Hidden Liquidity

1. Introduction

Electronic limit order books are central to financial markets. They are common in international financial markets, and both the NYSE and NASDAQ have pending mergers that will enable them to enhance their electronic trading protocols.[1] Electronic limit order books also process large numbers of trades and orders. For example, INET executes about ¼ of all NASDAQ trades[2], and hidden limit orders comprise about 14 (45) percent of the total limit orders submitted (quoted depth) at the Paris Euro-NM (D'Hondt, DeWinne, and Francois-Heude 2004), and about 12 percent of all order executions and shares traded through the Island ECN (Hasbrouck and Saar 200).

While for the most part electronic limit order books are transparent, in that they reveal order prices and quantities, many allow "hidden orders," in which the order's (and trade's) information is not revealed to the market nor reflected in the National Best Bid and Offer (NBBO) quotes. Considerable theoretical (e.g., Glosten and Milgrom 1985, Copeland and Galai 1983) and empirical (e.g., Lee, Mucklow, and Ready 1993; Krinsky and Lee 1996; Affleck-Graves, Callahan, and Chipalkatti 2002) examine market maker reactions in response to changes in information asymmetry. Little is known however about traders' hidden order strategies around information events. This study examines (a) how hidden order activity changes, and (b) the cross-sectional determinants of those changes, around quarterly earnings announcements.

This issue is important for several reasons. First, hidden orders are prevalent. Second, it is possible that increases in the number of hidden orders or their order sizes might mitigate, at

[1]International examples include the Australian Stock Exchange, Euronext, the London Stock Exchange, the Spanish Stock Exchange, the Toronto Stock Exchange, and several others. NYSE is merging with the Archipelago Exchange while NASDAQ is merging with INET, the electronic trading platform formed by the merger of the Island and Instinet ECNs.

[2] For example, in March 2005, INET's total matched average daily U.S. equity share volume was 574 million shares, or 13.8% of the U.S. equity market. This volume consisted of 493 million shares of NASDAQ-listed stocks, or a 26.9% share of the NASDAQ-listed market, and 81 million shares of U.S. exchange-listed stocks, or 3.5% of the U.S. exchange-listed market. See www.investor.instinetgroup.com for more details on annual INET volume.

least to some extent, the drop in quoted depth typically observed at earnings announcements (Lee et al 1993). Thus, a trader's ability to supply liquidity to the market without disclosing key order details (e.g., full order size) that might reveal that trader's private information might be an important mechanism in enhancing overall market liquidity. Third, extant theory is based primarily on dealer markets in which the dealer uses price and quantity quotes to protect himself against informed traders. Hidden orders might provide an analogous mechanism by which anonymous traders protect themselves in electronic limit order markets.

Earnings announcements provide a powerful setting in which to examine hidden order activity since (a) earnings announcements are "anticipated" events (they occur quarterly, most firms release earnings at a relatively standard lag relative to quarter-end, and many firms publicize "expected" dates on which they plan to release earnings), and (b) earnings announcements convey information to the market. Analytical studies suggest private information acquisition activities will increase before anticipated information events (Demski and Feltham 1994; McNichols and Trueman 1994), and specialists will protect themselves against trading with better-informed traders by reducing market liquidity. A hidden limit order, since it conceals potentially informative details about the trader's private information (e.g., full order size), might be particularly useful to the trader at a time of heightened private information gathering and active trading. On the other hand, the benefit of concealed information via a hidden limit order carries a potentially important cost, in that the hidden order loses time priority to the non-hidden orders in the electronic limit order book. Thus, the hidden order risks execution after other traders have usurped some, or all, of that trader's private information.

We address three research questions. Our first research question examines *whether hidden order usage changes around earnings announcements*. We focus on four attributes of hidden limit orders: hidden order volume as a percentage of overall trading volume, the average size of an executed hidden order trade, the number of hidden orders placed, and the full size of

hidden limit orders placed.[3] If traders find hidden limit orders useful in concealing their information, we expect these hidden order attributes to increase around earnings announcements. Alternatively, if traders' concerns of risking unexecuted orders due to loss of time priority outweigh the benefits of concealing their information via hidden orders, we expect decreases in hidden order measures around earnings announcements.

Our second research question examines *whether changes in hidden order activity around earnings announcements are related to aspects of the firm's pre-announcement information environment, the information conveyed by the earnings announcement, and/or changes in quoted liquidity around the earnings announcement.* Research shows that quoted liquidity measures are related to measures of the firm's information environment (Yohn 1998; Affleck-Graves et al 2002; Roulstone 2003) and the information conveyed by the earnings announcement (Lee et al 1993). We expand this line of inquiry to examine whether changes in hidden order activity around earnings announcements are related to the number of analysts following the firm, the dispersion in analysts' earnings forecasts before the earnings announcement, the level of earnings surprise (actual minus expected earnings), the stock market reaction to the earnings announcement, and changes in quoted spreads and depths.

Our third research question examines *whether changes in hidden order usage around earnings announcements differ for buy versus sell orders*. Evidence suggests that institutional traders comprise a large percentage of the users of electronic limit order trades. Further, Macey and O'Hara (1997) note in a review of prior research that "trade direction is one of the most important factors affecting the execution costs of large trades." Thus, we assert trade direction might also be important in understanding hidden order activity.

[3] A hidden limit order has a full size (e.g., 10,000 shares) that the trader wishes to trade, and a display condition (e.g., 1,000 shares) that provides the increments in which the full size should be traded. Thus, an order of 10,000 shares with display of 1,000 shares will appear as 10 hidden limit order trades in our data. We develop an algorithm to reconstruct the total order size for one order from which multiple hidden limit order trades might have been generated.

Our sample comprises 746 firms over 2002-2004. We show that hidden order activity significantly increases around earnings announcements. In particular, hidden (displayed) order volume, as a percentage of total trading volume, significantly increases (decreases) on days 0 and +1 relative to the I/B/E/S quarterly earnings announcement date. In addition, the number of hidden orders placed, the average size of a hidden order trade executed, and the full size of a hidden order placed, all significantly increase around quarterly earnings announcements. Interestingly, increases in these latter three variables persist for about seven trading days after the earnings announcement date.

Our analyses also provide insight into the cross-sectional determinants of changes in hidden orders around earnings announcements. Increases in hidden order volume, as a percentage of overall trading volume, are greater for firms with larger analyst following, more dispersion in analysts' earnings forecasts, greater earnings surprise, and larger changes in quoted depths, and smaller for firms with greater stock price reaction to the earnings announcement and larger changes in quoted spreads. We also document that changes in hidden order activity around earnings announcements are related to measures of the firm's pre-announcement information environment, the information conveyed by the announcement, and changes in quoted liquidity around the earnings announcement. Finally, we document important differences in the impact of forecast dispersion and the level of earnings surprise on changes in hidden order variables, depending on whether the order is buyer or seller-initiated.

