Returns, Volatility and Liquidity on the ASX: Undisclosed vs. Disclosed Limit Orders

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ABSTRACT

This paper investigates the information content of the two types of limit orders on the Australian Stock Exchange ASX: undisclosed orders (ULOs) and limit orders. Given the large order quantity contained in ULOs, we attempt to examine the impact of ULO submissions, cancellations and executions on price changes and volatility over differing intervals within a day. Motivation is generated by the ASX decision to abolish the use of ULOs in favour of iceberg orders. Intraday analysis shows that the impact of both ULO and disclosed order submissions are no longer than one day. ULO buying/selling order submissions at the best bid/ask price increase/decrease returns and price volatility significantly more than disclosed orders. The cancellations of ULOs cause significantly larger price volatility than disclosed limit order cancellations. Compared with disclosed limit order submissions, there is an increase in liquidity from the significantly reduced spread upon DLO submissions.

Keywords: Intraday effects; Returns volatility; Undisclosed limit orders.

1. Introduction

Australian Stock Exchange (ASX) regulations used to offer limit order traders the option to not reveal the quantity of an order with a value in excess of $200,000 (otherwise known as an undisclosed limit order, or ULO). A regulation intended to protect large liquidity suppliers from unnecessary order exposure (Aitken, Berkman and Mak, 2001). By reducing the "free option" value of limit orders[1], the ASX potentially enhanced market liquidity. However, little is known about user characteristics of ULOs on the ASX. We examine, what additional information content exists within an ULO as opposed to an ordinary, disclosed limit order (DLO).

Our results are novel in a number of ways: we examine the usage of ULOs following three changes in regulations.[2] We also examine the usage of ULOs within a timeframe that precedes an assigned change in ULO regulation.[3] The sample adopted is of highly liquid stocks of the ASX/S&P 20 that constitute over 64% of Australian Stock Exchange market capitalisation (Standard&Poors 2005). The paper extends prior studies by examining the information content of ULOs submitted behind the best price, as well as the information content of cancelled ULOs. (See Aitken, Allen and Yang (2003) and Aitken, Berkman and Mak (2001)). It further examines the level of information content of ULOs against 'matched' disclosed limit orders as well as 'matched' market orders.[4]

Our analysis of intraday order data finds that both aggressive limit order submissions and cancellations are associated with short-term price impacts.[5] These price impacts are statistically significant for both disclosed limit orders and undisclosed limit orders measured at 1, 2, 5, and 10 minute intervals subsequent to order submission (cancellation). However, there is no evidence that ULO submissions/cancellations are significantly more informative than DLO submissions/cancellations. A direct comparison of the price reaction to ULO submission and market order submission is also performed. At no analysed time interval are market order submissions significantly more informative than aggressive ULO submissions.

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[1] This concept is first described by Copeland and Galai (1983).
[2] Details of regulation changes are outlined in Section 2.
[3] The ASX's Decision on Reforms document, "Enhancing Liquidity on the Australian Equities Market", was published on the ASX website February 2005, available at: http://www.asx.com.au/investor/pdf/market_reforms_decision_paper.pdf.
[4] The Matching Strategy is outlined in Section 3.
[5] Aggressive limit order submission is defined as an order submission that is at or better than the best price, but less that the opposing best price. Although these limit orders do not take liquidity immediately upon execution, they are positioned on the limit order book for potential traders that demand immediacy. Order data is grouped into three separate categories of orders.

Proxies for volatility and liquidity are also examined surrounding ULO submission and cancellation. ULO submissions are not associated with greater volatility than disclosed limit order submissions at all time intervals. There is a significant reduction in the proportional bid-ask spread following aggressive ULO submission. This reduction in proportional spread is greater than the reduction in proportional spread following aggressive disclosed limit order (DLO) submission. This difference is statistically significant at all measured time intervals.

2. Some prior literature

It has long been understood that both transparency, and liquidity, are important characteristics of a well functioning securities market. Greater transparency may enhance market liquidity by reducing the profit making opportunities for informed traders relative to uninformed traders (Pagano and Roell, 1996), yet alternatively, excess transparency might lead to a reduction in liquidity, (see for example, Bloomfield and O'Hara, 1999).

Liquidity exists within order-driven markets through the placement of limit orders by liquidity suppliers. These orders are exposed to the market to attract order flow from liquidity demanders, who place market orders. The level of order exposure risk held by these liquidity suppliers is directly related to the level of pre-trade transparency (D'Hondt, De Winne and Francois-Heude, 2003). Since auction markets are inherently more transparent than dealer markets (Pagano and Roell 1996), the ex-ante exposure of limit orders raises three potential problems for liquidity suppliers. Firstly, order exposure can be harmful to liquidity suppliers if it reveals their trading motives, see (Easley and O'Hara, 1987). This may lead to other market participants changing their trading strategies, reducing the probability that the large limit order will execute. The large limit order trader must then place the limit order at a less favourable price to improve their probability of execution, or submit several smaller orders over time (Esser and Monch, 2004). Secondly, order exposure is harmful if it provides a valuable free trading option. The value of this option increases when the stock price is volatile, when the time between trades increases, when the order is aggressively priced, and when the limit order is of a large size (Copeland and Galai, 1983). Thirdly, order exposure is harmful if it allows for profit taking by parasitic traders (Pardo and Pascual, 2004). So whilst the traditional perspective is that increasing transparency increases equality, and liquidity, total or excess transparency may harm the market by raising these costs of supplying liquidity.

