More depth to depth: Liquidity of fleeting and static orders

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Brian S. Roseman

University of Mississippi

Abstract:

Fleeting orders are short limit orders that are only on the limit order book for a few seconds before being deleted, and are significantly different than more patient, static, limit orders that are added to the limit order book and await execution. This paper investigates the impact that fleeting orders have on market quality, and how fleeting orders differ from static orders. Attention is also given to the extent that total depth can be decomposed into the two components of fleeting and static depth. The results suggest that static orders have a large impact on both top-of-book liquidity and depth liquidity measures. Fleeting orders have little impact on total liquidity, suggesting that fleeting orders contribute noise to markets, rather than contributing to depth and liquidity.

I. Introduction

Exchanges and institutional traders devote considerable resources into decreasing the latency of transmitting market messages and increasing the speed of order placement (Gao, Yao, Ye (2014)). Efforts to decrease latency include placement of traders' proprietary trading computers next to exchange servers, known as co-location, as well as development of trans-city networks (Garvey and Wu (2010)). These networks include fiber optic cables, lasers, radio waves, and microwave towers used to connect traders in New York City and other cities such as Chicago and London.[1] There is not a universally held opinion on whether these advances positively or negatively impact market quality. One externality of high speed markets is the increase in the order-trade ratio, which coincides with a decrease in the average duration of an order (Hasbrouck and Saar (2009), Hendershott, Jones, and Menkveld (2011)). Many orders are placed for microseconds and then quickly deleted. Quick, fleeting orders are receiving increased attention in the microstructure literature because of the potential impact on market quality (Hasbrouck (2013), Baruch and Glosten (2013)). Whether or not fleeting orders and low-latency orders improve market quality is the focus of this paper.

I compare the characteristics of fleeting orders against longer duration orders to study market quality in low-latency markets. Much of the literature on market quality in low-latency markets looks at the type of traders placing the order (i.e. algorithmic and/or high frequency traders) rather than the characteristics of the order, leading to conflicting conclusions on whether to classify algorithmic and high frequency traders as helpful or harmful to financial markets. Studies such as Hendershott, Jones, and Menkveld (2011), Menkveld (2013) and Brogaard, Hendershott, and Riordan (2014) provide evidence that high frequency and algorithmic trading improve market quality, while studies such as McInish and Upson (2012), Gerig (2015), and Kirilenko, Kyle, Sadami, Tuzun (2014) provide evidence to the contrary. The question of interest regarding market quality is not *who* places the orders, rather *what* orders are being placed, since a class of traders can pursue different order strategies, which either benefit or harm markets, at different times. I take a different approach on the subject in that I look at the orders being submitted, irrespective of the trader, and investigate how the order type

[1] Spread Networks has a fiber optic line that connects Chicago to New York City (Laughlin, Aguirre, Grundfest (2014)). Hibernia Networks manufactured a high capacity trans-Atlantic fiber optic path between New York and London. McKay Brothers offers microwave towers to connect traders across different locations around the world. Anova Technologies delivers high-frequency data through laser and radio networks.

impacts market quality. Empirically, I separate short duration (fleeting) orders from long duration (static) orders. Using three order-level data sets from Nasdaq OMX and one dataset from BATS Global markets, I recreate the limit order book for four different exchanges[2]. In addition, and in an effort to disentangle the effects of fleeting orders from the effects of static orders, I also recreate two artificial limit order books, one that is comprised of fleeting orders, and one that is comprised of patient orders. By artificially separating the limit order book into these two components, I am able to measure and compare market quality (i.e. depth, spread, price impact) of fleeting and static orders. This approach provides a number of contributions to the literature on liquidity, limit orders markets, and high frequency trading. First, separating the order types allows for a direct comparison of the market quality of fleeting orders, which provide liquidity only for a few seconds, against the market quality of static orders, which are submitted to the limit order book for longer durations. Since both human and algorithmic traders can pursue strategies of submitting static orders and fleeting orders, separating the two order types effectively tests the impact of the order type on market quality rather than the trader's impact on market quality.

A second contribution of my study is that I show depth can be separated into two components, patient depth and fleeting depth, wherein each component has a unique and varying impact on total depth and liquidity. A partitioned view of depth is more appropriate in low latency markets. Traditionally, depth is defined as the total number of shares available to trade at prices at (or near) the best bid and offer at a specific point in time. This simple definition does not, however, distinguish between starkly different types of order and trading strategies. Limit order traders can trade patiently (e.g. Glosten (1994), Handa and Schwartz (1996), and Rosu (2009)), or, as recent high frequency trading papers show, aggressively (e.g. Hasbrouck and Saar (2009) Menkveld (2013), Baruch and Glosten (2013)).

Although my study is the first to empirically decompose depth into fleeting and static components, the existing work on limit order markets suggest that depth is composed of orders from various types of traders. Theoretical literature suggests that limit order traders pursue a number of strategies. Glosten (1994) considers patient limit order traders to be uninformed investors who make a market for impatient traders who submit

[2] This preliminary version only investigates the NASDAQ exchange.

market orders. Impatient traders may be either informed or noisy. In Glosten's model, limit order traders are patient and supply liquidity to impatient traders. In a different setting suggested by Rosu (2009), in which all participants are informed traders, limit orders are also submitted by patient traders. However, Rosu assumes that each trader is a liquidity trader, and information is constant and known by all market participants. In this framework, all agents incur waiting costs. Limit orders are submitted by traders with low waiting costs, and traders with high waiting costs submit market orders. However, not all limit orders are assumed to be patient. In Rosu's model, if depth in the limit order book is high and the spread is at a minimum, then impatient traders will either submit market orders, or submit quick, fleeting, limit orders. Fleeting orders are orders that are added and quickly canceled, which are starkly different than patient limit orders that supply liquidity. Theoretical work by Baruch and Glosten (2013) show that fleeting orders are the result of liquidity supplying traders preventing their stale prices from being picked off. To avoid pickoff risk, a liquidity providing trader will cancel stale quotes and replace them with new randomly priced ones. Theories by Rosu, and Baruch and Glosten suggest that liquidity and depth are composed of both patient and fleeting orders. In related empirical work, Hasbrouck and Saar (2009) observe that one third of limit orders are canceled within two seconds. Further, Hasbrouck (2013) documents flickering and volatile best bid and best offer quote prices that may be the result of high frequency traders rapidly submitting and canceling nonmarketable orders. I build upon these studies by empirically showing the extent that patient orders and fleeting orders each have on total liquidity and depth.

The third contribution of this study is that I investigate previously untested assumptions and implications from the theoretical literature on fleeting orders and low-latency limit order markets. A major obstacle in the analysis of fleeting orders is the difficulty in constructing the limit order book, and the difficulty in distinguishing between the impact that a fleeting order and static order has on total depth, which the approach in this study overcomes. In Rosu's (2009) model, traders may switch between limit orders and market orders depending on the state of the limit order book. Fleeting orders increase when the depth in the limit order book is high. I test Rosu's model by looking at the structure of the limit order book and composition of fleeting and static orders. I also test theoretical predictions from Baruch and Glosten (2013), who provide a number of implications on flickering quotes. In their model, flickering quotes behave differently depending on the number of traders in the market. They show that although there may be fleeting orders that lead to flickering quotes, when there are many traders submitting flickering quotes, depth will appear to be static.

