contrast, individual investors' sell orders are less aggressive than individual buy orders in large and mid cap stocks. In small cap stocks, the sell orders of individual investors are more aggressive than their buy orders.

4.4. The order aggressiveness of buy and sell orders

We investigate the order aggressiveness of institutional investors' buy and sell orders in Table 4. We observe consistent results regarding the opposite-side market depth, the bid-ask spread and volatility for both buy and sell orders. In addition, in large cap and mid cap stocks, the majority of the coefficient estimates for the dummy variable for the first trading hour are negative and significant, which indicates that institutional investors tend to be more aggressive early on in the trading day in their buying and selling activities. Institutional investors are also more aggressive in their selling activities when the same-side market depth increases in all three groups of stocks while there is no clear-cut evidence for the impact of same-side market depth on institutional buying activities in mid cap stocks.

Table 4
The determinants of institutional buy and sell order aggressiveness.

	Large cap stocks			Mid cap stocks			Small cap stocks		
	Coeff	% t-stat> 1.96	% t-stat< −1.96	Coeff	% t-stat> 1.96	% t-stat< −1.96	Coeff	% t-stat> 1.96	% t-stat< −1.96
Panel A: Institutional buy orders									
Depth$_{same}$	−0.0486	10.00%	60.00%	−0.0129	50.00%	43.33%	−0.1001	13.33%	50.00%
Depth$_{opposite}$	0.1085	80.00%	6.67%	0.1177	70.00%	13.33%	0.1396	56.67%	13.33%
Spread	0.7894	66.67%	6.67%	0.2248	63.33%	20.00%	0.1432	66.67%	13.33%
Volatility	−0.6095	26.67%	56.67%	0.0873	53.33%	33.33%	−0.0599	20.00%	33.33%
FirstInt	−0.1161	0%	93.33%	−0.0415	26.67%	60.00%	0.0080	13.33%	26.67%
Size	−0.1294	0%	100.00%	−0.0418	6.67%	83.33%	0.0356	53.33%	20.00%
Panel B: Institutional sell orders									
Depth$_{same}$	−0.0550	6.67%	63.33%	−0.0737	10.00%	56.67%	−0.1855	20.00%	56.67%
Depth$_{opposite}$	0.0984	83.33%	3.33%	0.0732	56.67%	20.00%	0.0707	43.33%	16.67%
Spread	0.4835	73.33%	10.00%	0.1052	50.00%	13.33%	0.1118	56.67%	10.00%
Volatility	−0.5995	23.33%	46.67%	−0.1045	40.00%	30.00%	−0.0949	30.00%	36.67%
FirstInt	−0.0933	6.67%	80.00%	−0.0435	16.67%	60.00%	0.0316	23.33%	3.33%
Size	−0.1292	0%	100.00%	−0.0612	6.67%	93.33%	0.0133	23.33%	40.00%

This table presents results from the investigation of the determinants of institutional investors' buy and sell order aggressiveness. We estimate the following ordered probit model for institutional investors' buy and sell orders: $Z_i = \beta_1 \text{Depth}_{same,i} + \beta_2 \text{Depth}_{opposite,i} + \beta_3 \text{Spread}_i + \beta_4 \text{Vola}_i + \beta_5 \text{FirstInt}_i + \beta_6 \text{Size}_i + \varepsilon_i$, where Z_i is the latent order aggressiveness, $\text{Depth}_{same,i}$ ($\text{Depth}_{opposite,i}$) is the natural logarithm of the same-side (opposite-side) market depth, in terms of the number of shares, at the time of order submission. Spread_i is the relative bid-ask spread at the time of the order submission. Vola_i is defined as the standard deviation of the 20 most recent mid-quote returns multiplied by 100. FirstInt_i is the dummy variable for the first hour of the trading day. Size_i is the natural logarithm of the number of shares in the particular order. "Coeff" refers to the average of the estimated coefficients. % t-stat> 1.96 (% t-stat< −1.96) refers to the percentage of coefficients that is positive (negative) and significant at the 5% level.