Bloomfield and O'Hara (1999) investigate the role of transparency and find differential effects for pre-trade and post-trade transparency; with quote transparency having no discernable effect on market performance. Flood, Huisman and Koedijik (1999) find a clear trade-off between liquidity and transparency, and Boehmer et al. (2005) contrast with Madhavan, Porter and Weaver (2005) and Aitken, Berkman and Mak (2001). Handa and Schwartz (1996) suggest that "investors want three things from markets: liquidity, liquidity, liquidity", yet there is no simple relationship between pre-trade transparency and liquidity. With an open limit order book and the selective disclosure of broker identification, the ASX may be considered to be a highly pre-trade transparent market.[6] The ASX is motivated to encourage limit order submission through reducing the unnecessary overexposure of liquidity suppliers. The allowance of undisclosed limit orders (ULOs) by market regulators on the ASX reduces pre-trade transparency for potentially greater liquidity (Aitken, Berkman and Mak, 2001). They find that when the relative tick is small traders are more likely to use ULOs because the cost of front-running is lower.

There are two dominant paradigms that surround the usage of ULOs; the "traditional" perspective suggests that ULOs are used by large patient traders. These traders are assumed to be large uninformed traders who use ULOs as a defensive option within an otherwise transparent market. The second perspective suggests that informed traders may exploit ULOs as a trading strategy. Biais, Hillion and Spatt, (1995) find that the state of the order book is an important factor that influences order submission. Aitken, Berkman and Mak (2001) compare the price reaction to the submission of an ULO, to the submission of a "matching" disclosed limit order (DLO).[7] They find that the submission of limit orders measured at one and two minutes are generally *not* associated with any statistically significant price reaction.

2.1 Regulation changes to undisclosed limit orders

Three changes to ULO regulation have occurred over the last decade. On 24 October 1994, the ASX raised the minimum threshold for the usage of ULOs from $10,000 to $25,000, and on 16 October 1996, this threshold was increased further to $100,000. More recently n 1 July 2001, the threshold rose to a level of $200,000.[8] Aitken, Berkman and Mak, (2001) examined the change in market liquidity following the two regulation changes in 1994 and

[6] Further analysis of the ASX and SEATS is given in Section 4.1.
[7] This matching procedure will be discussed in more detail in Section 3.
[8] Given these three changes to ULO regulation and pre-trade transparency within the ASX over the last decade, it is compelling to examine how remaining ULOs may are used under current regulations.

1996. The 1994 regulation change resulted in lower on-market volume and significantly wider bid-ask spreads.

2.2 International Evidence about hidden limit orders

A considerable literature has raised awareness of the role that hidden limit orders (HLOs) have within electronic order-driven markets.[9] HLOs account for over 16% of the LOB on the Brussels Computer Aided Trading System (CATS) System (Degryse 1999); 14% of all orders submitted, and 45% of all depth on the Paris Euro-Nouveau Marché (D'Hondt, Winne and Francois-Heude, 2001); around 12% of order executions on the Island ECN; 22% of the inside depth of Nasdaq stocks under the Super SOES system (Tuttle, 2003); 50% of the book depth (over the best five levels) on the Euronext (D'Hondt, Winne and Francois-Heude, 2003); and 6.54% of submitted volume on the Toronto Stock Exchange (Anand and Weaver, 2004).

The main distinguishing feature of ASX ULO regulation that differs from international HLO regulation is that of time priority. Generally, the hidden quantity within overseas systems sacrifices all time priority. This means, that to encourage order exposure, all disclosed orders at the same price as a HLO, will execute before the hidden quantity, and distinction makes ASX ULO regulation unique.

3. Description of the ASX and SEATS

On 30 June 2005, the ASX was ranked eighth on the Morgan Stanley Capital International (MSCI) global ranking index, with 1774 listed companies, and A$975 billon worth of domestic market capitalisation (ASX 2005). The average daily turnover was approximately A$3.18 billion, with around 87,500 trades per day. However, the ASX remains quite concentrated with the ASX/S&P 20 constituting in excess of 64% of market capitalisation (Standard & Poors 2005). The ASX is an electronic pure order-driven market. Trading occurs continuously from around 10 am until 4 pm.[10] The market opens, and closes, with a call. The ASX is a centralised automated market that connects brokers through a series of interconnected terminals. The limit order book (LOB) is open to the brokers under a system called the Stock Exchange Automated Trading System (SEATS). The full LOB is

[9] For simplification, and to avoid confusion over terminology, all overseas hidden/undisclosed/iceberg orders will be called hidden limit orders (or HLOs). All undisclosed limit orders (or ULOs) will refer to domestic ASX regulation.

[10] The ASX utilises a staggered opening to avoid 'scooping' (or gaming) strategies by brokers.

displayed to both brokers and traders offering a high level of pre-trade transparency.[11] Orders are matched up and executed according to strict price and then time priority. SEATS was introduced on 19 October 1987, allowing the ASX to become a fully automated securities market. The SEATS system does not allocate any formal dealers or specialists. Although brokers may trade as principal under certain regulatory requirements (Aitken, Garvey and Swan, 1995), the Australian SEATS is primarily a client order-driven market. Since 1995, the ASX has allowed for the minimum quantity of shares to be purchased or sold to be a single share and for the maximum quantity to be 999,000,000 (ASX 2005). The open LOB means that number of shares to be purchased or sold is displayed to the remaining market participants. However, like some other order driven markets, such as, the Paris Bourse and the Toronto Stock Exchange, the ASX provides traders with the option to hide the quantity of some limit orders. Until recently regulation allowed all limit orders with a value in excess of $200,000 the option of not revealing the quantity of the order on the LOB. The order type (bid or ask), and price of the order remains on the LOB, whilst the quantity field is replaced with "/u" to represent the undisclosed volume.[12] The ASX regulation of these undisclosed limit orders is unique. No minimum quantity is required to be revealed to the market, and the undisclosed limit order does not sacrifice price or time priority (as seen within international markets that use HLOs or iceberg orders). The undisclosed component of the order executes first (it has time priority), such that the full quantity of the order will only revealed when its value drops below $200,000.