II. Background

Prior research does not explicitly define depth as being comprised of two separate components. Previous studies do, however, suggest traders pursue multiple strategies when supplying liquidity. Theoretical work suggests that limit order traders may patiently supply liquidity. These traders make a market for impatient traders by placing orders and waiting for execution (i.e. Glosten (1994), Foucault, Kadan, and Kandel (2005), Handa and Schwartz (1996)). Limit order traders may also submit fleeting orders to increase the probability of execution when the limit order book is full (Rosu (2009)) or to manage undercutting exposure (Baruch and Glosten (2013)). These studies suggest depth in low-latency markets is not the composition of uniform orders. Rather, depth is composed of two categories of orders: static depth and fleeting depth. Static depth is defined as orders that are placed, and patiently await execution, while fleeting depth is defined as the depth that is provided by traders who submit and quickly cancel orders. Each type of depth has a different impact on total liquidity.

II.A. Static Depth

Traditional theories of limit order markets assume patient liquidity providers place limit orders while market orders and marketable limit orders are placed by impatient liquidity demanders. In the model of Glosten (1994), limit order traders are risk averse market makers. These traders patiently place orders to provide liquidity. In the Foucault, Kadan, and Kandel (2005) framework, impatient traders submit market orders and patient traders submit limit orders, providing liquidity for the impatient traders, suggesting that patient traders improve liquidity. In the Rosu (2009) model, all traders have waiting costs, and the aggressiveness of the trader is determined by whether the trader's waiting costs are high or low. In equilibrium, impatient traders submit market orders, while patient traders submit limit orders and wait for execution from an impatient trader. Unless the limit order book is full[3], Rosu shows the new limit orders will be placed aggressively within the bid-ask spread. Orders that patiently await execution should be a positive component of depth, and orders that are placed inside the spread should improve liquidity measures such as quoted and effective spread. These studies provide theoretical support that patient depth, which is composed of static orders, should be a positive component of liquidity. I refer to this as the static depth hypothesis.

Hypothesis 1: Static depth has a positive impact on liquidity

II.B. Fleeting Depth

Fleeting orders are quick orders that are submitted and canceled almost immediately. Although fleeting orders are typically limit orders, the characteristics of these orders are different from limit orders in the traditional sense (Hasbrouck and Saar (2009)). Theoretical studies such as Rosu (2009) and Baruch and Glosten (2013) highlight a number of reasons that traders pursue fleeting order strategies. A special case of the Rosu theoretical model, when depth is high and the spread is at a minimum, traders will enter into a game of attrition where fleeting orders are used to entice the opposite side of the limit order book to submit a market order. Limit order traders only submit fleeting orders when the limit order book is full, and the orders are always submitted within the spread. Empirically, this suggests that fleeting orders are more likely for limit order books experiencing high depth or low spreads. The theory also carries the strong implication that fleeting orders are always placed within the bid-ask spread.

Baruch and Glosten (2013) develop a model where fleeting orders are the result of competing liquidity supplying traders. In Baruch and Glosten's model, traders submit competitive orders. However, limit order traders are exposed to time sensitive risk. To avoid time sensitive risk, traders withdraw outstanding orders and submit new orders quickly. The frequent adding and cancelling of orders will yield a flickering quote, but as the number of traders that pursue this strategy increase, the aggregate quotes in the market will have stable depth and appears to be static. Baruch and Glosten's theory suggests that during periods when there is high depth

[3] Rosu (2009) defines the limit order book as being full when the bid-ask spread is at a minimum, nonzero tick size. The model also assumes that there is a maximum number of limit orders allowed on the limit order book, which is not true empirically. I consider a 'full' limit order book to be when the spread is low and depth is high.

and many fleeting orders, the best bid and offer should appear static. The cumulative depth provided by fleeting orders should yield constant, forecastable, depth.

Both the theories by Baruch and Glosten (2013), and Rosu (2009) suggests that during periods of high depth and low spread, fleeting orders have a positive impact on total depth and liquidity. Rosu predicts that fleeting orders are price improving that are always submitted within the spread. Baruch and Glosten predict that fleeting orders are simply orders placed by liquidity supplying traders who are managing pick off risk. I refer to these theories collectively as the static depth hypothesis.

Hypothesis 2: Fleeting depth has a positive impact on liquidity

Hypothesis 3: Fleeting depth is more likely when the spread is low and depth is high

Hypothesis 4: Fleeting orders are only placed within the bid-ask spread

III. Data and Methodology

III.A. Data Sources and Sample

The empirical analysis in this paper utilizes several different databases. Since measures of depth require construction of the limit order book, I use order-level datasets for three different exchanges from Nasdaq OMX Group. The largest dataset in this study is the Nasdaq TotalView-ITCH database, which includes order submissions, deletions, updates, and executions for orders placed on the Nasdaq exchange. Nasdaq OMX Group also provides two other equity datasets, Nasdaq OMX BX and Nasdaq OMX PSX. Both are used in this study. With these order datasets I am able to reconstruct the limit order book. Additional stock information comes from the Center for Research and Securities Prices (CRSP) and daily trading characteristics come from the Securities and Exchange Commission (SEC) Midas database.

Due to size and computational constraints, my sample comprises the first 10 trading days of August 2014. A number of filters are used. Since data for three of the Exchanges used in the study are owned by Nasdaq OMX, my sample includes only Nasdaq listed securities. Additional filters eliminate stocks that do not trade at least 1,000 shares each day of the sample, as well as stocks that do not have a closing price of five dollars for each day of the sample. The limit order book is created dynamically so that every order, update message, and execution is implemented into the limit order book, which yields a best bid and offer that is accurate to the nanosecond. When creating the limit order book, I remove stub-quotes from the computations. Stub-quotes are orders that have an extremely low probability of execution (Egginton, Van Ness, Van Ness (2014)). When the exchanges open for trading, the data show many bid orders with prices of one penny, and sell orders that exceed $100,000. These orders have a low probability of execution, and may erroneously skew the measures of depth that are used in this study. For this reason I do not use orders that are less than three dollars, or orders that are greater than $5,000 when rebuilding the limit order book. The created limit order book provides depth at the top of the book and beyond the top of the book when each new message during the trading day is received. Depth is accurate to the nanosecond.

Panel A of Table 1 presents the characteristics of the stocks that are used in the sample. The average stock trades at a price of $37.26, has a market capitalization of $5,519 Million, and has 665.33 trades totaling 1,159,250 shares traded per day. The average stock in the sample receives 16,246 fleeting orders and 13,598 static orders each day.

[Insert Table 1 here]

III.B. Separating the limit order book

One difficulty for studies of market quality in low-latency markets is isolating the effects of multiple sources of liquidity improvement. For example, if market quality improves (spread decreases or depth increases) following the increase in algorithmic trading, as in Hendershott, Jones, and Menvkeld (2011), the improved liquidity may be partially due to non-algorithmic traders responding to increased competition induced by the algorithmic trader. I employ a novel way to test the effects of multiple sources of liquidity improvement.