This study provides several contributions. First, to our knowledge ours is the first study to examine how hidden orders impact liquidity around earnings announcements. We document several new empirical regularities, which in sum suggest that hidden depth increases around earnings announcements, thus mitigating, at least to some extent, the decreases in (quoted) depth typically found at earnings announcements. Thus, our evidence suggests the benefit of concealing information via hidden orders encourages certain traders to provide liquidity in

instances where they otherwise might not trade. Second, ours is also the first study to examine, and document, important determinants of hidden order activity around earnings announcements.

2. Related research

2.1 Hidden orders

Several studies examine various aspects of hidden orders. For example, Esser and Monch (2005) analytically model the optimal strategy of a trader who wishes to liquidate a large position in a single stock within a finite trading window. They then reconstruct the limit order book for a single stock trading on XETRA, the automated trading system on the German Stock Exchange, using data over the first three calendar months of 2002. Their evidence shows that the average volume of a hidden order (16,037 shares) dwarfs that of both pure limit (964 shares) and market orders (1,069 shares). The limit price on these hidden orders is typically 5 to 15 cents above the best bid price. Esser and Monch (2005) also show, for this firm in this sample period, less than 18 percent of all hidden sell orders are executed completely, almost 30 percent received a partial fill before being cancelled or expiring, and the majority (52 percent) of all hidden sell orders were canceled or expired completely unexecuted. In sum, Esser and Monch's (2005) evidence suggests that hidden orders tend be from large traders, who frequently cancel the orders before execution, suggesting that such traders might be trading based on private information.

Pardo and Pascual (2005) attempt to determine, using a sample of 79 firms trading on the Spanish Stock Exchange in 2000, whether hidden orders are motivated by liquidity needs or represent informed trades. Pardo and Pascual (2005) find that hidden orders are concentrated in index stocks, and hidden limit order traders are momentum traders that exhibit herding behavior. Finally, the authors show that when a hidden limit order is detected by other traders, these other traders increase their trading, but on the *opposite* side of the market of the hidden order. In sum, the bulk of Pardo and Pascual's (2005) evidence suggests that hidden order trades are motivated by liquidity concerns.

DeWinne and D'Hondt (2005) examine a sample of 82 Euronext stocks over a three-month period over the last calendar quarter in 2002. For this sample, the displayed depth comprises only about 50 percent of the total depth available, again suggesting the importance of considering hidden depth. These authors' results suggest that the presence of hidden orders impacts traders' behavior; that is, traders seem to infer the existence of hidden depth and adjust their trading strategies accordingly.

In contrast to the above studies, our study examines a longer time period (three calendar years, 2002-2004) for a larger sample of stocks (746). Perhaps more important, our focus is on hidden order activity around quarterly earnings announcements. As earnings announcement dates are relatively predictable (Bagnoli, Kross and Watts 2004), quarterly earnings convey value-relevant information to the market (e.g., Bartov, Givoly, and Hayn 2002), and quoted spreads and depths change around earnings announcements (Lee et al 1993; Krinsky and Lee 1996), we believe study of hidden order strategies around earnings announcements is both natural and important. Next we discuss research that examines changes in specialists' quotes around earnings announcements.

2.2 Changes in quoted market liquidity around earnings announcements

Lee et al (1993) document that quoted spreads (depth) increase (decrease) around earnings announcements of sample of NYSE firms in 1988. Further, the increase in spreads is related to the market reaction to the earnings announcement, as captured by trading volume and cumulative abnormal stock return, to the earnings announcement. Krinsky and Lee (1996) decompose the quoted spread into its three components (adverse selection, order processing, and inventory holding) and find that the adverse selection component of the spread significantly increases around earnings announcements, while the inventory holding and order processing spread components significantly decrease around earnings announcements.

Yohn (1998) examines changes in spreads around quarterly earnings announcements for a sample of NYSE and AMEX firms over 1988-1990. In addition to confirming results in Lee et

al (1993), Yohn (1998) finds that in the nine days before the announcement date, spreads are negatively related to public information availability (measured as market value of equity and number of analysts following), and positively related to earnings variability and the prior market reaction (earnings response coefficient) to prior unexpected earnings. However, changes in spreads around the earnings announcement dates are not related to information availability nor earnings variability. In related work, Roulstone (2003) finds that non-announcement spreads (depths) are lower (higher) for firms with higher analyst following; that is, increased analyst following is associated with enhanced market liquidity.

Like Krinsky and Lee (1996), Affleck-Graves et al (2002) examine the relations between the adverse selection cost component of the spread around quarterly earnings announcements and measures of earnings predictability. Affleck-Graves et al (2002) find that adverse selection costs increase on the trading day of and trading before the earnings announcement for NASDAQ firms for less predictable earnings, but do not increase for NASDAQ firms with more predictable earnings.

In sum, evidence across these studies suggest that aspects of a firm's information environment (e.g. number of analysts following, earnings predictability), are related to measures of market liquidity during non-announcement periods. In addition, evidence in Affleck-Graves et al (2002) suggests that earnings predictability impacts the change in market liquidity at earnings announcement dates. Our study builds on this stream of related work by examining heretofore unexamined metrics of market liquidity, based on hidden orders, around earnings announcements. For example, for more widely-followed firms, the earnings announcement can be expected to provide less new information to the market, and traders' information is likely impounded quickly into stock prices. For such firms, traders' demand for the anonymity of hidden orders might be diminished relative to the need for more immediate execution, thus the use of hidden orders might be less pronounced than in less well-followed firms, where traders' might be very concerned with disclosing information (e.g., order size) that might reveal value-relevant private information to

the market. Likewise, considerable research focuses on whether firms' earnings meet or exceed analyst expectations (e.g., Brown 2001; Bartov et al 2002). Meeting (missing) analyst expectations is good (bad) news, typically accompanied by stock price increases (decreases). Hidden order usage might also vary with firm performance relative to expectations.

2.3 Buy versus sell orders

Considerable research examines how trade direction (buy versus sell) impacts execution costs. For example, research suggests institutional buy orders incur higher implicit trading costs than do institutional sell orders (e.g., Kraus and Stoll 1972; Holthausen, Leftwich, and Mayers 1987, 1990; Chan and Lakonishok 1993, 1995; Keim and Madhavan 1996. Chan and Lakonishok (1993) and (Saar 2001) explore information-based explanations to explain this buy-sell cost asymmetry. Chiyachantana et al (2004) use Plexus institutional trading data and document that the buy-sell cost asymmetry is sensitive to underlying market conditions (bullish versus bearish). Since institutional traders are frequent users of electronic limit orders, we examine whether there is an asymmetric response of buy and sell hidden order activity around earnings announcements.