ULOs were to be discontinued in the March quarter 2006, in conjunction with the decommissioning of SEATS and introduction of the CLICK XT™ system[13] (ASX 2005). ULOs are to be replaced with the internationally recognised iceberg order type. Iceberg orders contain both a visible and hidden component. Iceberg orders do not require a minimum hidden quantity, rather each order is (typically) required to display a minimum disclosed volume. All disclosed volume at the same price is executed first before the

[11] However, broker identification is only displayed to other brokers. In the December quarter 2005 the ASX is moving towards removing the pre-trade exposure of broker identification. Similarly to the ULOs, this regulation change attempts to trade-off pre-trade transparency to encourage potentially greater liquidity provision.

[12] For private investors it is probable that they do not have access to the quantity of all individual orders. However, private investors generally do have access to amalgamated order quantities on market depth screens. The undisclosed quantity is not included within these amalgamated quantities either.

[13] The existing SEATS is a robust and capable trading system with significant excess capacity and the CLICK™ system is currently used for derivatives trading, for instruments such as, equity options, index options, index futures, and commodity futures. However, the future CLICK XT™ system may provide efficiencies for the ASX by allowing participants access to all ASX products under the one system.

hidden volume. Then unlike ULOs the presence of an iceberg order is not flagged on the open LOB, or SEATS Trader Workstation. The ASX is also looking to set minimum visible value to around $10,000.

4. The data, research methods and hypotheses

The sample period used runs between 2nd January 2003 and 31st December 2004. This period gives an indication of the current usage of ULOs on the ASX given their regulation has been unchanged since 2001. This sample period permits an examination of whether the ASX's concerns about ULOs is justified. The stocks examined include seventeen of the S&P/ASX 20.[14]

We focus on the price reaction to limit order submission and cancellation. (See Walsh (1997) for discussion of why orders are better than trades for the measurement of information content). We analyse three separate categories of orders.

1) *Aggressive limit order submissions*.[15] Orders with a price, equal to, or better than the best same side price, and less than the best opposing price (i.e. order must not be a marketable limit order).
2) *Less aggressive limit order submissions*. Orders placed behind the best price, however within one or two ticks of the best price.
3) *Aggressive limit order cancellations*. Orders cancelled whilst positioned equal to, or better than, the best same side price on the limit order book.

Many previous studies ignore the role of limit order cancellations (see Cho and Nelling (2000)). Coppejeans and Domowitz (2002) observe that the three key events that affect the state of the LOB include; trades, order submissions, and order cancellations. If an order submission can be taken as information event, so could an order cancellation. Three categories of orders are selected as potential candidates for intraday analysis. We only examines orders that are submitted (cancelled) between 10:30 am and 3:30 pm during normal trading.

This paper analyses a set of ULOs and matching disclosed limit orders (DLOs) using the following criteria: 1) the matching order must be within 10% of the volume of the ULO, 2) the matching order must be of the same type, either a buy or a sell order, and

[14] See Table A1 for the full list of analysed stocks. News Corporation Inc. and News Corporation Inc. Preference shares experience a change of stock code, reverse stock split and movement out of the ASX/S&P 20 index, and are removed from the sample. Westfield Holdings Ltd. (WSF) also changed to Westfield Group (WDC). Section One analysis examines intraday order for all seventeen listed stocks. Section Two analysis is restricted to six ASX-listed companies.

[15] This is the identical order type to that investigated by Aitken, Berkman and Mak (2001).

status, either entered or cancelled, 3) the matching order must be placed within 20 trading days of the ULO, 4) the matching order must not be within 10 minutes before or after ULO submission/cancellation, 5) the bid-ask spread of the matched limit order must be within two ticks of the bid-ask spread of the ULO, 6) the position in the order book of the matched order must match the position of the ULO. A match is obtained once a DLO satisfies all of the above criteria. To avoid multiple matches from the proposed matching strategy the following process is adopted. The absolute deviation between the ULO and matching order is minimised for the following variables, listed according to preference: 1st Order size (or volume), 2nd The bid-ask spread: The spread is the primary, implicit cost of trading, and 3rd Price. To further limit the number of matching orders, such that each ULO has only one matching order, the variation of trading days is also taken into account. The study minimises the absolute variance in the number of trading days between the ULO and the matching order. This can be seen as a fourth preference criterion. Finally, with much of the intraday volatility already accounted for, by eliminating the first half-hour and last half-hour of the trading day, variation in the time of the day is used for the fifth preference criteria. Based on these five 'preference' criteria, no order that met the requirements of the matching strategy is eliminated, and no ULO had multiple matches. This procedure is replicated to attain matching market orders, utilising the set of Category 1 orders previously described.

The main risk faced by informed limit order traders is the risk of non-execution (Anand and Weaver, 2004). However, uniquely on the ASX, an ULO does not sacrifice time priority. All international systems have regulations that specify that the hidden component of a HLO/iceberg order looses *all* time priority, to disclosed volume at the same price. Thus, it is hypothesised that an informed limit order trader may prefer the use of an ULO, to an ordinary DLO. Given informed traders preference for lower transparency, a greater proportion of informed traders are presumed to utilise ULOs. Therefore, a greater price reaction is hypothesised for an ULO submission (cancellation) relative to that of an ordinary DLO.

> ***H1**: The mean price reaction to the submission (cancellation) of an **ULO** is greater than the mean price reaction to the submission (cancellation) of a **DLO**.*[16]

[16] Note that no priori assumption is made into the precise level of information content of a DLO.

The limit order submission (cancellation) is taken as the event, and the short-term price reaction is measured at 1, 2, 5, and 10 minutes, and day close, subsequent to the event. The hypothesis is employed for all three categories of ULOs (and matching DLOs). ULOs create uncertainty into the amount of depth on the market, and this causes "uncertainty in execution timing" (ASX 2005). The submission of an ULO is expected to generate additional uncertainty into the general level of prices due to lower level of pre-trade transparency. This price uncertainty following the placement of an ULO will lead to a greater variance in returns compared to the placement of a DLO.