I create three separate limit order books. The first limit order book is the 'true' limit order book, which represents the limit order book that traders see in real time. This limit order book includes all orders added, executed, updated, and deleted. I also create two artificial limit order books, a 'fleeting' limit order book, and a 'static' limit order book. The fleeting limit order book is comprised of only orders that supply liquidity for two seconds or less, while the static limit order book is comprised of only orders that provide liquidity for greater than two seconds. The argument for studying depth in this manner is that both fleeting and static orders have an impact on total liquidity, but it is uncertain which type of order is driving the actual limit order book. With three limit order books I am able to see at each moment what is the market quality (spread and depth) of fleeting and static orders. Using these three limit order books I am able to isolate and test the effects of short-duration and long-duration orders on total market liquidity.

III.C. Liquidity measures and variables

A major focus of this paper is testing the differences in market quality provided by orders that are static from the market quality provided by orders that are fleeting. To test the market quality of static and fleeting orders, I compute three spread measures used in Goyenko, Holdern, Trzcinka (2009), as well as two additional depth measures, yielding five liquidity measure that are computed for each of the three limit order books described above. The limit order book computations yield a market quality measure for that nanosecond the limit order book is updated. For much of the empirical tests I average market quality measures to the minute. My full dataset yields the average spread and depth for each stock, each minute of the trading day for each of the limit order books computed.

The first measure is the quoted spread, the difference between the best bid and offer for stock *j* at time *t*. Quoted spread is defined as

$$Quoted\ Spread = p_{jt,ask} - p_{jt,bid}. \tag{1}$$

I compute the quoted spread using the true limit order book, as well as the quoted spread for the fleeting limit order book and the quoted spread for the static order book. Using each of the three limit order books yields three different measures of quoted spread: the true quoted spread, the quoted spread of fleeting orders, and the quoted spread of static orders.

I compute the effective spread for all three limit order books as

$$Effective\ Spread = 2 * |p_{j,t} - m_{j,t}|, \tag{2}$$

where the effective spread is twice the absolute distance from the price of a trade at time *t* to the midpoint of the BBO for stock *j*. The third common measure of market quality I use is the price impact that a trade has on the limit order book. In a highly liquidity market a trade will have a low price impact. Using the method of computing the price impact for three limit order books, I am able to see how fleeting orders and static orders react to information contained in trades. The price impact identifies the change in the BBO from the time of a trade to the BBO five minutes after the trade execution, which is considered the permanent component of the spread (Goyenko, Holdern, Trzcinka (2009)). I express it as a percentage of the original midpoint for stock *j* at time *t*. Price impact is defined as

$$Price\ Impact = 2 * \frac{|m_{j,t} - m_{j,t+5}|}{m_{j,t}}. \quad (3)$$

Measuring market quality only at the top of book does not fully reflect the market quality of a security. Therefore, limit order book depth is used as an additional measure of market quality. I use two separate depth measures, the cost of a round trip trade (CRT) and the depth-weighted average price (DWAP). The CRT is defined in Domowitz, Hansch, and Wang (2005), and reflects the ex-ante cost a trader would encounter by buying and selling *q* number of shares. I modify the notation of Domowitz et al. slightly, and express CRT as

$$CRT = \left[\sum_{j=1}^{k-1} D_{j,ask}\, P_{j,ask} + \left(q - \sum_{j=1}^{k-1} D_{j,ask}\right) P_{k,ask}\right] - \left[\sum_{j=1}^{k'-1} D_{j,bid} P_{j,bid} + \left(q - \sum_{j=1}^{k'-1} D_{j,bid}\right) P_{k,bid}\right], \quad (4)$$

where *k* is the number of ticks that a sell order of *q* shares has to travel on the ask side of the limit order book before *q* shares are filled, *k'* is the number of ticks a buy order of *q* shares has to travel before being completely filled. The depth and price of tick *j* is represented by D_j and P_j. The first term of equation (4) is the cost to sell *q* shares, while the second term is the cost to buy *q* shares. The difference between the first and second term represents the total cost to buy and sell *q* shares of a security simultaneously, or the cost of a round trip trade of size *q*. Although Domowitz et al. consider 10 values of *q* between 1 and 2,701 in their depth simulations, computational constraints limit me to five values. I consider values of *q* equal to 100, 500, 1,000, 5,000 and 10,000 shares. Much of the empirical portions of this paper will focus on *q* values of 1,000 and 5,000. I express the CRT on a per share basis, which I define as the CRT_{SPREAD}, as

$$CRT_{SPREAD} = \frac{CRT}{q}. \quad (5)$$

CRT_{SPREAD} can be interpreted in the same manner as quoted spread, with the difference being that it takes into the number of shares at the top of the limit order book. The CRT is computed for all the limit order books in the study. If static orders and fleeting orders have a positive impact on market quality, then the CRT_{SPREAD} should be low.

DWAP is the second measure of limit order book market quality that I use in this study. I calculate DWAP similar to Roseman, Upson, and Van Ness (2015) and Johnson and Upson (2013) as

$$DWAP = \frac{\sum_{i=1}^{I} P_i D_i}{\sum_{i=1}^{I} D_i}, \tag{6}$$

where there are I ticks on a given side of the limit order book, with a price of P_i and depth of D_i at tick i. I calculate the DWAP for both the bid and ask side of the limit order book, and take the difference to get the $DWAP_{SPREAD}$.

$$DWAP_{spread} = DWAP_{ask} - DWAP_{bid}. \tag{7}$$

In total, I have three spread measures for top of book market quality: quoted spread, effective spread and price impact, as well as two spread measures that reflect depth in the limit order book: CRT and DWAP. All five measures of market quality are computed for the true limit order book, the fleeting limit order book, and the static limit order book. After computing each of the five measures for each nanosecond, they are averaged to the minute level for much of the empirical analyses.

Panel B of Table 1 presents the liquidity measures for the average stock in my sample for the Nasdaq exchange. The average stock has a quoted spread of 7 cents, effective spread of 3 cents, and a negligible price impact. The CRT100 is the per share cost that a trader can expect to pay in transaction costs from simultaneously buying and selling 100 shares, and reflects depth beyond the top of the book. If there is greater than 100 shares in depth at the best bid and best offer, then the CRT100 will equal the quoted spread. If there is less than 100 shares at the best bid and best offer, the CRT100 will be greater than the quoted spread. The average stock in the sample has a CRT100 of 8 cents. It is not always possible to complete a round trip trade due to illiquidity. A trader wishing to buy and sell 500, 1,000, 5,000, and 10,000 shares can expect to pay 13, 22, 149, and 190 cents respectively. The average DWAPspread is 1,066 cents. The average CRT1000 is 3.24 times the quoted spread, the CRT5000 is 20.93 times the quoted spread, and the DWAP spread is 37.59 times the quoted spread. In Panels C and D of Table 1 I also report the liquidity measures for the fleeting and static limit order books.

In addition to the measures of liquidity, there are a number of other variables that I use in the study. Rosu (2009) makes predictions about the aggressiveness of an order. I define order aggressiveness similar to Griffiths, Smith, Turnball, and White (2000), who measure aggressiveness relative to the BBO. A buy order is most aggressive if it is higher than the ask price (i.e. crossing the market). A less aggressive order is placed within the BBO, and the least aggressive orders are placed less than the best bid. A similar scale of order aggressiveness is used for sell orders. I use range as a measure of daily volatility similar to O'Hara, Yao, and Ye (2014), which is the difference between the daily high and low price.