3. Overview of electronic limit order markets and our hidden order data

3.1 Overview of electronic limit order markets

Unlike a market with specialists (e.g. the NYSE) or dealers (e.g. the NASDAQ), an automated limit order market is a trading platform where anonymous buyers and sellers post price-quantity pairs – the quoted bid (or ask) prices and associated quantities ("depths") of a stock that she is wiling to sell (or buy). Unlike other markets, the automated limit order market does not include an intermediary who has a mandate to post bid and ask prices at all times. Instead, as investors submit their buy and sell prices and quantities, these orders enter the order book and are organized by strict price-time priority. An investor who subscribes to INET can directly enter his price-quantity bid into the system using the OUCH protocol. All valid orders queue up in the

limit order book by price priority. When two orders enter the book at the same price, time priority decides the ranking of the order in the book.

The highest bid price and the lowest ask price in the order book form the "inside spread." When two orders are placed at the same price, the order placed earlier gets priority in the order book. When an incoming order meets or crosses the best price on the opposite side, a trade is executed. As a result of the 1997 order handling rules the best quotes on an electronic limit order platform (such as Instinet, ArcaEx, etc.) are backward integrated into the NASDAQ Level II feed and displayed to the entire market.[4]

An important feature of most electronic limit order books is the order display options it allows investors. Most limit order markets (for example, EuroNext, INET, Australian Stock Exchange, Spanish Stock Exchange) allow investors to place hidden limit orders where part or all of the total posted depth is non-displayed. For example, on INET when a customer posts a hidden order, INET does not display this order and does not show it on the Level II feed. The order sits 'hidden' on the INET limit order book and if it gets a crossing order, it gets execution.[5] This is a key feature of our data source, which we discuss next.

3.2 INET limit order book data

For the INET electronic limit order book information, we use the proprietary ITCH data. ITCH is the vendor-level data feed of the INET electronic platform. ITCH disseminates information about all orders and executions on INET in real time. INET provides its more than 800 U.S. broker-dealer subscribers access to the one of the largest electronic trading platforms in

[4]For detailed information on the 1997 order handling rules refer to Barclay (2001).

[5] As a simple example, suppose for stock XYZ the inside INET prices are $20.10 and $20.20 and an investor submits a hidden bid order at $20.11. When INET gets a sell order at $20.11 or below, the hidden order will get executed at $20.11. Since the $20.11 price was hidden from the market, other investors could not see it and therefore could not step-ahead of this order (by bidding $20.12), and thus the hidden order got execution at its quoted price.

the U.S., capturing over 25 percent of NASDAQ trading volume. INET's electronic limit order book matches incoming orders with existing orders in the book based on the following priorities:

a) Price – the limit order price of the order,

b) Display – non-display or 'hidden' orders lose time priority over display orders, and,

c) Time – the exact time the order was placed (in milliseconds).

INET does not accept market orders. All incoming orders are limit orders. If a trader wants immediate INET execution, (s)he must place a limit order that meets or crosses the best opposing price. Upon receiving an order from the subscribing broker-dealer/investor, the INET system performs a series of checks (i.e., it verifies the stock symbol and checks that the security is not halted, etc.). After clearing those checks, INET's system instantaneously scans its limit order book to determine if there is a matching order. If a matching order exists, the incoming order is executed immediately. If a matching order does not exist, a display order is placed on INET's limit order book until a matching order is received, or until the order is cancelled.[6] If the order is entered as a non-display order, then it is entered into the limit order book but is hidden from view by other traders. INET automatically clears all unmatched limit orders from its system at the end of each trading day.

The ITCH feed is made up of a series of sequenced messages that describe orders added to, removed from, and executed on INET. There are six types of messages:

Add Order – an add order message indicates that a new order has been accepted by the INET system and added on to the display book. It includes a day-unique order reference number, a time stamp, buy or sell reference, price and the display condition (hidden or displayed).

Modify Order – references an order previously submitted, using the order reference number. A modify order always reduces the number of shares currently pending in the referenced open order by the number of shares indicated. An increase would be a new add order.

[6] While there is no source to obtain consolidated information on cancelled orders at the end of the day on INET, Hasbrouck and Saar (2002) document that for their sample over ¼ of all limit orders submitted to the Island ECN are cancelled within two seconds or less.

Order Executed – is a message sent whenever an order on the book is executed in whole or in part. The execution price is always equal to the limit price of the order as indicated in the add-order message.

Order Cancel – is a message sent whenever an order on the book is modified as a result of being cancelled in part or whole.

Trade Message – provides information about execution events that involve orders not visible on the INET book. Since no add-order message is sent for non-displayed orders, it is not possible to send a modify order message when a hidden order is executed. Instead a trade message is transmitted when a hidden order is executed in whole or in part.

Broken Trade – is a message sent when a trade falls under the "clearly erroneous" category, pursuant to INET's clearly erroneous procedure. A trade break is final; once a trade is broken, it can not be reinstated.

When a non-display order is entered, it is not possible to identify a time for the order placement, since no add order message is generated. However, when a hidden order is executed, a trade message is generated. Thus, we develop an algorithm to identify hidden orders in the limit order book after the order has been executed.[7]

We do not include orders which are cancelled and include only executed orders. Since our focus is on hidden orders, we capture all information on each hidden order trade from the LOB. Thus for each hidden order, we identify whether the order was a buy or a sell order, the trade size for each hidden buy and sell and the daily number of hidden order trades disaggregated by buy and sell. Additionally, we implement an inter-temporal order aggregating algorithm by tracking all hidden order trades which come from one single order. Hidden orders often have a smaller display condition than the total order size. For example, a 10,000 share order may have a 1,000 shares display condition, and once the first 1,000 are executed, the next 1,000 will be

[7] Because hidden orders can be inferred only after execution, it is not possible to identify hidden order cancellations in the ITCH data feed.

shown in the LOB. Our algorithm identifies all such 1,000 hidden order trades that came from the original 10,000 share order placement and reports the original order size of 10,000.

4. Sample and data

4.1 Sample selection

Our data come from four different sources: INET, I/B/E/S, the Trade and Quote database (TAQ), and CRSP. From the ITCH database we identify all stocks that continuously traded on the INET ECN from 01/02/2002 to 12/31/2004. This yields 866 firms in total. For each firm with data on the ITCH database, we collect data for each quarterly earnings announcement on I/B/E/S over January 1, 2002, through December 31, 2004. Our third data source is the Trade and Quote (TAQ) data provided by the NYSE. We use the TAQ data to collect information on a stock's price, quoted bid and ask prices and depth. Finally, we obtain stock return data from the CRSP daily return files. We are left with 746 firms in our final sample.

4.2 Variable measurement

4.2.1 Measurement of hidden liquidity measures

Using the message stamps in the ITCH files, we identify two broad categories of orders – the displayed order volume ($DISPLAY_{i,q,d,t}$) and the hidden order volume ($HVOL_{i,q,d,t}$), each measured in shares for firm i on day d around announcement of quarter q earnings in year t. Both variables are scaled by that firm's total share volume on that day. In addition, we focus on three aspects of hidden orders: average hidden order trade size ($HTRDSIZ_{i,q,d,t}$), number of hidden orders placed ($HORDNUM_{i,q,d,t}$), and the total size of hidden orders ($HTOTSIZ_{i,q,d,t}$). $HVOL_{i,q,d,t}$, $HTRDSIZ_{i,q,d,t}$, $HORDNUM_{i,q,d,t}$, and $HTOTSIZ_{i,q,d,t}$ are used to compute our primary dependent variables. Table 1 provides definitions for all the variables used in this study.