> ***H2:*** *The variance of price reaction following* ***ULO*** *submission is greater than the variance of price reaction following* ***DLO*** *submission.*

The traditional perspective is that informed traders must trade using market orders, and thus, market orders must contain a greater level of information content (Rock, 1990). However, to minimise price impact, or to supply liquidity, informed traders may place limit orders under certain conditions, see Bloomfield and O'Hara (2005) and Kaniel and Liu (2004). To compare ULOs directly with the impact of market orders we test the following hypothesis.

> ***H3:*** *The mean price reaction to the submission of an aggressive* ***ULO*** *is greater than the mean price reaction to the submission of a market order.*

Since the submission of an ULO reduces the level of pre-trade transparency on the LOB this may correspond to a reduction in the level of liquidity. The existence of additional information content within an ULO (see Hypothesis 1) may contribute to a reduction in liquidity, through higher levels of information asymmetry. There is evidence of this within order driven markets, see Brockman and Chung (1999) and Ahn, Cao and Hamao (2002). The cancellation (of an ULO) removes the part of the adverse selection cost induced by the submission of an ULO, as the trader no longer wishes to trade at that price. We use the proportional spread as a simple proxy for the change is liquidity.

> ***H4****: The mean increase (decrease) in proportional spread following* ***ULO*** *submission (cancellation) is greater than the mean increase (decrease) in proportional spread following* ***DLO*** *submission (cancellation).*

To determine the price reaction we examine returns at 1, 2, 5, 10 minutes and at the day close following ULO/matching DLO, submission, or cancellation. The price reactions to limit orders are measured as the change in price of the opposing quote. For example, for a

buy limit order will be measured as the ask-ask log return, and for sells it is the bid-bid log return[17]. Formally stated,

Return for a buy order: $R_{Buy} = \ln (A_t / A_0)$

Return for a sell order: $R_{Ask} = \ln (B_t / B_0)$

where A_o (B_o) is the best ask (bid) at the time of the order submission/cancellation, and A_n (B_n) is the best ask (bid) at time t= 1, 2, 5, 10 minutes. Returns calculation for the day close is also calculated. This calculation is performed by taking the log of the daily closing price divided by the spread midpoint at the time of order submission/cancellation.

The returns of matching market orders are measured as the change in price of the same side quote. For example, for a buy market order returns will be measured as the log change in the best bid prices, and for a sell market order returns will be measured as the log change in the best ask prices. The two years of order data also provides a large set of matched ULOs/DLOs/market orders. This allows for the use of standard t-tests to compare the difference of mean returns for the different categories of paired or "matched" orders. A simple F-statistic is used to examine the variance of means. This statistic will present evidence regarding ASX's concerns over ULOs destabilising prices.

An additional concern to the ASX may be the affect that ULO submission has on liquidity. A simple proxy for liquidity is the bid-ask spread. Since this study examines a range of stocks, the proportional bid-ask spread is examined. This study examines the direct impact of order submission (cancellation) on proportional bid-ask spreads. The proportional spread is calculated by dividing, the difference between the best ask and the best bid, by, one half of the sum of the best ask and the best bid. The percentage change in proportional spread is calculated from,

Percentage change in spread: $\%\Delta S = \ln (\text{Proportional Spread}_t / \text{Proportional Spread}_0)$

Again, t = 1, 2, 5, 10 minutes following order submission, and $\text{Proportional Spread}_0$ stands for the time of order submission.

[17] For example, for a buy limit order, returns will be calculated as $\ln(A_n/A_o)$. Where A_o is the best ask at the time of the order submission/cancellation, and A_n is the best ask at time n= 1, 2, 5, 10 minutes, day end.

5. Results

We examine matched orders for seventeen ASX-listed stocks[18] from between 2 January 2003 and 31 December 2004. The intraday market reaction to each matched ULO is compared to that of a matching DLO or market order.

Table 1 presents the results for the mean price reactions to matched sets of ULOs and DLOs. Analysis of each order category is given below. Panel A summarises the results for aggressively entered limit orders. Aggressive submission of DLOs and ULOs (Category 1 orders) is associated with a statistically significant mean price reaction measured at 1, 2, 5, and 10 minutes subsequent to order submission. On average, the submission of aggressive buy limit order is associated with an increase in the best ask price, and on average, the submission of sell limit order is associated with a decrease in the best bid price. This finding is an indication of the short-term informativeness of the LOB. For ULOs, the magnitude of the price reaction increases from 0.029% at 1-minute interval following submission, through to 0.042% at 10-minutes following submission. The price reaction to DLOs remains stable at around 0.03% between the 1-minute and 10-minute interval. However, at no measured time interval (1, 2, 5, 10 minutes and day close) are the mean price reactions to ULOs greater in terms of statistical significance at the 5% level. Panel B shows the results of less aggressive limit orders which provide no evidence of significant price reactions. Neither DLO submissions, nor ULO submissions, are associated with a statistically significant price reaction at the 5% level of significance at any measured time interval. The results for aggressive limit order cancellations are shown in Panel C. These are also associated with statistically significant price reactions over each measured time interval (except for cancelled DLOs). This means that on average, cancelled buy limit orders are followed by a decrease in the best ask price, whilst cancelled sell limit orders are followed by an increase in the best bid price. A greater price reaction to a cancelled ULO, compared to that of a DLO is only statistically significant at the 1-minute interval. The Variance of price reaction is also examined in Table 1 that provides F-statistics that examine the ratio of variances of returns. Returns for all limit orders are calculated as the change in the best price on the opposing side of the order book. Thus, these statistics examine if the submission of an ULO leads to greater variation on the opposing side of the

[18] See Table A1 for the full list of analysed stocks.

order book.[19] It is hypothesised that the decrease in the level of pre-trade transparency following the submission of an ULO will generate greater price uncertainty that will lead to a greater variance of returns.