IV. The impact of fleeting and static depth on total liquidity

The empirical tests in this section are broken into two broad categories. The first group of tests, reported in this section, identify the impact that static orders and fleeting orders have on total depth, specifically addressing the hypotheses on whether fleeting and static orders impact total liquidity. In addition, I also compare the differences of fleeting orders against static orders. The second group of tests, reported in the following section, investigate the theoretical predictions or fleeting orders.

Many theoretical papers on limit order markets assume that patient liquidity providers improve liquidity by making a market for impatient traders who submit market orders (i.e. Glosten (1994), Foucault, Kadan, Kandel (2005)). These theories suggest that static and patient orders should have a positive impact on total liquidity. Theory also suggests that fleeting orders, although less patient than static orders, may also have a positive impact on liquidity. Recent theory by Rosu (2009) and Baruch and Glosten (2013) suggest that fleeting orders are price improving orders submitted by liquidity supplying traders. Rosu's (2009) model predicts that fleeting orders are placed within the bid-ask spread, suggesting that the market quality of the fleeting limit order book should improve liquidity measures at the top of the limit order book like quoted spread, effective spread, and price impact. Theory by Baruch and Glosten (2013) suggest that fleeting orders are liquidity providing limit orders placed by traders managing their pick-off risk. Although the orders may be fleeting, the trader will replace the order with a new order. If these traders are liquidity providing traders, then the cumulative market quality from fleeting orders should improve the market quality of the complete limit order book.

In Table 2, I report nine different liquidity measures for the total limit order book, as well as for the fleeting limit order book and static limit order book. The three top of book measures include the quoted spread, effective spread, and price impact. For the complete limit order book these are respectively 7.51 cents, 3.52 cents, and 0 percent. Using the methods described in the previous section, I form two subsets of the complete limit order book. Using only static orders I form a static limit order book, and using fleeting orders I form a fleeting limit order book. I compute the same market quality measures for the artificial limit order books as the total limit order book. The quoted and effective spread for the static limit order book are respectively 7.73 cents and 3.75 cents, and for the fleeting limit order book they are respectively 23.79 and 8.37 cents. The price impact is negligible.

[Insert Table 2 here]

One of the objectives of this paper is to test the extent that static and fleeting depth each impact total depth. To test whether static orders have a positive impact on total liquidity I compare the liquidity measures of the static limit order book against the liquidity measures of the complete limit order book. If the static and fleeting limit order book have positive impacts on the complete limit order book, the differences should be insignificant. From columns 4 and 5 of Table 2, the quoted spread of the static limit order book is 0.22 cents larger than the total limit order book, and the effective spread is 0.23 cents larger. Both are statistically significant, but economically small. I repeat the test for fleeting orders, where the quoted spread is 16.28 cents larger and the effective spread 4.85 cents larger. The average fleeting quoted spread is 16.06 cents higher than the static limit order book, and the effective spread is 4.62 cents higher.

These preliminary tests suggest that on average, the static limit order book contributes to a large portion of the total limit order book. Given that the total spread measures are less than the static and fleeting spread measures should not lead to confusion. The quoted spread of the complete limit order book will always be the minimum of the fleeting and static order at a given point in time, and the fleeting and static quoted spread will not always be at the top of the limit order book.

In Panel B I report the depth measures. In the analyses I focus on three main measures of depth. The cost of a round trip trade for a 1,000 share and a 5,000 share order. Both of these measures can be interpreted in a similar way as the quoted spread. The difference being that the CRT measure reflects depth beyond the top of the limit order book. The third measure is the depth weighted average price spread (DWAPspread), which is the difference between the depth weighted bid price and the depth weighted ask price. These three measures are consistently used throughout the analysis. I also express these measures as a ratio over the quoted spread.

Depth measures of liquidity are not as straight forward to interpret as the top of book measures of liquidity. Fleeting and static orders may selectively provide liquidity throughout the trading day, and as a result, at a given minute during the trading day there may not be enough fleeting or static depth to complete a trade. Therefore, interpretation of depth measures should be done in conjunction with the percentage of time when a round trip trade can be made. Panel B of Table 2 reports depth measures for the complete limit order book, static limit order book, and fleeting limit order book, while Panel C reports the percent of time during the day that a trader can successfully buy and sell q number of shares. From Panel B, looking at the total limit order book depth reveals that a trader wishing to buy and sell 1,000 shares of the average stock can expect to pay 23.71 cents per share. In addition, Panel C reports that a trader is able to complete a 1,000 share trade 100% of the time.

Comparing fleeting and static orders yields interesting results. The cost to trade 1,000 shares using exclusively static orders would cost a trader 28 cents per share. A trade using exclusively fleeting orders is 8.03 cents cheaper, at 19.98 cents per share. Comparing cost alone, however, is not sufficient. The static limit order book is able to provide 1,000 shares of depth at the bid and offer side of the limit order book 99% of the time for the average stock. The fleeting limit order book, however, can only accommodate a 1,000 shares at the bid and offer side of the limit order book 29% of the time for the average stock. The results suggest that for the average minute, for the average stock, fleeting orders are priced competitively, but these orders are used selectively for providing liquidity to the market.

A concern these results is that fleeting orders are orders submitted primarily by algorithmic traders[4] who primarily trade in large securities. For example, Brogaard, Hendershott, and Riordan (2014) find that high frequency traders trade over $241 million in large capitalization securities, but only $4.8 and $0.48 million in

[4] Hasbrouck and Saar (2013) find their measure of algorithmic trading, strategic runs, is highly correlated with HFTs from the NASDAQ HFT database. Strategic runs are fleeting orders lasting 100ms.

medium and small capitalization securities. In Table 3, I report the CRT depth measures, partitioned by market capitalization quintiles. The CRT cost measure is presented, along with the percentage of time available to complete the trade in brackets. The results show that fleeting orders do supply more liquidity in high capitalization securities, but the amount of time is still much lower than static orders.

[Insert Table 3 here]

Thus far I have considered fleeting and static orders as independent factors that impact total liquidity. The true limit order book that is displayed in real time is created by traders submitting both fleeting and static orders simultaneously. I address the simultaneous impact that fleeting and static orders have on total liquidity while controlling for other major influences like time of day, price, minute volatility, and stock volatility. The main regression estimates the effect that fleeting and static liquidity have on complete liquidity. I run cross-sectional minute regressions of the following form:

$$Total_{i,t} = \beta_0 + \beta_1 Static_{i,t} + \beta_2 Fleeting_{i,t} + \beta_x X_{i,t} + \lambda_i + \lambda_t + \varepsilon_{i,t} \quad (8)$$

Where *Total* is the liquidity measure for the total limit order book for firm *i* at minute *t*. I use both top-of-book liquidity measures (spread and price impact) and depth liquidity measures (CRT and DWAP). *Static* is the liquidity measure for the static limit order book, and *Fleeting* is the liquidity measure for the fleeting limit order book. The regression results for top-of-book liquidity measures are reported in Table 4, and depth liquidity measures are reported in Table 5. Control variables are represented by the vector *X*, and includes the log of the market capitalization for firm *i*, log of the daily closing price, the price volatility for minute *t* and the daily price range. I also include fifteen minute time of day fixed effects and firm fixed effects.