We focus on "abnormal" changes in ITCH variables around earnings announcements. We define our non-event period as the 20 days {-20 to -11} and {+11 to +20} relative to the

I/B/E/S earnings announcement date. Following Lee, Ready, and Seguin (1994) and Corwin and Lipson (2004), we then compute firm-specific averages of each of our ITCH variables in this non-event period, and examine changes in these variables around the earnings announcement date, relative to their non-event means. These changes are then expressed as a percentage of their non-event period means. For example, for each firm-day surrounding the quarterly earnings announcement date, we define abnormal hidden order volume as

$$\Delta HVOL_{i,q,d,t} = \frac{HVOL_{i,q,d,t} - \overline{HVOL_{i,q,N,t}}}{\overline{HVOL_{i,q,N,t}}} * 100, \quad (1)$$

where the second term after the equal sign is the mean value of hidden order volume over the nonannouncement period N, defined above.

4.2.2 Independent variables

For each firm on the ITCH database, we collect, for each quarterly earnings announcement on I/B/E/S over January 1, 2002, through December 31, 2004, the following:

- Quarterly earnings announcement date,
- Actual reported value of quarterly earnings per share ($ACT_{i,q,t}$),
- Last consensus mean forecast of that quarter's earnings before the announcement ($EXP_{i,q,t}$),
- The standard deviation in analysts' forecasts of that quarter's earnings, scaled by the absolute value of last consensus mean forecast of that quarter's earnings ($DISP_{i,q,t}$),[8]
- The number of analysts' forecasting that quarter's earnings ($NUMEST_{i,q,t}$).

$NUMEST_{i,q,t}$ and $DISP_{i,q,t}$ form our "pre-announcement" information environment variables. We take natural logs of both to combat skewness, and following Roulstone (2003) take the absolute value of $DISP_{i,q,t}$.

We then define earnings surprise ($SURP_{i,q,t}$) as $ACT_{i,q,t}$ minus $EXP_{i,q,t}$. Following Lee et al (1993), we also the include stock market response to the earnings announcement. This variable

[8] Other studies (e.g. Roulstone 2003) also examine this scaled measure of dispersion, sometimes referred to as the "coefficient of variation."

($CAR_{i,q,t}$) is the risk-adjusted cumulative abnormal stock return from trading day 0 to trading day +1, where trading day 0 is the announcement date from I/B/E/S. We compute the market model parameters to compute $CAR_{i,q,t}$ using daily stock returns and value-weighted market returns from CRSP, over an estimation period extending from day -146 to day -11, relative to the earnings announcement date. Following Lee et al (1993) we take the absolute value of $CAR_{i,q,t}$. Together, $SURP_{i,q,t}$ and $CAR_{i,q,t}$ capture the information conveyed by the earnings announcement.

Finally, we measure changes in "quoted liquidity" as the changes in quoted spread ($\Delta SPREAD_{i,q,d,t}$), and quoted depth ($\Delta DEPTH_{i,q,d,t}$) around the earnings announcement. These variables are measured using the approach discussed in section 4.2.1 (equation 1), and then cumulated over days 0 through +1 relative to the earnings announcement date. Finally, we control for $\Delta DISPLAY_{i,q,d,t}$ and stock price ($PRICE_{i,q,d,t}$).[9]

5. Results

5.1 Univariate analyses

We perform univariate and multivariate tests. Our univariate tests examine the significance of the changes in our ITCH variables from their non-event means. We also perform these tests for sample partitions based on a) analyst following (above or below median), b) dispersion in analysts forecasts (above or below median), and c) whether the firm met or failed to meet analysts' expectations.

Table 2 presents the (across sample) mean values of percentage changes in hidden order variables, displayed orders, and quoted spreads and depths. From Table 2, it is evident that hidden orders, as a percentage of overall volume, increase significantly around earnings announcements. For example, on day 0 (+1) $\Delta HVOL$ increases on average by over 5 (9) percent relative to its nonevent period mean, and both increases are statistically significant at less than the

[9] Henceforth we drop subscripts for notational convenience.

0.01 level. Conversely, *ΔDISPLAY* decreases on average by over 1 percent on each of the days 0 and +1. Thus, hidden (displayed) orders comprise an increasing (decreasing) portion of share volume around quarterly earnings announcements.

Likewise, hidden order trade sizes, total sizes, and the number of hidden orders are all significantly higher on days 0 and +1 surrounding the earnings announcement, and significant increases in each of these variables relative to non-event means persist well after the earnings announcement. In sum, these results suggests hidden order activity is significantly elevated around quarterly earnings announcements. Thus, our results suggest hidden orders provide significant liquidity to the market at a time when "quoted liquidity" (quoted spreads and depths) typically falls (Lee et al 1993).

Finally, Table 2 also shows that quoted liquidity (as measured by quoted depth and spread) falls around earnings announcements for our sample, consistent with evidence in Lee et al (1993). Although quoted depth (at both bid and ask) surprisingly increases on day 0, the percentage decreases on days +1 and +2 are larger than the day 0 increase (all are statistically significant at no worse than the 0.05 level), while both quoted and relative spreads significantly increase on each of the days -1 through day +1.

5.2 Multivariate regression analyses

We use ordinary least squares to estimate variations of the following model:

$$\Delta DEPVAR = \alpha_0 + \alpha_1 Ln(NUMEST) + \alpha_2 Ln(DISP) + \alpha_3 |SURP| + \alpha_4 |CAR| + \alpha_5 PRICE + \alpha_6 \Delta DISPLAY + \alpha_7 \Delta SPREAD + \alpha_8 \Delta DEPTH + e, \quad (2)$$

where *ΔDEPVAR* is either *ΔHVOL*, *ΔHORDNUM*, *ΔHTRDSIZE*, or *ΔHTOTSIZ*. To combat skewness in their distributions we use the natural logarithms of *NUMEST* and *DISP*. Following Affleck-Graves et al (2002) and Lee et al (1993) respectively we use the absolute values of *SURP* and *CAR*.

Table 4 presents the results of estimating equation (2) separately with our four dependent variables. The first column of results in Table 4 reveals that the increase in hidden order volume, relative to total trading volume, is related to variables that capture the firm's pre-announcement information environment, the information conveyed by the earnings announcement, and changes in quoted liquidity around the earnings announcement. In particular, the coefficients on *Ln(NUMEST)*, *Ln(DISP)*, |*SURP*|, and *ΔDEPTH* are each positive and significant at $p<0.01$, while the coefficients on |*CAR*| and *ΔSPREAD* are both negative and significant at $p<0.01$.