Table 1: ULO-DLO mean percentage returns

	1 min	2 min	5 min	10 min	Day Close
Panel A: Aggressive orders entered (1776 orders)					
ULOs	0.029	0.034	0.039	0.042	0.007
	(15.22*)	(14.98*)	(14.06*)	(10.65*)	(0.37)
DLOs	0.028	0.030	0.031	0.033	0.005
	(14.39*)	(13.42*)	(7.36*)	(6.94*)	(0.28)
t-statistic	0.34	1.10	1.61	1.38	0.06
F-statistic	0.95	1.00	0.44*	0.67*	1.00
Panel B: Less Aggressive orders entered (825 orders)					
ULOs	0.002	0.004	0.005	0.001	0.015
	(0.96)	(1.40)	(1.10)	(0.09)	(0.60)
DLOs	-0.002	-0.003	0.009	0.002	-0.039
	(0.83)	(0.97)	(1.89)	(0.36)	(1.59)
t-statistic	1.26	1.64	-0.61	-0.20	1.54
F-statistic	0.90	0.76*	0.91	0.89**	1.04
Panel C: Aggressive order cancelled (539 orders)					
ULOs	-0.034	-0.045	-0.044	-0.058	-0.100
	(8.77*)	(9.45*)	(7.59*)	(7.52*)	(3.02*)
DLOs	-0.022	-0.040	-0.044	-0.056	-0.042
	(6.21*)	(8.27*)	(7.27*)	(6.03*)	(1.45)
t-statistic	2.28**	0.80	-0.02	0.14	1.31
F-statistic	1.20*	0.99	0.91	0.68*	1.30*

Table 1 examines the mean price reaction for all matched ULOs, between 2 January 2003 and 31 December 2004. Each ULO is paired with a matching DLO. The matching and preference criterion is outlined in Section 6.11. Values in the parentheses are t-statistics for the null hypothesis that the mean return is zero. The t-statistic at the bottom of each panel tests the null hypothesis that the mean price reaction to ULO submission (cancellation) is greater than the mean price reaction to DLO submission (cancellation). The F-statistic at the bottom of each panel tests the null that the variance of returns following ULO submission (cancellation) is greater than the variance of returns following DLO submission (cancellation). For the t-statistics and F-statistics, ** represents significance at the 5% level, and * represents significance at the 1% level. All returns are expressed as percentages. All values are correct to 2 decimal places.

[19] This is also an ideal measure as it is thought that ULOs are potentially being misused by brokers. It is often suggested that brokers may use ULOs to create "an indication of buyer or seller pressure in order to support or achieve a desired price on the opposite side of the order book.

None of the ten F-statistics presented in Panels A and B, exhibit greater variance in returns following ULO submission compared to DLO submission. On the other hand, in three (four) of the ten cases the submission of a DLO leads to a significantly greater level of variance in returns measured at the 1% (5%) level of significance, a finding inconsistent with Hypothesis 2.

Statistically significant F-statistics are also found for the cancellation of orders. Variance of returns following ULO cancellation are significantly higher (lower) than DLO returns measured at the 1 minute (10 minute, day close) following order cancellation. Since the cancellation of an ULO essentially leads to the removal of ex-ante opaqueness, it was to be expected that the variance of returns be equal following ULO/DLO cancellation.

The following analyses separate the bid and ask orders and the results are presented in Table 2. Panels A/B show the results of aggressively placed orders. The separation of buy and sell orders demonstrates that ULO buys are associated with significantly greater mean price reactions than DLO buys, measured at two and five minute intervals. By day close however, the difference in price reaction between ULOs and DLOs is negligible. There is no evidence that ULO sells are more informative than DLO sells. The calculation of returns at day close finds that limit order sells are associated with a significant negative price reaction, whilst buy limit order submissions are associated with negative returns. This day close pattern appears consistently throughout the study, across all order types.20 Buy orders appear willing to pay a premium during the normal trading day, as these orders experience a price reversal at the closing call.

ULOs do not lead to greater volatility on the opposing side of the order book. Again, F-statistics show that in only one of the ten occasions is the variance of returns following ULO submission greater than that of DLO submission. However, in five of the ten occasions DLO returns display significantly greater variance of returns compared to an ULO. The ASX has concerns that ULOs are exploited by brokers to generate a perception of buying/selling pressure, leading to greater price uncertainty on the opposing side of the limit order book (ASX 2005). This finding provides preliminary evidence against Hypothesis 2. We now evaluate Hypothesis 2 for Category 2 orders: the less aggressively entered orders shown in Panel C/D. Returns for both buy and sell ULOs are not statistically different from zero, or from DLO returns. It is therefore unlikely that these orders contain any information content relevant to the short-term movement of prices. Once again, in

[20] This is consistent across both market orders and the three limit order categories.

none of the ten intervals are ULO submissions associated with a significantly greater variance in returns measured at the 1% level. Again, ULOs do not lead to greater volatility on the opposing side of the order book. ASX concerns that ULOs may be exploited by brokers, leading to greater price uncertainty on the opposing side of the limit order book, appear to be unwarranted. The results for aggressive cancelled orders are shown in Panels E/F. The cancelled ULO buys are associated with a statistically greater price impact measured at the 1, and 2 minute interval than DLO buys. This may be consistent with the additional information content found within Category 1 ULO buy orders. However, there is never any statistically different price impact for ULO/DLO cancelled sell orders. Thus, it is unlikely that the market perceives ULO sells to be any more informed than DLO sells.

The analysis into the information content of ULO/DLOs is also performed by examining all ULOs with a value between $200,000 and $1,000,000. The exclusion of all ULOs with a value in excess of $1 million eliminates approximately one third of matched sample.