The results of investigating the order aggressiveness of individual investors' buy and sell orders are given in Table 5. For individual investors, the buy and sell order aggressiveness are positively (negatively) related to the same-side market depth (the opposite-side market depth) and the order size. In addition, the results in Panel B of Table 5 indicate that the majority of the coefficient estimates for the dummy variable for the first trading hour in large cap stocks are positive and significant. This finding suggests that individual investors are less aggressive in their selling activities early on in the trading day. The most significant difference between buy and sell orders for individual investors is observed in the effect of spread on order aggressiveness in mid cap stocks. In mid cap stocks, when the spread increases, individual investors tend to submit less aggressive buy orders but more aggressive sell orders.

Table 5
The determinants of individual buy and sell order aggressiveness.

	Large cap stocks			Mid cap stocks			Small cap stocks		
	Coeff	% t-stat> 1.96	% t-stat< −1.96	Coeff	% t-stat> 1.96	% t-stat< −1.96	Coeff	% t-stat> 1.96	% t-stat< −1.96
Panel A: Individual buy orders									
Depth$_{same}$	−0.0857	0%	83.33%	−0.0841	13.33%	70.00%	−0.1842	6.67%	60.00%
Depth$_{opposite}$	0.0685	70.00%	10.00%	0.0506	56.67%	20.00%	0.1140	56.67%	23.33%
Spread	1.0864	80.00%	10.00%	0.0945	60.00%	30.00%	0.0138	36.67%	36.67%
Volatility	−0.9154	16.67%	40.00%	0.1818	43.33%	20.00%	−0.0011	23.33%	33.33%
FirstInt	0.0185	36.67%	26.67%	0.0058	26.67%	26.67%	0.0321	30.00%	26.67%
Size	−0.0376	20.00%	76.67%	−0.0543	10.00%	80.00%	−0.0127	23.33%	50.00%
Panel B: Individual sell orders									
Depth$_{same}$	−0.0799	6.67%	76.67%	−0.0830	20.00%	73.33%	−0.1240	16.67%	56.67%
Depth$_{opposite}$	0.0602	80.00%	10.00%	0.0735	70.00%	10.00%	0.1351	70.00%	10.00%
Spread	0.6936	70.00%	6.67%	−0.0666	23.33%	50.00%	0.0143	40.00%	26.67%
Volatility	−0.8928	30.00%	40.00%	−0.0507	26.67%	26.67%	−0.1585	20.00%	43.33%
FirstInt	0.0594	80.00%	3.33%	0.0134	43.33%	33.33%	0.0172	33.33%	26.67%
Size	−0.0364	16.67%	76.67%	−0.0395	16.67%	73.33%	−0.0252	30.00%	60.00%

This table presents results from the investigation of the determinants of individual investors' buy and sell order aggressiveness. We estimate the following ordered probit model for individual investors' buy and sell orders: $Z_i = \beta_1 \, Depth_{same,i} + \beta_2 \, Depth_{opposite,i} + \beta_3 \, Spread_i + \beta_4 \, Vola_i + \beta_5 \, FirstInt_i + \beta_6 \, Size_i + \varepsilon_i$, where Z_i is the latent order aggressiveness, $Depth_{same,i}$ ($Depth_{opposite,i}$) is the natural logarithm of the same-side (opposite-side) market depth, in terms of the number of shares, at the time of order submission. $Spread_i$ is the relative bid-ask spread at the time of the order submission. $Vola_i$ is defined as the standard deviation of the 20 most recent mid-quote returns multiplied by 100. $FirstInt_i$ is the dummy variable for the first hour of the trading day. $Size_i$ is the natural logarithm of the number of shares in the particular order. "Coeff" refers to the average of the estimated coefficients. % t-stat>1.96 (% t-stat<−1.96) refers to the percentage of coefficients that is positive (negative) and significant at the 5% level.