The final three columns of Table 4 presents results of estimating equation (2) with *ΔDEPVAR* defined as *ΔHORDNUM*, *ΔHTRDSIZ*, and *ΔHTOTSIZ* respectively. In interpreting these results it is important to recall that each variable is scaled by its mean value over the nonevent period, whereas *ΔHVOL* is scaled by total trading volume. Thus, one cannot interpret *ΔHORDNUM* and *ΔHTRDSIZ* as components of *ΔHVOL*, as the variables use different scalars.

With respect to the impact of pre-announcement information environment on hidden order strategies around earnings announcements, traders in more widely-followed firms submit more hidden orders, with a higher full size, while traders in firms with more dispersed analyst earnings expectations submit fewer hidden orders, with a smaller full size. The average trade size of executed hidden orders is inversely related to both *Ln(NUMEST)* and *Ln(DISP)*, although neither coefficient is significant at conventional levels.

Information conveyed by the earnings announcement also impacts hidden order activity around earnings announcements. Larger earnings surprises are related to fewer numbers of hidden orders placed and smaller full size of hidden orders, but a higher average trade size on executed hidden order trades. A larger market response to the earnings announcements is related to significant increases in all three hidden order activity variables. Finally, hidden order traders also seem to gauge their activity based on changes in quoted market liquidity. Larger increases in quoted depth (spread) are associated with increases (decreases) in all three hidden order variables.

Table 5, which presents results of estimating equation (2) separately on buyer versus seller-initiated transactions, reveals further insights into hidden order activity. First, while increased levels of dispersion and earnings surprise are related to larger hidden order volume at the earnings announcement, both results are concentrated in buy orders. In addition, the coefficients on *ΔSPREAD* and *ΔDEPTH* switch signs across the buy and sell regressions; however, only the coefficient on *ΔSPREAD* in the "buy" regression is statistically significant.

For the most part the hidden order activity variables in the last three columns of Table 5 bear similar relations to the independent variables in the buy and sell regressions. However, these separate regressions reveal insights with respect to the role of dispersion. Specifically, dispersion is not significant in explaining any of the changes in *ΔHORDNUM*, *ΔHTRDSIZ*, or *ΔHTOTSIZ* in the "buy" regressions, but is inversely related to each of these dependent variables in the "sell" regressions.

5.3 Sensitivity analyses

We cumulate the "change" variables used in our regression analyses over the days 0 through +1 relative to the I/B/E/S earnings announcement date. Evidence in DellaVigna and Pollet (2005) suggests that for our sample period, the I/B/E/S earnings announcement date almost perfectly matches the Lexis-Nexis newswire date, thus motivating our cumulation period of {0, +1}. We estimated the regressions reported in Tables 4 and after cumulating all "change" variables over the period {-1, +1} relative to the I/B/E/S announcement date. Results, reported in Tables 6 and 7, are qualitatively similar to those previously reported.

6. Conclusion

Hidden limit orders, where key order details are not displayed to the market, are an increasingly important phenomenon on many organized stock exchanges and electronic trading platforms. This study examines hidden order activity around quarterly earnings announcements for a sample of 746 New York or NASDAQ stock exchange firms over 2002-2004. The results

show that trades from hidden (displayed) orders comprise an increasing (decreasing) portion of overall trading volume around quarterly earnings announcements. Further, the number of hidden orders placed, the average trade size of hidden orders executed, and the full size of hidden orders placed all increase around earnings announcements. This evidence suggests that hidden orders provide an important source of liquidity to the market, at a time when decreases in quoted depth and increases in quoted spreads typically lessen overall market liquidity (Lee et al 1993). We also document several significant cross-sectional determinants of changes in hidden order activity around earnings announcements. Finally, we also show that the impact of earnings surprise and the dispersion in analysts' earnings forecasts on changes in certain hidden order variables depends on whether the hidden order is buyer or seller-initiated.

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TABLE 1
Variable Definitions

$NUMEST_{i,q,t}$	Number of individual analysts' quarterly earnings forecasts included in the consensus forecast of upcoming quarterly earnings, from the I/B/E/S Summary database
$DISP_{i,q,t}$	Dispersion in analysts' quarterly earnings forecasts included in the consensus forecast of upcoming quarterly earnings, scaled by the absolute value of the mean analyst forecast of upcoming quarterly earnings, all from the I/B/E/S Summary database
$SURP_{i,q,t}$	Earnings surprise, measured as actual quarterly earnings per share minus the most recent consensus forecast of that quarter's earnings per share, per the I/B/E/S Summary database
$CAR_{i,q,t}$	Cumulative abnormal stock return around days {0, +1} relative to the quarterly earnings announcement date. Market model parameters are estimated using daily stock returns and value-weighted market returns from the CRSP Daily return file over an estimation period spanning days {-146, -11} relative to the earnings announcement date
$PRICE_{i,q,t}$	Stock price per share, per the Trade and Quote Database
$HVOL_{i,q,d,t}$	Hidden order volume, measured as total share volume of hidden orders divided by total share volume
$HTRDSIZ_{i,q,d,t}$	Mean size of hidden order trades, per the ITCH database
$HTOTSIZ_{i,q,d,t}$	Total size of hidden orders, per the ITCH database
$HORDNUM_{i,q,d,t}$	Number of hidden orders placed in the order book, per the ITCH database
$DISPLAY_{i,q,d,t}$	Displayed order volume, measured as total share volume from displayed orders divided by total share volume, per the ITCH database
$SPREAD_{i,q,d,t}$	Difference between best quoted bid and offer share price, per the Trade and Quote Database
$DEPTH_{i,q,d,t}$	Quoted ask depth plus quoted bid depth, per the Trade and Quote Database

Subscripts i, q, d, and t refer to firm, quarter, day, and year respectively.