Table 2: ULO-DLO mean percentage returns- Buy/Sell orders separated

	1 min	2 min	5 min	10 min	Day Close
Panel A: Aggressive buy orders entered (959 orders)					
ULOs	0.032	0.039	0.044	0.050	-0.037
	(11.46*)	(11.94*)	(11.47*)	(9.21*)	(1.30)
DLOs	0.026	0.029	0.032	0.037	-0.039
	(10.24*)	(9.03*)	(7.46*)	(6.79*)	(1.40)
t-statistic	1.57	2.22**	2.08**	1.78	0.07
F-statistic	1.20*	1.04	0.80*	1.03	1.00
Panel B: Aggressive sell orders entered (817 orders)					
ULOs	-0.025	-0.027	-0.032	-0.031	-0.058
	(10.07*)	(9.04)	(8.22*)	(5.63*)	(2.48**)
DLOs	-0.030	-0.031	-0.029	-0.029	-0.058
	(10.10*)	(10.17*)	(3.83*)	(3.52*)	(2.47**)
t-statistic	1.28	1.05	-0.40	-0.25	-0.01
F-statistic	0.70*	0.93	0.27*	0.46*	1.00
Panel C: Less aggressive buy orders entered (446 orders)					
ULOs	0.003	0.003	0.009	0.004	-0.022
	(0.86)	(0.78)	(1.45)	(0.63)	(0.60)
DLOs	-0.001	-0.005	0.005	-0.002	-0.076
	(0.40)	(1.02)	(0.72)	(0.26)	(2.25**)

t-statistic	0.86	1.29	0.43	0.62	1.08
F-statistic	0.78*	0.72*	0.80*	0.84**	1.18**
Panel D: Less aggressive sell orders entered (379 orders)					
ULOs	-0.002	-0.005	0.000	0.004	-0.059
	(0.49)	(1.23)	(0.04)	(0.53)	(1.81)
DLOs	0.003	0.001	-0.013	-0.007	-0.005
	(0.84)	(0.26)	(2.15**)	(0.83)	(0.15)
t-statistic	-0.93	-1.02	1.46	0.97	-1.12
F-statistic	1.09	0.81**	1.10	0.96	0.85
Panel E: Aggressive buy orders cancelled (291 orders)					
ULOs	-0.032	-0.043	-0.041	-0.051	-0.185
	(5.87*)	(6.32*)	(4.90*)	(4.53*)	(3.64*)
DLOs	-0.014	-0.025	-0.031	-0.044	-0.061
	(3.23*)	(5.01*)	(4.56*)	(3.36*)	(1.63)
t-statistic	2.63*	2.11**	0.88	0.40	1.95
F-statistic	1.62*	1.83*	1.47*	0.73*	1.82*
Panel E: Aggressive sell orders cancelled (248 orders)					
ULOs	0.037	0.047	0.048	0.065	0.001
	(6.59*)	(7.19*)	(5.96*)	(6.45*)	(0.02)
DLOs	0.032	0.057	0.059	0.070	0.020
	(5.40*)	(6.58*)	(5.65*)	(5.39*)	(0.44)
t-statistic	0.61	-0.86	-0.87	-0.26	-0.31
F-statistic	0.90	0.58*	0.58*	0.61*	0.81**

Table 2 examines the mean price reaction for all matched ULOs between 2 January 2003 and 31 December 2004. Each ULO is paired with a matching DLO. The matching and preference criterion is outlined in Section 6.11. Values in the parentheses are t-values for the null hypothesis that the mean return is zero. The t-statistic at the bottom of each panel tests the null hypothesis that the mean price reaction to ULO submission (cancellation) is greater than the mean price reaction to DLO submission (cancellation). The F-statistic at the bottom of each panel tests the null that the variance of returns following ULO submission (cancellation) is greater than the variance of returns following DLO submission (cancellation). For the t-statistics and F-statistics, ** represents significance at the 5% level, and * represents significance at the 1% level. All returns are expressed as percentages. All values are correct to 2 decimal places.

Table 3 examines the null hypothesis that bid limit orders are associated with a statistically greater mean price impact, than ask limit orders. Panel A displays strong evidence that aggressive bid ULO submissions are indeed associated with a statistically significant greater price reaction than ULO ask submissions measured at 2, 5, and 10-

minute intervals. Table 3, Panel C also provides strong evidence that the cancellation of aggressive bid DLOs are associated with a statistically significant lower price reaction, than cancelled DLO asks, measured at 1, 2, 5 minute intervals.

Table 3: Bid-Ask limit order asymmetry t-statistics

	1 min	2 min	5 min	10 min	Day Close
Panel A: Aggressive orders entered					
ULOs	1.85	2.87*	2.20**	2.45**	-2.59*
DLOs	-1.02	-0.45	0.40	0.80	-2.65*
Panel B: Less aggressive orders entered					
ULOs	0.94	1.43	1.02	0.03	0.74
DLOs	-0.86	-0.93	1.98**	0.43	-1.45
Panel C: Aggressive orders cancelled					
ULOs	-0.67	-0.41	-0.63	-0.94	2.83*
DLOs	-2.51**	-3.13*	-2.26**	-1.38	0.70

Table 3 presents t-statistics correct to 2 decimal places. t-statistics test the null hypothesis that the mean price reaction to bid limit order submission (cancellation) is greater than the mean price reaction to ask limit order submission (cancellation). ** represents significance at the 5% level, and * represents significance at the 1% level.

The price reaction to limit order submission is compared directly to the price reaction of market orders using a procedure identical to the matching strategy used for DLOs in hypothesis one. Each Category 1 ULO is paired with a matching market order. The results are presented in Table 4. Both market orders and aggressively placed ULOs demonstrate significant short-term price reactions (excluding day close returns). Market order returns are calculated by taking the same side change in the quote. This means that for market orders, on average, a buyer-initiated market order is associated with a subsequent increase in the best bid, and a seller-initiated market order is associated with a subsequent decrease in the best ask. However, at no measured time interval are the returns for ULOs statistically greater than the returns for market orders.