Table 4 presents the results from estimating equation 8 using top of book liquidity measures. I consider the quoted spread in models [1] through [3], effective spread in models [4] through [6] and price impact for models [7] through [9]. Each liquidity measure is computed with the fleeting and static measure independently, as well as the measures regressed simultaneously. The results for top all the top of book liquidity measures are fairly consistent. Both static and fleeting measure of liquidity are usually positively associated with total liquidity. However, the static limit order book has a larger impact on total liquidity. On average, a one dollar increase in the fleeting quoted spread leads to a 1.47 cent increase in the total quoted spread (with the same holding true for a decrease in spread) while a one dollar increase in the static quoted spread leads to an 86.99 cent increase in the total quoted spread (with the same holding true for a decrease in spread). The Wald statistics report that the coefficients for the static and fleeting liquidity measures are significantly different from each other. There are similar results for the effective spread and price impact for static depth, but fleeting depth does not have a significant impact on total liquidity. The top of book liquidity results provide support for the static depth hypothesis, but little support for the fleeting depth hypothesis. I now turn to beyond-top-of-book measures.

[Insert Table 4 here]

Table 5 presents the results from estimating equation 8 using depth liquidity measures. The specifications are identical to the models in Table 4, where depth measures are used in place of top-of-book measures. In models [3], [6], and [9] both static and fleeting depth are regressed on total depth. From model [3], a one dollar increase in the cost to trade 1000 shares on the static limit order book leads to a 78 cent increase in the total limit order book (with the same holding true for a one dollar decrease), while fleeting depth has no impact on the total limit order book. Similar results hold true for the cost to trade 5000 shares in column 6. The magnitude shifts in the depth-weighted average price regression, where fleeting depth has a larger impact on the total limit order book.

[Insert Table 5 here]

The results displayed in tables 4 and 5 have interesting implications. Both the top-of-book and depth measures of liquidity provide ample support for the static depth hypothesis, which states that static orders have a positive and significant impact on total liquidity. Static orders are consistently at the top of the limit order book, providing competitive prices for traders. Static orders also remain on the limit order book to allow traders to complete large roundtrip trades. I find little support for the fleeting depth hypothesis. Fleeting orders have a small impact on top of book of liquidity measures, and in most of the depth specifications do not contribute significantly to depth. These results suggest that fleeting orders may more appropriately be described as contributing noise to the markets, rather than contributing to depth and liquidity.

V. Theoretical implications of fleeting liquidity

In this section I test the largely untested theoretical predictions on fleeting orders. Rosu (2009) predicts that fleeting orders only occur when the spread is low, and depth is high. Rosu also predicts that fleeting orders are only submitted within the bid-ask spread. Baruch and Glosten (2013) predict that when there are a many fleeting orders, the depth provided by fleeting orders should be static and constant.

First, I test the prediction of Rosu (2009) that fleeting orders only occur when the limit order book is full (spread is at a minimum nonzero tick size, and the limit order book is full). Empirically it is unlikely for a limit order book to ever be classified as full, since this would require the exchange to set a cap on the number of orders allowed on the limit order book. Therefore I test this theory by comparing fleeting orders during periods of high depth relative to periods of low depth. I partition fleeting orders for a given stock-day into depth quintiles. I test Rosu's theory by comparing the ratio of fleeting orders to static orders during the minutes that experienced the highest depth against the minutes that experienced the lowest depth. Panel A and B display the results for sorting on the cost of a round trip trade, while Panel C reports the results for sorting based off of quoted spread. All three panels report more fleeting orders when depth is high, but the ratio of fleeting orders to static orders is lower when depth is high. I perform an additional test where I sort depth based on market capitalization across stocks, and find that there are more fleeting orders for large stocks compared to small stocks. The results from Table 6 provide little support for Rosu's prediction that fleeting orders only occur when depth is high.

[Insert Table 6 here]

Rosu's (2009) theory also predicts that fleeting orders are only submitted within the bid-ask spread. To test this theory I separate all orders into one of three categories: orders that improve the BBO (submitted within the spread), orders that match the BBO, and orders behind the BBO. I calculate the number of fleeting, static, and total orders that fit into these three categories. I also calculate the percent of fleeting orders, static orders, and total orders that are in these categories. Table 7 reports the results. Approximately 15% of fleeting orders, and 10% of static orders are submitted within the bid-ask spread, making 12% of total orders being price improving orders. Over 38% of fleeting orders match the BBO, while just over 32% of static orders match the BBO. Approximately 48% of fleeting orders are behind the BBO while 58% of static orders are behind the

BBO. These differences are all significant at the 1% level. The differences between fleeting and static orders are also significant. Although the results show that there are more fleeting orders that are submitted within the bid-ask spread compared to static orders, nearly half of all fleeting orders are not competitive orders, providing little support that fleeting orders are submitted exclusively within the bid-ask spread.

[Insert Table 7 here]

The lest theoretical prediction I test is from Baruch and Glosten (2013), who predict that fleeting orders may lead to forecastable and constant depth. The theory suggests that when there are only a few traders submitting fleeting orders, quotes will flicker and depth will not be constant. However, as the number of traders submitting fleeting orders increase, depth will be constant and quotes will appear static. I test this theory by partitioning stock-days into three fleeting order partitions based on the number of fleeting orders. In each partition I calculate the volatility of the total quoted spread, the static quoted spread, and the fleeting quoted spread. If depth is constant and forecastable when there are many fleeting orders, then the volatility of the fleeting quoted spread should be low, and indifferent from the total quoted spread in the highest tercile of fleeting orders.

Table 8 reports the results of this test. In the lowest tercile of fleeting orders, the standard deviation of the quoted spread is 8.40 cents higher for fleeting orders compared to static orders. In the tercile of high fleeting orders, the standard deviation of the fleeting quoted spread is 8.65 cents higher than the total quoted spread. Additionally, the standard deviation of the fleeting quoted spread is greater in the high fleeting order tercile compared to the low fleeting order tercile. These results suggest that when there are many fleeting orders in the market, the volatility of the fleeting order quoted spread is even greater, which does not support the theory of Baruch and Glosten (2013). These results further support the notion that fleeting orders introduce noise into financial markets.

[Insert Table 8 here]

V. Conclusion.

This paper investigates market quality in low latency markets. One of the externalities of low-latency markets is fleeting orders, which are orders that only provided liquidity for a short period of time before being deleted. I compare the characteristics of fleeting orders against longer duration orders to study market quality in low-latency markets. Theory suggests that liquidity providing traders may submit fleeting orders and static orders. Empirically, I separate short duration (fleeting) orders from long duration (static) orders to isolate the impact that each type of order has on market quality. In addition to comparing fleeting orders against static orders, I determine how much each type of order contributes on total liquidity.

The results suggest that static orders have a large and significant impact on total liquidity. The best bid and best offer prices are largely determined by fleeting orders. Additionally, static orders significantly contribute to the total depth in the market. I find little support that fleeting orders positively impact liquidity. Fleeting orders have little to no impact on the best bid and offer, and do not provide depth for traders submitting large trades. The results suggest that fleeting orders provide more noise than liquidity.