TABLE 2

Percentage changes in liquidity measures around earnings announcements

						ΔDEPTH		ΔSPRD	
Day	ΔHVOL	ΔHTRDSIZ	ΔHTOTSIZ	ΔHORDNUM	ΔDISPLAY	Ask	Bid	Quoted	Relative
-10	2.62	2.46	3.24	-7.90**	-0.21	-1.06	0.05	0.64	2.16
-9	-1.75	-0.36	-1.48	-2.33	1.00***	0.66	-1.31	0.69	2.38
-8	-0.58	1.57	0.94	5.77	0.31	-0.58	-0.61	1.78	2.82*
-7	0.60	1.47	1.81	2.50	0.11	-1.67	0.16	2.42***	3.01***
-6	-0.02	1.21	3.27	26.45	0.24	-1.47	-0.24	3.51***	3.63***
-5	2.13	4.80***	6.04	1.54	0.17	-2.07	-0.32	5.92***	7.24***
-4	-3.63*	-1.73	-0.94	-2.13	0.95**	-1.89	-0.88	4.89***	6.21***
-3	-4.42*	-0.62	-0.63	-2.35	1.01**	-0.58	-0.77	0.57	1.27
-2	-3.32*	2.25	3.95*	13.52	0.69*	-0.63	-1.37	1.81**	2.74**
-1	1.78	1.64	2.35	13.95***	-0.06	-0.07	-0.22	5.42***	7.03***
0	5.17***	13.27***	16.19***	172.77***	-1.51***	4.71**	3.48**	8.30***	9.11***
1	9.14***	17.52***	21.99***	142.88***	-1.35***	-9.00**	-7.39**	2.55***	3.14***
2	2.12	10.03***	10.31***	61.83***	0.57	-5.91**	-6.99**	-0.23	0.09
3	-2.59	8.71***	9.29***	33.29***	0.67	3.05**	2.33	0.48	0.77
4	-2.39	2.85*	3.35	31.14***	1.22***	3.71*	3.18	-2.92*	-2.05
5	10.95	4.94**	6.27**	21.68***	-0.03	4.75*	4.29	-2.55	-1.62
6	-0.52	4.27*	5.44	17.05***	0.29	2.73*	2.46	-0.60	0.18
7	-1.39	3.10***	6.57**	13.04***	0.19	1.35	1.25	-0.05	0.03
8	0.58	1.05	1.54	7.90***	0.12	0.41	1.77	0.49	0.39
9	-1.20	0.83	1.87	3.74	0.37	-0.22	0.67	1.54	1.30
10	0.41	-0.52	-0.74	2.67	0.20	2.34	2.00	-0.10	-0.37

The sample includes 746 firms over January, 2002 to December, 2004.

HVOL is hidden order volume, measured as total share volume of hidden orders divided by total share volume; HTRDSIZ is the mean size of a hidden order trade; HTOTSIZ is the total size of a hidden order; HORDNUM is the number of hidden orders placed in the order book; ΔDISPLAY is displayed order volume, measured as total share volume from displayed orders divided by total share volume. These variables are computed from data obtained from the ITCH database.

Table 2 continued

DEPTH is the quoted depth per the TAQ database, partitioned into depth at ask price and depth at bid price for purposes of this table; and quoted SPREAD is the difference between the best quoted bid and offer price, per the TAQ database; relative SPREAD is the quoted spread deflated by share price. Subscripts (see Table 1) are omitted. Values of each firm-day-year variable are expressed as percentages (see below) from a nonevent average.

The table reports median percentage changes in each variable, across the sample, for each day relative to the I/B/E/S quarterly earnings announcement date (day 0). Percentage changes are computed as the variable measured on the specified day, minus the mean measure of that variable during 'nonevent' days, stated as a percentage of that variable's 'nonevent' day mean, then scaled by 100. We define the nonevent period as the ten trading days before (t_0-20 to t_0-11) and the ten trading days after (t_0+11 to t_0+20) the I/B/E/S quarterly earnings announcement date, and compute nonevent means for each variable over these 20 days centered on the earnings announcement date.

***, ** and * indicate that the median percentage change is significantly different from zero at the 0.01, 0.05, and 0.10 levels respectively, based on a Wilcoxon test.

TABLE 3
Correlations

	HVOL	NUMEST	DISP	DISPLAY	SPREAD	SURP	CAR	PRICE
NUMEST	-0.009							
DISP	-0.027	-0.663						
DISPLAY	-0.870	0.070	0.009					
SPREAD	-0.006	0.047	-0.019	-0.024				
SURP	0.017	-0.004	0.022	-0.003	0.013			
CAR	-0.018	-0.092	0.095	-0.010	0.006			
PRICE	0.080	0.413	-0.319	-0.034	0.001	0.062	-0.174	
DEPTH	-0.058	0.102	-0.012	0.082	0.196	0.025	0.159	-0.036

The table reports Pearson correlations between variables used in the regression analyses.

HVOL is hidden order volume, measured as total share volume of hidden orders divided by total share volume, per the ITCH database; NUMEST is the number of individual analysts' quarterly earnings forecasts included in the consensus forecast of upcoming quarterly earnings, from the I/B/E/S Summary database; DISPLAY is displayed order volume, measured as total share volume from displayed orders divided by total share volume; SPREAD is the difference between the best quoted bid and offer price, per the TAQ database; SURP is earning surprise, measured as actual quarterly earnings per share minus the most recent consensus forecast of that quarter's earnings per share per the I/B/E/S Summary database; CAR is the cumulative abnormal stock return over days {0, +1} relative to the I/B/E/S earnings announcement date, computed from the CRSP Daily return file; and PRICE is share price. Subscripts (see Table 1) are omitted.

TABLE 4

Cross-sectional determinants of changes in hidden liquidity measures around days {0, +1} relative to earnings announcement date

Independent Variable	Dependent variable			
	ΔHVOL	ΔHORDNUM	ΔHTRDSIZ	ΔHTOTSIZ
Intercept	-6.11	17.39	31.70	16.98
	(0.01)	(0.00)	(0.31)	(0.00)
Ln(NUMEST)	7.66	4.33	-25.09	8.73
	(0.00)	(0.04)	(0.12)	(0.00)
Ln(DISP)	0.70	-1.01	-1.16	-1.59
	(0.00)	(0.00)	(0.66)	(0.00)
|SURP|	8.92	-17.81	220.25	-25.62
	(0.06)	(0.03)	(0.00)	(0.02)
|CAR|	-52.27	107.63	4640.83	114.46
	(0.00)	(0.00)	(0.00)	(0.00)
PRICE	0.22	-0.31	5.52	-0.52
	(0.00)	(0.00)	(0.00)	(0.00)
ΔDISPLAY	-3.15	-0.62	-6.27	-0.87
	(0.00)	(0.00)	(0.00)	(0.00)
ΔSPREAD	-0.03	-0.17	-1.08	-0.24
	(0.00)	(0.00)	(0.00)	(0.00)
ΔDEPTH	0.03	0.29	0.67	0.33
	(0.00)	(0.00)	(0.00)	(0.00)
Adjusted R^2	0.76	0.11	0.16	0.10

The table reports coefficient estimates, p-values (two-tailed significance tests), and Adjusted R^2's from ordinary least squares regressions. 5736 observations are used in each estimation.

HVOL is hidden order volume, measured as total share volume of hidden orders divided by total share volume; HTRDSIZ is the mean size of a hidden order trade; HTOTSIZ is the total size of a hidden order; HORDNUM is the number of hidden orders placed in the order book; DISPLAY is displayed order volume, measured as total share volume from displayed orders divided by total share volume; DEPTH is the quoted depth per the TAQ database, partitioned into depth at ask price and depth at bid price for purposes of this table; and SPREAD is the difference between the best quoted bid and offer price, per the TAQ database.

Δ denotes a variable is measured as a change from a nonevent average. For each of the days {0, +1} relative to the I/B/E/S earnings announcement date, each of these variables is expressed as a percentage deviation from its nonevent period mean. Percentage changes are computed as the variable measured on

Table 4 continued
the specified day, minus the mean measure of that variable during 'nonevent' days, stated as a percentage of that variable's 'nonevent' day mean, then scaled by 100. We define the nonevent period as the ten trading days before (t_0-20 to t_0-11) and the ten trading days after (t_0+11 to t_0+20) the I/B/E/S quarterly earnings announcement date, and compute nonevent means for each variable over these 20 days centered on the earnings announcement date. These variables are then cumulated over days {0, +1} relative to the I/B/E/S earnings announcement date.