A clear pattern also arises for the variance of returns. Over short-horizons, the variance of market order returns is significantly greater than that of ULOs. This is significant for all measured time intervals up to 10 minutes following submission. The submission of a (non-marketable) limit order is a passive event. Market orders on the other

hand are active. They demand execution certainty and remove standing orders from the limit order book. The market must adjust to the change in the level of liquidity. Thus, the submission of market order may generate additional volatility on both sides of the order book.

Table 4: ULOs-Market orders mean percentage returns

	1 min	2 min	5 min	10 min	Day Close
Entered aggressive orders (808 orders)					
ULOs	0.032	0.039	0.042	0.048	-0.013
	(11.26*)	(11.68*)	(10.08*)	(8.34*)	(0.39)
Market Orders	0.036	0.041	0.052	0.046	-0.028
	(6.57*)	(6.61*)	(6.75*)	(6.89*)	(0.90)
t-statistic	-0.76	-0.39	-1.08	0.19	0.34
F-statistic	0.26*	0.28*	0.30*	0.73*	1.10

Table examines the mean price reaction for matched ULOs between 2 January 2003 and 31 December 2004. Each ULO is paired with a matching market order. The matching and preference criterion is outlined in Section 6.11. Values in the parentheses are t-values for the null hypothesis that the mean return is zero. The t-statistic at the bottom of each panel tests the null hypothesis that the mean price reaction to ULO submission (cancellation) is greater than the mean price reaction to market order submission (cancellation). The F-statistic at the bottom of each panel tests the null that the variance of returns following ULO submission (cancellation) is greater than the variance of returns following market order submission (cancellation). For the t-statistics and F-statistics, ** represents significance at the 5% level, and * represents significance at the 1% level. All returns are expressed as percentages. All values are correct to 2 decimal places.

Table 5 separates buy and sell orders. At no measured time interval is there any statistically significant difference in price reaction between market buy orders, and buy ULOs. Examination of the sell orders finds some (weak) evidence of sell market orders being more informative than sell ULOs at the 5 minute interval.

Table 5 presents the mean price reactions to matching market orders and shows the mean price reaction (averaged between 1 and 10 minutes) for market order buys is 0.04%, and for market order sells, it is 0.04%.

Potential asymmetry of buy and sell orders is examined in Table 6. Significantly greater mean price reactions to aggressive entered buy ULOs over sell ULOs is similar to the data presented in Table 3. However, there is no evidence of any significant asymmetry within market orders between 1 and 10 minutes.

Table 5: ULOs-Market orders mean percentage returns- Buy/Sell orders separated

	1 min	2 min	5 min	10 min	Day Close
Panel A: Buy-orders (404 orders)					
ULOs	0.038	0.052	0.053	0.068	-0.075
	(8.94*)	(10.17*)	(8.30*)	(8.01*)	(1.33)
Market Orders	0.037	0.040	0.045	0.056	-0.101
	(4.20*)	(4.40*)	(4.60*)	(5.58*)	(1.95)
t-statistic	0.06	1.08	0.76	0.88	0.33
F-statistic	0.23*	0.31*	0.44*	0.71*	1.19**
Panel A: Sell-orders (404 orders)					
ULOs	-0.025	-0.025	-0.031	-0.027	-0.049
	(6.87*)	(6.01*)	(5.79*)	(3.58*)	(1.49)
Market Orders	-0.035	-0.042	-0.059	-0.036	-0.044
	(5.35*)	(4.98*)	(4.95*)	(4.08*)	(1.26)
t-statistic	1.33	1.78	2.12**	0.71	-0.10
F-statistic	0.31*	0.25*	0.20*	0.76*	0.89

Table examines the mean price reaction for matched ULOs between 2 January 2003 and 31 December 2004. Each ULO is paired with a matching market order. The matching and preference criterion is outlined in Section 6.11. Values in the parentheses are t-values for the null hypothesis that the mean return is zero. The t-statistic at the bottom of each panel tests the null hypothesis that the mean price reaction to ULO submission (cancellation) is greater than the mean price reaction to market order submission (cancellation). The F-statistic at the bottom of each panel tests the null that the variance of returns following ULO submission (cancellation) is greater than the variance of returns following market order submission (cancellation). For the t-statistics and F-statistics, ** represents significance at the 5% level, and * represents significance at the 1% level. All returns are expressed as percentages. All values are correct to 2 decimal places.

Table 6: ULOs/Market orders Bid-Ask asymmetry t-statistics

	1 min	2 min	5 min	10 min	Day Close
ULOs	2.26**	3.99*	2.66*	3.53*	-1.90
Market orders	0.19	-0.15	-0.92	1.53	-2.32**

Table presents t-statistics for the null hypothesis that the mean price reaction to buy limit/market order submission is greater than the mean price reaction to sell limit/market order submission. ** represents significance at the 5% level, and * represents significance at the 1% level. All t-statistics are correct to 2 decimal places.

Table 7 examines the direct impact of limit order submission (cancellation) upon the proportional spread[21]. Aggressive ULO submissions are found to have a significant impact upon the proportional bid-ask spread, at all measured time intervals following submission.

[21] The proportional spread provides a simple proxy for the change in the level of liquidity.

At 1-minute following ULO submission, there is a significant decrease in the proportional spread of 2.4%. The proportional spread continues to decrease by up to 4.6%, 5-minutes following ULO submission. Aggressive DLO submissions are also associated with mean decreases in the proportional spread. However, these decreases are smaller and are only statistically different from zero at the 5-minute interval. The reduction in the mean proportional spread following aggressive ULO submission is also significantly greater than the change in proportional spread following DLO submission at *all* time intervals.

Analogous to the investigation of returns in hypothesis one, the investigation into spreads is impacted by the change in liquidity caused by the limit order submission (cancellation) itself. Thus, the measurement of the spread (that includes the same side quote) is not free from this potential bias. This finding may imply that ULOs that are placed more aggressively within the spread and/or are harder to fill. Nevertheless, this also means that ULOs are associated with significantly greater liquidity, as measured by the change in proportional spread.[22] Additionally, the mean proportional spread also continues to decrease following the order submission.