This paper also tests previously untested implications of the theoretical literature on fleeting orders. Rosu (2009) predicts that fleeting orders are more likely when depth is high and spread is low. I find that there are more fleeting orders submitted when depth is high, as well as more static orders. However, the ratio of fleeting orders to static orders is higher when depth is low. Rosu (2009) also predicts that fleeting orders are only submitted within the bid-ask spread. I find that approximately 55% of fleeting orders are submitted within the bid-ask spread, which is not statistically different than the number of static orders submitted within the bid-ask spread. These results only partially support the theory by Rosu. Baruch and Glosten (2013) predict that large numbers of fleeting orders should have constant and forecastable depth. I find that during periods of high fleeting order activity, volatility of the best bid and offer for the total limit order book and fleeting limit order book increase, which does not support the theory by Baruch and Glosten, and adds to the notion that fleeting orders are introducing noise to financial markets.

This paper, to my knowledge, is the first to empirically determine to what extent both fleeting orders and static orders contribute to total depth. Fleeting depth and static depth, although both submitted by liquidity supplying traders, have different contributions to total depth. Fleeting depth does provide liquidity cheaper than static depth, however the availability to trade against fleeting depth is much lower since fleeting depth appears to selectively supply liquidity. Static depth consistently provides liquidity. The results in this paper suggest that it is appropriate to describe liquidity as two components, and that there is in fact more depth to depth, wherein each component has a different impact on total liquidity.

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Table 1
Summary Statistics

This table presents summary statistics for the data used in the study. Panel A displays firm summary statistics, where price, trades, shares traded, and market cap are respectively the closing price, number of daily trades, number of shares traded, and the market capitalization for the average firm in our sample. Fleeting orders are the number of orders on the limit order book for two seconds or less, and static orders are the number of orders that provide liquidity for greater than two seconds for the average firm in our sample on the Nasdaq exchange. Panels B, C, and D report limit order book (LOB) summary statistics at the minute level for the average firm in our sample. Panel B is depth for the complete, or 'real', LOB. Panels C and D are two artificial LOBs, where Panel C reports the depth contributed from static limit orders, and Panel D reports the depth from fleeting limit orders. The depth measures include three top of book measures (quoted spread, effective spread, and price impact) and nine depth measures. Depth measures include the ex-ante per-share cost to buy and sell q number of shares (the cost of a round trade, CRT) and the difference between the depth-weighted average offer and the depth weighted average bid price (DWAP-spread). These depth measures are also reported as a ratio over the quoted spread. Data comes from CRSP, the SEC MIDAS dataset, and the Nasdaq Total-View ITCH order-level dataset.

	No Obs.	Mean	Median	St. Dev.	Min	Max
Panel A: Firm level daily summary statistics						
Price	7,445	37.26	24.86	58.66	5.00	1,309.28
Trades	7,445	665.33	290.50	1,235.03	16.75	22,234.75
Shares Traded(000s)	7,445	1,159,250	323,204	3,462,070	15,869	62,584,615
Market Cap (000s)	7,445	5,519,186	1,046,328	25,642,471	54,764	575,613,638
Fleeting Orders	1,186	16,246.10	6,388.50	35,401.23	185.00	672,061
Static Orders	1,186	13,598.67	7,778.00	17,688.14	615.00	201,012
Panel B: Complete limit order book minute level liquidity summary statistics						
Top of book liquidity						
Quoted Spread	3,148,658	0.07	0.03	0.14	0.00	45.02
Effective Spread	1,481,932	0.03	0.01	0.22	0.00	187.66
Price Impact	1,481,932	0.00	0.00	0.02	0.00	9.92
Depth Liquidity						
CRT100	3,148,651	0.08	0.04	0.15	0.00	45.05
CRT500	3,148,651	0.13	0.06	0.25	0.00	79.61
CRT1000	3,148,654	0.22	0.10	0.41	0.00	111.24
CRT5000	3,127,492	1.49	0.40	2.82	0.00	147.95
CRT10000	2,547,370	1.90	0.66	3.40	0.00	239.23
DWAP-Spread	3,148,658	10.66	7.32	14.82	0.13	356.86
CRT1000/Quoted	3,148,651	3.24	2.55	2.91	1.00	439.70
CRT5000/Quoted	3,127,489	20.93	10.75	31.04	1.00	1,861.91
DWAP/Quoted	310,048	37.59	40.52	10.23	1.00	50.00

	No Obs.	Mean	Median	St. Dev.	Min	Max
Panel C: Static limit order book minute level liquidity summary statistics						
Top of book liquidity						
Quoted Spread	3,009,303	0.07	0.04	0.15	0.01	44.34
Effective Spread	1,374,459	0.04	0.02	0.23	0.00	187.66
Price Impact	1,482,433	0.00	0.00	0.01	0.00	0.76
Depth Liquidity						
CRT100	3,009,097	0.08	0.04	0.17	0.01	44.34
CRT500	3,002,171	0.17	0.08	0.31	0.01	80.91
CRT1000	2,980,988	0.27	0.12	0.52	0.01	162.78
CRT5000	2,530,631	1.53	0.40	2.96	0.01	166.61
CRT10000	1,917,921	1.92	0.66	3.55	0.01	255.42
DWAP-Spread	3,009,310	8.62	5.60	13.35	0.01	490.06
CRT1000/Quoted	2,980,985	3.68	2.80	4.46	1.00	4,751.51
CRT5000/Quoted	2,530,628	21.42	10.64	32.63	1.00	2,854.42
DWAP/Quoted	940,165	28.31	28.46	12.66	1.00	50.00
Panel D: Fleeting limit order book minute level liquidity summary statistics						
Top of book liquidity						
Quoted Spread	2,456,068	0.23	0.11	1.18	0.01	507.69
Effective Spread	705,377	0.08	0.03	0.47	0.00	232.57
Price Impact	1,482,433	0.00	0.00	0.00	0.00	0.23
Depth Liquidity						
CRT100	2,448,177	0.24	0.12	1.25	0.01	557.24
CRT500	1,232,424	0.18	0.10	1.29	0.01	571.55
CRT1000	882,937	0.19	0.11	1.18	0.01	634.18
CRT5000	160,692	0.15	0.08	0.59	0.01	8.30
CRT10000	57,659	0.31	0.07	1.26	0.01	9.07
DWAP-Spread	2,456,068	0.50	0.29	1.83	0.01	590.79
CRT1000/Quoted	882,937	3.78	2.74	8.34	1.00	1,319.42
CRT5000/Quoted	160,692	7.38	4.90	20.09	1.00	442.38
DWAP/Quoted	2,453,804	4.61	2.94	4.26	0.01	50.00

Table 2
Fleeting and Static depth against total depth

This table reports the differences of liquidity measures from the fleeting and static LOBs against total liquidity from the complete LOB. The total LOB includes all orders, while the static and fleeting LOBs are subsets of the complete LOB. The fleeting LOB is comprised of only limit orders that provide liquidity for two seconds or less, whereas the static LOB is only comprised of limit orders providing liquidity greater than two seconds. Columns [1] through [3] report the liquidity measures for the total, static and fleeting LOB respectively. Column [4] is the difference between the static and total LOB, while column [5] reports the difference between the fleeting and total LOB. Column 6 reports the differences between the fleeting and static LOB.