4.5. Implication of results

Overall, consistent with prior theoretical and empirical literature,[14] we find strong evidence that institutional and individual order aggressiveness are positively related to the same-side market depth and negatively related to the opposite-side market depth. Market depth can be viewed as a proxy for the execution probability and thus will affect investors' order aggressiveness. When the same-side market depth increases, the execution probability of the incoming limit order is reduced. Therefore, investors are more likely to submit more aggressive orders to obtain higher execution priority in the

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[14] See for example, Biais et al. (1995), Parlour (1998), Griffiths et al. (2000), Ranaldo (2004), Beber and Caglio (2005), Hall and Hautsch (2006), Ellul et al. (2007), Aitken et al. (2007b) and Cao et al. (2008).

book. In contrast, an increase in the market depth on the buy (sell) side increases the execution probability of limit orders on the sell (buy) side. This reduces the non-execution risk for limit orders and therefore, investors may prefer limit orders over market orders when the opposite-side market depth increases.

Our empirical results regarding the impact of bid-ask spread on order aggressiveness supports a negative relation between order aggressiveness and the bid-ask spread. Both institutional and individual investors submit less aggressive orders when spreads tend to be high. Individual investors submit more aggressive orders in mid cap stocks as compared to large cap stocks when the spread widens. This finding implies that non-execution risk is a significant factor for individual investors while trading mid cap stocks. Individual investors differ from institutional investors in their timely knowledge of the order book. This informational disadvantage induces them to place more aggressive orders even when the spread is high for mid cap stocks.

Our finding regarding the effect of volatility on order aggressiveness suggests a negative relation between order aggressiveness and volatility in mid cap stocks. This is consistent with the prediction of the Foucault (1999) model. In large cap stocks, we document a positive relation between institutional investors' order aggressiveness and volatility. Consistent with Foucault (1999), we argue that increases in volatility imply greater "picking-off" risk for limit order submitters. In addition, AAHM suggest that since institutional investors often pay higher fees for more continuous monitoring of the state of the limit order book, the "picking-off" risk is more applicable to individual investors. Therefore, institutional investors have incentives to incur higher monitoring costs and place aggressive orders when volatility increases in order to profit from "picking-off" stale limit orders. Since monitoring is lower for mid and small cap stocks (Liu, 2009) and the transaction costs are higher for those stocks compared to large cap stocks, it is much more difficult and less profitable for institutional investors to adopt this trading strategy in mid and small cap stocks. Thus, we observe a positive relation between volatility and order aggressiveness for institutional investors in large cap stocks but not in mid cap and small cap stocks. A positive relation between order aggressiveness and volatility for institutional investors is consistent with the notion that institutional investors monitor the limit order book more closely and "pick-off" stale limit orders when volatility increases.[15]

The results in Table 2 and the results regarding the dummy variable for the first trading hour presented in Table 3 also indicate that institutional investors and individual investors in our study follow a different order submission pattern over the trading day. Institutional investors are potentially better-informed, they submit more aggressive orders early on in the trading day when information asymmetry is high and prices have not converged to their true value. As trading progresses and information is incorporated into prices, institutional investors switch t[16]o using limit orders and

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[15] The "picking-off" activities are more likely to originate from active institutions such as hedge funds and proprietary trading desks rather than mutual funds and insurance companies (AAHM).

[16] See for example, Szewczyketal. (1992), Alangaretal. (1999), Dennis and Weston (2001), Chakravarty (2001) and Anandetal. (2005).

provide liquidity to the market. This pattern in the order submissions of institutional investors is consistent with the experimental findings of the informed traders' order submission pattern as documented in Bloomfield et al. (2005). However, in contrast to Bloomfield et al. (2005), institutional investors increase their order aggressiveness towards the end of the day. Individual investors behave in the opposite direction to institutional investors; they are less aggressive early on in the trading day when information asymmetry and the "picking-off" risk are high. As trading progresses, individual investors become more aggressive in their order submissions, especially when the trading expiration approaches. The increase in order aggressiveness of institutional and individual investors towards the end of the trading day is consistent with Harris's (1998) prediction. Institutional and individual investors appear to have daily trading targets and they become more aggressive towards the end of the trading day to achieve their trading targets.