Panel B, Table 7 presents similar results to that in Table 1 and Table 7 shows less aggressive limit order submissions have no statistically significant impact upon the proportional spread, at any measured time interval. This is expected given that limit orders entered behind the best price have no impact upon the spread, and only add to market depth.

In contrast to evidence of significant short-term price impacts to limit order cancellations (seen in Table 1), Panel C, Table 7 shows that generally limit order cancellations have little impact upon the change in proportional spread. Only DLO cancellations are associated with a significant increase in the proportional spread, at the 1 minute time interval. It was hypothesised that the mean decrease in the proportional spread following ULO cancellation is greater than the mean decrease following DLO spread. The market appears to react slowly to ULO cancellation. The spread increases at 1 and 2 minute intervals, before decreasing gradually at the 5 and 10 minute interval. However, the decrease in the proportional spread in not significant from zero, or from the change in spread following DLO cancellation.

[22] This analysis is only relevant for the comparison of ULOs, and matching DLOs. It is not used for the comparison of ULOs to market orders.

Table 7: ULO-DLO mean % change in proportional spread

	1 min	2 min	5 min	10 min
Panel A: Aggressive Orders Entered (1763 orders)				
ULOs	-2.42	-3.52	-4.63	-4.00
	(3.29*)	(4.81*)	(6.16*)	(4.84*)
DLOs	-0.25	-1.01	-1.75	-1.23
	(0.33)	(1.31)	(2.27**)	(1.55)
t-statistic	-2.05**	-2.35**	-2.67*	-2.41**
F-statistic	0.94	0.90*	0.96	1.09**
Panel B: Less Aggressive orders entered (822 orders)				
ULOs	0.14	-0.18	0.01	-0.54
	(0.16)	(0.18)	(0.01)	(0.47)
DLOs	0.83	0.94	1.68	0.06
	(0.84)	(0.85)	(1.46)	(0.05)
t-statistic	-0.51	-0.74	-1.05	-0.37
F-statistic	0.88**	0.84*	0.92	1.01
Panel C: Aggressive Orders Cancelled (539 orders)				
ULOs	1.22	0.32	-0.89	-1.83
	(1.00)	(0.27)	(0.69)	(1.69)
DLOs	2.95	-0.48	1.12	-0.78
	(2.91*)	(0.49)	(0.97)	(0.66)
t-statistic	-1.09	0.52	-1.16	-0.66
F-statistic	1.46*	1.52*	1.23*	0.73*

Table examines the mean percentage change in proportional spread for matched ULOs between 2 January 2003 and 31 December 2004. Each ULO is paired with a matching DLO. The matching and preference criterion is outlined in Section 6.11. Values in the parentheses are t-values for the null hypothesis that the mean change in proportional spread is zero. The t-statistic at the bottom of each panel tests the null hypothesis that the mean price reaction to ULO submission (cancellation) is greater than the mean price reaction to market order submission (cancellation). The F-statistic at the bottom of each panel tests the null that the variance of proportional spread following ULO submission (cancellation) is greater than the variance of proportional spread following market order submission (cancellation). For the t-statistics, and F-statistics, ** represents significance at the 5% level, and * represents significance at the 1% level. All changes in proportional spreads are expressed as percentages. All values are correct to 2 decimal places.

6. Conclusion

The intraday price reaction between ULOs and matching DLOs/market orders is examined and the submission of aggressive limit orders is found to be associated with significant (short-term) price reactions. The large price reaction to market orders, relative to limit orders, by Aitken et al. (2001) is also likely to have been caused by liquidity. Short-term liquidity imbalances driven by large market orders on illiquid stocks may affect both sides

of the order book and be misinterpreted as information (Hall and Hansch 2004). Despite evidence of short-term information content ULO submissions and cancellations provide little evidence of additional information content over that of ordinary DLOs, and market orders. The submissions of ULOs are also associated with lower volatility of returns when compared to that of DLOs and market orders. The proportional spread shows a significant decrease following the submission of ULOs. This decrease in the proportional spread is significantly greater than for DLOs. Our findings fail to support all four suggested hypotheses: ULOs are associated with a level of information content that is not significantly different to that of DLOs. Although no additional information content is uncovered with intraday analysis, the findings are consistent with the view that ULOs are used to lower the option value of limit orders and with the intentions of ASX ULO regulation. The ASX sacrifices pre-trade transparency for potentially enhanced levels of liquidity. This relation occurs by reducing the unnecessary overexposure of liquidity suppliers.

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Table A1: Sample of ASX-listed Stocks	
ASX Code:	**Company Name:**
AMC	Amcor Limited
AMP*	AMP Limited
ANZ*	Australia and New Zealand Banking Group Limited
AWC	Alumina Limited
BHP*	BHP Billiton Limited
CBA*	Commonwealth Bank Of Australia
CML	Coles Myer Limited
FGL	Foster's Group Limited
NAB*	National Australia Bank Limited
QBE	QBE Insurance Group Limited
RIO	Rio Tinto Limited
SGB	St George Bank Limited
TLS*	Telstra Corporation Limited
WBC	Westpac Banking Corporation
WES	Wesfarmers Limited
WOW	Woolworths Limited
WPL	Woodside Petroleum Limited

This table presents the 17 ASX-listed stocks used for analysis in Section 1, between 2 January 2003 and 31 December 2004. Section 2 analysis is restricted to six stocks (indicated by a * in the first column), between 2 January 2003 and 31 December 2004. Trade and order data is not available for AMP on 1, 2 May 2003, and 16 October 2003, and for ANZ on 24, 27 October 2003 due to suspended trading. News Corporation Inc. and News Corporation Inc. Preference shares experience a change of stock code, reverse stock split and movement out of the ASX/S&P 20 index, and are removed from the sample. Westfield Holdings Ltd. (WSF) changed to Westfield Group (WDC).