Ln(NUMEST) is the natural logarithm of the number of individual analysts' quarterly earnings forecasts included in the consensus forecast of upcoming quarterly earnings, from the I/B/E/S Summary database; Ln(DISP) is the natural logarithm of the dispersion in analysts' quarterly earnings forecasts included in the consensus forecast of upcoming earnings, scaled by the absolute value of the consensus mean analyst forecast of upcoming quarterly earnings; Ln|SURP| is the absolute value of the natural logarithm of earning surprise, measured as actual quarterly earnings per share minus the most recent consensus forecast of that quarter's earnings per share per the I/B/E/S Summary database; |CAR| is the absolute value of the cumulative abnormal stock return computed from the CRSP Daily return file; and PRICE is share price.

Subscripts (see Table 1) are omitted.

TABLE 5

Cross-sectional determinants of changes in hidden liquidity measures for buy and sell orders around days {0, +1} relative to earnings announcement date

	Dependent variable							
Independent	ΔHVOL		ΔHORDNUM		ΔHTRDSIZ		ΔHTOTSIZ	
Variable	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell
Intercept	-18.71	6.87	18.11	16.59	-9.14	59.91	14.13	23.08
	(0.00)	(0.11)	(0.00)	(0.00)	(0.82)	(0.04)	(0.02)	(0.00)
Ln(NUMEST)	6.87	8.22	4.66	6.88	-26.72	-23.52	7.75	10.84
	(0.01)	(0.00)	(0.05)	(0.00)	(0.20)	(0.12)	(0.01)	(0.00)
Ln(DISP)	1.73	-0.14	-0.44	-1.06	2.86	-5.25	-0.75	-1.84
	(0.00)	(0.69)	(0.26)	(0.01)	(0.40)	(0.03)	(0.14)	(0.00)
|SURP|	20.09	-0.41	-20.17	-15.64	195.69	252.35	-26.78	-24.57
	(0.04)	(0.96)	(0.03)	(0.08)	(0.01)	(0.00)	(0.03)	(0.07)
|CAR|	-16.24	-78.12	139.27	114.86	5488.06	4117.30	164.49	93.69
	(0.62)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)
PRICE	0.83	-0.25	-0.32	-0.41	6.48	4.72	-0.35	-0.72
	(0.00)	(0.01)	(0.00)	(0.00)	(0.82)	(0.04)	(0.02)	(0.00)
ΔDISPLAY	-3.11	-3.27	-0.52	-0.57	-5.75	-6.73	-0.69	-0.84
	(0.00)	(0.00)	(0.00)	(0.00)	(0.82)	(0.04)	(0.02)	(0.00)
ΔSPREAD	0.04	-0.11	-0.14	-0.19	-0.90	-1.21	-0.18	-0.27
	(0.01)	(0.11)	(0.00)	(0.00)	(0.82)	(0.04)	(0.02)	(0.00)
ΔDEPTH	-0.01	0.06	0.25	0.29	0.81	0.55	0.26	0.36
	(0.92)	(0.11)	(0.00)	(0.00)	(0.82)	(0.04)	(0.02)	(0.00)
Adjusted R^2	0.44	0.51	0.07	0.09	0.12	0.18	0.05	0.08

Table 5 continued
The table reports coefficient estimates, p-values (two-tailed significance tests), and Adjusted R^2's from ordinary least squares regressions. 5736 observations are used in each estimation. The model is estimated separately for buyer and seller-initiated trades.

HVOL is hidden order volume, measured as total share volume of hidden orders divided by total share volume; HTRDSIZ is the mean size of a hidden order trade; HTOTSIZ is the total size of a hidden order; HORDNUM is the number of hidden orders placed in the order book; DISPLAY is displayed order volume, measured as total share volume from displayed orders divided by total share volume; DEPTH is the quoted depth per the TAQ database, partitioned into depth at ask price and depth at bid price for purposes of this table; and SPREAD is the difference between the best quoted bid and offer price, per the TAQ database.

Δ denotes a variable is measured as a change from a nonevent average. For each of the days {0, +1} relative to the I/B/E/S earnings announcement date, each of these variables is expressed as a percentage deviation from its nonevent period mean. Percentage changes are computed as the variable measured on the specified day, minus the mean measure of that variable during 'nonevent' days, stated as a percentage of that variable's 'nonevent' day mean, then scaled by 100. We define the nonevent period as the ten trading days before (t_0-20 to t_0-11) and the ten trading days after (t_0+11 to t_0+20) the I/B/E/S quarterly earnings announcement date, and compute nonevent means for each variable over these 20 days centered on the earnings announcement date. These variables are then cumulated over days {0, +1} relative to the I/B/E/S earnings announcement date.

Ln(NUMEST) is the natural logarithm of the number of individual analysts' quarterly earnings forecasts included in the consensus forecast of upcoming quarterly earnings, from the I/B/E/S Summary database; Ln(DISP) is the natural logarithm of the dispersion in analysts' quarterly earnings forecasts included in the consensus forecast of upcoming earnings, scaled by the absolute value of the consensus mean analyst forecast of upcoming quarterly earnings; Ln|SURP| is the absolute value of the natural logarithm of earning surprise, measured as actual quarterly earnings per share minus the most recent consensus forecast of that quarter's earnings per share per the I/B/E/S Summary database; |CAR| is the absolute value of the cumulative abnormal stock return computed from the CRSP Daily return file; and PRICE is share price.

Subscripts (see Table 1) are omitted.

TABLE 6

Cross-sectional determinants of changes in hidden liquidity measures around days {-1, +1} relative to earnings announcement date

Independent Variable	Dependent variable			
	ΔHVOL	ΔHORDNUM	ΔHTRDSIZ	ΔHTOTSIZ
Intercept	-11.70	18.30	15.24	20.40
	(0.01)	(0.00)	(0.65)	(0.00)
Ln(NUMEST)	11.91	4.71	-47.36	9.42
	(0.00)	(0.08)	(0.01)	(0.00)
Ln(DISP)	1.17	-0.85	-1.37	-1.51
	(0.00)	(0.05)	(0.64)	(0.01)
|SURP|	17.20	-25.43	586.23	-36.52
	(0.02)	(0.02)	(0.00)	(0.01)
|CAR|	-30.32	96.16	3674.69	76.01
	(0.07)	(0.00)	(0.00)	(0.02)
PRICE	0.37	-0.33	7.21	-0.59
	(0.00)	(0.00)	(0.00)	(0.00)
ΔDISPLAY	-3.19	-0.39	-5.18	-0.48
	(0.00)	(0.00)	(0.31)	(0.00)
ΔSPREAD	-0.04	-0.13	-0.89	-0.20
	(0.00)	(0.00)	(0.00)	(0.00)
ΔDEPTH	0.03	0.29	0.28	0.33
	(0.00)	(0.00)	(0.01)	(0.00)
Adjusted R^2	0.75	0.10	0.19	0.08

The table reports coefficient estimates, p-values (two-tailed significance tests), and Adjusted R^2's from ordinary least squares regressions. 5736 observations are used in each estimation.