	Total LOB	Static LOB	Fleeting LOB	Total - Static	Total - Fleeting	Diff-in-Diff
	[1]	[2]	[3]	[4]	[5]	[6]
Panel A: Top of book liquidity measures						
Quoted Spread	0.0751	0.0773	0.23785	-0.0022*	-0.1628*	0.1606*
				(17.43)	(224.57)	-221.28
Effective Spread	0.0352	0.0375	0.08367	-0.0023*	-0.0485*	0.0462*
				(8.42)	(99.11)	-92.14
Price Impact	0.0022	0.0023	0.00289	-0.0001*	-0.0007*	0.0005*
				(4.98)	(20.08)	-10.52
Panel B: Depth liquidity measures						
CRT1000	0.2371	0.2802	0.19989	-0.0431*	0.0372*	-0.0803*
				(106.51)	(-43.11)	(85.59)
CRT5000	1.6441	1.6141	0.16304	0.0300*	1.4811*	-1.4511*
				(-11.46)	(-183.1)	(173.12)
CRT1000 / Quoted	3.3804	3.7644	3.87749	-0.3840*	-0.4971*	0.1131*
				(120.23)	(82.35)	(-15.7)
CRT5000 / Quoted	22.4085	22.2522	7.93254	0.1562*	14.4759*	-14.3197*
				(-5.45)	(-161.93)	(153.71)
DWAP spread	11.3161	8.9286	0.51593	2.3875*	10.8002*	-8.4127*
				(-195.58)	(-1067.10)	(936.13)
DWAP / Quoted	37.8434	28.6351	4.60688	9.2083*	33.2365*	-24.0283*
				(-357.33)	(-3194.40)	(2554.21)
Panel C: Percentage of minutes able to buy and sell q shares						
q=100	1.00	1.00	0.95	0.00*	0.05*	-0.05*
				(-18.26)	(-42.58)	(42.31)
q=500	1.00	1.00	0.42	0.00*	0.58*	-0.58*
				(-15.35)	(-119.18)	(118.61)
q=1000	1.00	0.99	0.29	0.01*	0.71*	-0.70*
				(-15.36)	(-147.39)	(144.31)
q=5000	0.99	0.84	0.05	0.16*	0.95*	-0.79*
				(-38.69)	(-417.09)	(176.02)
q=10000	0.79	0.63	0.02	0.16*	0.77*	-0.61*
				(-23.51)	(-166.30)	(111.31)

Table 3
Cost and percent of time to complete a round trip trade.

This table reports the cost of a round trip trade for trades of size q, separated by market capitalization quintiles. Brackets report the percent of time that a trader is able to complete a round trip trade for. The data is partitioned by market capitalization quintiles, where Q1 represents the smallest 20% of securities in the sample and Q5 represents the largest 20%. Column [6] reports the difference between the largest 20% and smallest 20%. * represents significance at the 1% level.

	Q1 Small	Q2	Q3	Q4	Q5 Large	Q5 – Q1	
	[1]	[2]	[3]	[4]	[5]	[6]	Test Statistic
			Panel A: Total Limit Order Book				
q=100	0.06	0.08	0.10	0.08	0.08	0.02*	-3.19
	[1.00]	[1.00]	[1.00]	[1.00]	[1.00]	[0.00]	-0.98
q=500	0.12	0.16	0.19	0.15	0.12	0.00	-0.77
	[1.00]	[1.00]	[1.00]	[1.00]	[1.00]	[0.00]	-0.98
q=1,000	0.19	0.26	0.32	0.25	0.19	0.00	0.17
	[1.00]	[1.00]	[1.00]	[1.00]	[1.00]	[0.00]	0.00
q=5,000	1.04	1.80	2.58	2.12	0.92	-0.12	1.66
	[1.00]	[0.99]	[0.99]	[1.00]	[1.00]	[0.00]	-1.27
q=10,000	1.84	2.53	3.88	3.76	2.15	0.31	-2.21
	[0.79]	[0.71]	[0.68]	[0.81]	[0.97]	[0.18]*	-16.42

	Q1 Small	Q2	Q3	Q4	Q5 Large	Q5 – Q1	
	[1]	[2]	[3]	[4]	[5]	[6]	Test Statistic
				Panel B: Static Limit Order Book			
q=100	0.07	0.09	0.11	0.09	0.08	0.01*	-3.04
	[1.00]	[1.00]	[1.00]	[1.00]	[1.00]	0.00*	-10.92
q=500	0.14	0.19	0.23	0.17	0.14	0.00	0.20
	[0.99]	[1.00]	[1.00]	[1.00]	[1.00]	0.00*	-8.66
q=1,000	0.23	0.31	0.38	0.31	0.22	-0.01	0.76
	[0.98]	[0.99]	[0.99]	[1.00]	[1.00]	0.02*	-8.19
q=5,000	1.23	1.92	2.78	2.45	1.40	0.18	-1.24
	[0.77]	[0.81]	[0.81]	[0.86]	[0.96]	0.19*	-17.06
q=10,000	1.82	2.48	3.72	3.64	2.73	0.91*	-3.21
	[0.57]	[0.54]	[0.52]	[0.65]	[0.86]	0.29*	-19.77
				Panel C: Fleeting Limit Order Book			
q=100	0.21	0.28	0.31	0.27	0.26	0.05*	-2.80
	[0.91]	[0.94]	[0.95]	[0.97]	[0.99]	[0.08]*	[-22.27]
q=500	0.30	0.60	0.67	0.44	0.34	0.04	-1.23
	[0.20]	[0.33]	[0.34]	[0.51]	[0.77]	[0.56]*	[-46.84]
q=1,000	0.57	1.73	0.97	0.78	0.43	-0.14*	2.72
	[0.08]	[0.17]	[0.21]	[0.37]	[0.67]	[0.58]*	[-47.55]
q=5,000	0.38	0.37	0.10	0.08	0.09	-0.29*	9.32
	[0.00]	[0.01]	[0.02]	[0.08]	[0.13]	[0.13]*	[-17.26]
q=10,000	2.67	1.68	0.08	0.06	0.08	-2.59*	18.40
	[0.00]	[0.00]	[0.00]	[0.03]	[0.05]	[0.05]*	[-10.70]

Table 4
The contribution of fleeting and static top-of-book liquidity on total top-of-book liquidity

This table relates the static and fleeting limit order book to the complete limit order book. The dependent variable in models 1 to 3 is the quoted spread, models 4 to 6 is the effective spread, and models 7 to 9 is price impact for stock *i* and time *t*, averaged to the minute. The two key variables in all equations is the static and fleeting measure of liquidity (quoted spread, effective spread, and price impact). I include midpoint price volatility for minute *t* to capture minute volatility, daily price range to capture stock volatility, the log of the daily closing price, and the market capitalization, as control variables. Estimates are obtained by ordinary least squares, I report test-statistics computed with robust standard errors clustered at the firm level in parentheses. All models include firm fixed effects, as well as minute dummy variables to control for time of day liquidity patterns. Wald tests are conducted to check if fleeting and static liquidity is identical in its contribution to total liquidity, with f-tests reported at the bottom of the table. ***, **, and * indicate significance at the 1%, 5%, and 10% levels respectively.