Our findings in Table 3 indicate that institutional investors tend to increase their order aggressiveness when submitting large orders. Many large orders are information driven. This is because in markets with pre-trade transparency, institutions would like to prevent front-running when they place large limit orders. In contrast, in small cap stocks, institutional investors are often less aggressive when they submit a large order. This is because there is less monitoring by other institutional investors and therefore lower risk of front-running. Individual investors in general are less likely to trade, seeking to exploit private information. Thus, they are less likely to be exposed to the risk of front-running. Therefore, we observe consistent results for the relation between order size and order aggressiveness for individual investors.

The evidence documented in Table 4 suggests that in large cap stocks, institutional investors are more aggressive in their buying activities than in their selling activities when volatility increases. In addition, institutions are more aggressive in their buying activities than in their selling activities in the first hour of the trading day. Individual investors are also less aggressive in their selling activities than in their buying activities in the first trading hour, especially in large cap stocks. These results indicate that if the order submissions of institutions and individuals in the first trading hour or in reaction to changes in volatility in large cap stocks can be explained by the information advantage institutions have over individuals, institutional buy orders are likely to be more informative than institutional sell orders. This finding is consistent with prior empirical evidence that buy orders are more likely to be motivated by information than sell orders (see, for example, Griffiths et al., 2000 and Ranaldo, 2004). Individual investors also display more aggressive selling behavior as compared to buying behavior when the bid-ask spread widens in mid cap stocks. It appears that they are less sensitive to transaction costs while selling but are more concerned with non-execution risk.

The economic theory of capacity-constrained pricing and congestion-based premiums suggest that higher trading volume and excess buying or selling pressure over market depth at the ask or bid quote can result in an increase in the ask quote and a decrease in the bid quote, which subsequently leads to wider spread.[17] Higher trading volume can also reduce non-execution risk and thus make orders less aggressive. Thus, these

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[17] See Harris et al. (1995) for a discussion and test of this theory.

arguments can also explain the effect of bid-ask spread on investors' order aggressiveness. Harris and McInish (2000) also suggest that these arguments are separate for buy-side regimes and sell-side regimes. Therefore, a question for future research is why do individual buyers' and sellers' respond differently to changes in spread for mid cap stocks while they respond in a similar manner for large cap stocks. Furthermore, why is this difference more apparent for individual buyers and sellers than institutional buyers and sellers?[18]

5. Conclusion

This paper investigates the determinants of the order aggressiveness of institutional and individual investors on the ASX. We report strong evidence that the order aggressiveness of institutional and individual investors is positively related to same-side market depth and negatively related to opposite-side market depth. These findings indicate that traders consider non-execution risk while deciding on their order placement strategy. Both individual and institutional traders submit less aggressive orders when spreads are high while trading large cap stocks. However, individual investors switch to a more aggressive strategy while trading mid cap stocks even if spreads are wide. We ascribe this critical difference between individual and institutional traders to their sensitivity to non-execution risk. Individual investors are at an informational disadvantage with respect to their timely knowledge of the order book as compared to institutional investors and hence alter their strategy to cope with non-execution.

Furthermore, institutional investors place more aggressive orders under volatile market conditions in order to profit from "picking-off" stale limit orders. As monitoring is lower and transaction costs are higher for mid cap and small cap stocks, traders are less aggressive in their order placement when volatility increases in these stocks. Institutional and individual investors follow different order placement strategies at the beginning of the trading day. Whereas institutional traders place more aggressive orders early in the trading day to exploit potential short-lived information, their individual counterparts are less aggressive initially and become more aggressive as the trading day progresses. Institutional traders also place more aggressive sell orders as compared to buy orders. This finding implies that their perceived opportunity costs of not selling exceed the costs of not buying. We believe that our research is potentially useful to traders, policy makers and fund managers. Further research on explicit measurement of trading costs during different phases of the market is likely to be valuable to both practitioners and policy makers.

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[18] We thank the referee for suggesting this line of research.

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