Table 6 continued
HVOL is hidden order volume, measured as total share volume of hidden orders divided by total share volume; HTRDSIZ is the mean size of a hidden order trade; HTOTSIZ is the total size of a hidden order; HORDNUM is the number of hidden orders placed in the order book; DISPLAY is displayed order volume, measured as total share volume from displayed orders divided by total share volume; DEPTH is the quoted depth per the TAQ database, partitioned into depth at ask price and depth at bid price for purposes of this table; and SPREAD is the difference between the best quoted bid and offer price, per the TAQ database.

Δ denotes a variable is measured as a change from a nonevent average. For each of the days {-1, +1} relative to the I/B/E/S earnings announcement date, each of these variables is expressed as a percentage deviation from its nonevent period mean. Percentage changes are computed as the variable measured on the specified day, minus the mean measure of that variable during 'nonevent' days, stated as a percentage of that variable's 'nonevent' day mean, then scaled by 100. We define the nonevent period as the ten trading days before (t_0-20 to t_0-11) and the ten trading days after (t_0+11 to t_0+20) the I/B/E/S quarterly earnings announcement date, and compute nonevent means for each variable over these 20 days centered on the earnings announcement date. These variables are then cumulated over days {-1, +1} relative to the I/B/E/S earnings announcement date.

Ln(NUMEST) is the natural logarithm of the number of individual analysts' quarterly earnings forecasts included in the consensus forecast of upcoming quarterly earnings, from the I/B/E/S Summary database; Ln(DISP) is the natural logarithm of the dispersion in analysts' quarterly earnings forecasts included in the consensus forecast of upcoming earnings, scaled by the absolute value of the consensus mean analyst forecast of upcoming quarterly earnings; Ln|SURP| is the absolute value of the natural logarithm of earning surprise, measured as actual quarterly earnings per share minus the most recent consensus forecast of that quarter's earnings per share per the I/B/E/S Summary database; |CAR| is the absolute value of the cumulative abnormal stock return computed over days {-1, +1} relative to the earnings announcement date, from the CRSP Daily return file; and PRICE is share price.

Subscripts (see Table 1) are omitted.

TABLE 7

Cross-sectional determinants of changes in hidden liquidity measures for buy and sell orders around days {-1, +1} relative to earnings announcement date

	Dependent variable							
Independent	ΔHVOL		ΔHORDNUM		ΔHTRDSIZ		ΔHTOTSIZ	
Variable	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell
Intercept	23.36	2.68	20.58	19.09	7.39	20.86	22.65	24.61
	(0.00)	(0.64)	(0.00)	(0.00)	(0.86)	(0.52)	(0.00)	(0.00)
Ln(NUMEST)	14.71	8.95	6.74	6.05	-47.74	-47.88	9.09	11.29
	(0.00)	(0.00)	(0.03)	(0.05)	(0.03)	(0.01)	(0.02)	(0.01)
Ln(DISP)	3.24	-0.56	0.15	-1.30	3.78	-6.37	-0.24	-2.21
	(0.00)	(0.24)	(0.76)	(0.01)	(0.30)	(0.02)	(0.71)	(0.00)
|SURP|	29.87	6.19	-24.48	-24.83	509.32	668.87	-35.91	-34.92
	(0.02)	(0.58)	(0.03)	(0.03)	(0.00)	(0.00)	(0.02)	(0.04)
|CAR|	-94.27	24.54	63.72	136.29	3838.89	3618.38	36.67	123.17
	(0.00)	(0.36)	(0.02)	(0.00)	(0.00)	(0.00)	(0.30)	(0.00)
PRICE	0.94	-0.06	-0.36	-0.49	7.85	6.67	-0.44	-0.85
	(0.00)	(0.59)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
ΔDISPLAY	-3.22	-3.23	-0.35	-0.31	-4.82	-5.49	-0.38	-0.42
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ΔSPREAD	0.02	-0.10	-0.11	-0.16	-0.77	-0.98	-0.14	-0.23
	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ΔDEPTH	0.02	0.04	0.26	0.32	0.42	0.15	0.27	0.36
	(0.30)	(0.01)	(0.00)	(0.00)	(0.00)	(0.11)	(0.00)	(0.00)
Adjusted R^2	0.47	0.55	0.06	0.09	0.12	0.22	0.04	0.07

Table 7 continued
The table reports coefficient estimates, p-values (two-tailed significance tests), and Adjusted R^2's from ordinary least squares regressions. 5736 observations are used in each estimation. The model is estimated separately for buyer and seller-initiated trades.

HVOL is hidden order volume, measured as total share volume of hidden orders divided by total share volume; HTRDSIZ is the mean size of a hidden order trade; HTOTSIZ is the total size of a hidden order; HORDNUM is the number of hidden orders placed in the order book; DISPLAY is displayed order volume, measured as total share volume from displayed orders divided by total share volume; DEPTH is the quoted depth per the TAQ database, partitioned into depth at ask price and depth at bid price for purposes of this table; and SPREAD is the difference between the best quoted bid and offer price, per the TAQ database.

Δ denotes a variable is measured as a change from a nonevent average. For each of the days {-1, +1} relative to the I/B/E/S earnings announcement date, each of these variables is expressed as a percentage deviation from its nonevent period mean. Percentage changes are computed as the variable measured on the specified day, minus the mean measure of that variable during 'nonevent' days, stated as a percentage of that variable's 'nonevent' day mean, then scaled by 100. We define the nonevent period as the ten trading days before (t_0-20 to t_0-11) and the ten trading days after (t_0+11 to t_0+20) the I/B/E/S quarterly earnings announcement date, and compute nonevent means for each variable over these 20 days centered on the earnings announcement date. These variables are then cumulated over days {-1, +1} relative to the I/B/E/S earnings announcement date.

Ln(NUMEST) is the natural logarithm of the number of individual analysts' quarterly earnings forecasts included in the consensus forecast of upcoming quarterly earnings, from the I/B/E/S Summary database; Ln(DISP) is the natural logarithm of the dispersion in analysts' quarterly earnings forecasts included in the consensus forecast of upcoming earnings, scaled by the absolute value of the consensus mean analyst forecast of upcoming quarterly earnings; Ln|SURP| is the absolute value of the natural logarithm of earning surprise, measured as actual quarterly earnings per share minus the most recent consensus forecast of that quarter's earnings per share per the I/B/E/S Summary database; |CAR| is the absolute value of the cumulative abnormal stock return over days {-1, +1} relative to the earnings announcement date, computed from the CRSP Daily return file; and PRICE is share price.

Subscripts (see Table 1) are omitted.