Dependent Variable	Quoted Spread			Effective Spread			Price Impact		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Intercept	0.0318	0.5393***	0.0555**	-0.0270*	0.1359**	0.0276	-0.0059	-0.0063	-0.0059
	(1.296)	(5.701)	(2.082)	(-1.683)	(2.499)	(1.496)	(-1.141)	(-1.155)	(-1.123)
Static Quoted spread	0.9269***		0.8699***						
	(32.005)		(25.785)						
Fleeting Quoted spread		0.0515***	0.0147***						
		(5.276)	(3.817)						
Static Effective spread				0.9611***		0.7138***			
				(38.137)		(14.035)			
Fleeting Effective spread					0.0077***	0.0007			
					(2.927)	(0.384)			
Static Price impact							0.5425***		0.5241***
							(4.264)		(3.864)
Fleeting Price impact								-0.0132	0.0113
								(-1.406)	(0.995)
Minute Price	-0.0000	0.0000***	-0.0000***	0.0000	0.0000	0.0000	0.0000***	0.0000***	0.0000***
Standard Deviation	(-0.076)	(3.229)	(-2.782)	(0.652)	(1.375)	(0.092)	(5.951)	(5.599)	(5.716)
Range	-0.0006***	-0.0016	-0.0013***	-0.0005***	0.0019	-0.0000	0.0001***	0.0001***	0.0001***
	(-4.224)	(-0.935)	(-4.694)	(-4.910)	(0.933)	(-0.050)	(2.769)	(2.912)	(2.757)
Log Price	0.0069**	0.0801***	0.0096***	-0.0027**	0.0315***	0.0055***	0.0000	0.0000	-0.0000
	(2.386)	(13.294)	(3.073)	(-2.339)	(9.819)	(3.143)	(0.018)	(0.121)	(-0.051)
Market Cap	-0.0029	-0.0404***	-0.0049**	0.0024**	-0.0115***	-0.0022*	0.0007**	0.0007**	0.0007**
	(-1.514)	(-7.458)	(-2.393)	(2.546)	(-3.828)	(-1.903)	(2.208)	(2.229)	(2.183)
Stock and Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test (Static=Fleeting)			582.01***			194.32***			15.74***
N	1071	1071	1071	1071	1071	1071	1071	1071	1071
No. Obs	2,803,925	2,340,823	2,335,426	1,318,129	691,040	623,363	1,389,765	1,340,491	1,340,406
R-Squared	0.8404	0.3309	0.8455	0.9058	0.0790	0.7161	0.0825	0.0787	0.0832

Table 5
The contribution of fleeting depth and static depth on total depth

This table relates the static and fleeting limit order book to the complete limit order book. The dependent variable in models 1 to 3 is the cost to buy and sell 1000 shares, models 4 to 6 is the cost to buy and sell 5000 shares, and models 7 to 9 is depth weighted average spread for stock *i* and time *t*, averaged to the minute. The two key variables in all equations is the static and fleeting measure of depth. I include range, the daily high minus the daily low, the log of the closing price, and the market capitalization, as control variables. Estimates are obtained by ordinary least squares, I report test-statistics computed with robust standard errors clustered at the firm level in parentheses. All models include firm fixed effects, as well as minute dummy variables to control for time of day liquidity patterns. Wald tests are conducted to check if fleeting and static liquidity is identical in its contribution to total liquidity, with f-tests reported at the bottom of the table. ***, **, and * indicate significance at the 1%, 5%, and 10% levels respectively.

Dependent Variable	CRT 1000			CRT 5000			DWAP Spread		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Intercept	-0.2343	1.3356**	-0.1436	-0.3644	1.8509	-3.0450	138.9580***	135.3132***	146.0591***
	(-1.510)	(2.370)	(-0.719)	(-0.223)	(0.856)	(-1.062)	(7.603)	(6.037)	(7.349)
Static CRT 1000	0.6342***		0.7896***						
	(10.744)		(13.582)						
Fleeting CRT 1000		0.0371***	0.0060						
		(5.493)	(1.043)						
Static CRT 5000				0.6598***		0.9303***			
				(12.425)		(40.991)			
Fleeting CRT 5000					0.0037	0.0072			
					(1.170)	(0.999)			
Static DWAP spread							0.0890**		0.0819**
							(2.403)		(2.444)
Fleeting DWAP spread								0.2142***	0.1947***
								(4.070)	(3.868)
Minute Price	0.0000***	0.0000***	0.0000	0.0000	-0.0000*	-0.0000***	-0.0000	-0.0000***	-0.0000***
Standard Deviation	(3.247)	(5.238)	(0.639)	(1.572)	(-1.798)	(-3.089)	(-0.730)	(-2.963)	(-2.920)
Range	0.0083***	0.0112***	0.0010	0.0032	-0.0100	-0.0122*	-0.2867*	-0.3091**	-0.3080**
	(3.889)	(3.964)	(0.618)	(0.705)	(-0.427)	(-1.826)	(-1.788)	(-2.361)	(-1.965)
Log Price	0.0626***	0.1842***	-0.0209	0.3643***	0.2134	-0.2111	7.3626***	8.5509***	7.1391***
	(4.820)	(3.732)	(-0.905)	(2.916)	(1.320)	(-1.035)	(5.509)	(5.923)	(5.065)
Market Cap	0.0114	-0.1183**	0.0138	-0.0257	-0.1514	0.2294	-10.6886***	-10.5314***	-11.0213***
	(1.082)	(-2.579)	(0.910)	(-0.204)	(-0.921)	(1.053)	(-9.636)	(-8.094)	(-9.500)
Stock and Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test (Static=Fleeting)			170.51***			1433.87***			6.13**
N	1,071	1,068	1,068	1,071	418	418	1,071	1,071	1,071
No. Obs	2,780,332	817,513	816,446	2,358,279	131,100	130,925	2,803,925	2,340,823	2,335,426
R-Squared	0.7216	0.1020	0.8188	0.7240	0.1631	0.9864	0.0663	0.0358	0.0741

Table 6
Depth in volume quintiles

This table displays the number of fleeting and static orders at depth quintiles. Depth is first ranked at the minute level within a stock, and then averaged across stocks. Panel A ranks are formed according to the trading costs to simultaneously buy and sell 1000 shares of a stock. Panel B ranks are formed according to the cost to buy and sell 5000 shares of a stock. Panel C ranks are formed according to the DWAP spread, which is the difference between the depth-weighted average offer price and the depth-weighted average bid price. Q1 represents low levels of CRT and DWAPspread, which is indicative of high depth, while Q5 represents low depth. Column [6] reports the differences. * represents significance at the 1% level.

	Q1 High Depth	Q2	Q3	Q4	Q5 Low Depth	Q5 – Q1
	[1]	[2]	[3]	[4]	[5]	[6]
Panel A: Total CRT1000 Depth						
Fleeting Orders	5,039.91	5,851.41	5,618.42	2,965.89	1,449.04	-3,590*
						(15.96)
Static Orders	4,190.59	4,344.81	3,792.39	1,930.94	1,371.50	-2,819*
						(33.68)
Fleeting/Static Orders	0.73	0.82	0.96	1.22	1.22	0.48*
						(31.53)
Panel B: Total CRT5000 Depth						
Fleeting Orders	5,303.50	5,254.21	4,430.47	3,166.31	2,749.49	-2,554*
						(10.56)
Static Orders	4,060.30	3,816.14	3,234.28	2,360.15	2,132.32	-1,928*
						(23.79)
Fleeting/Static Orders	0.83	0.84	0.90	1.01	1.15	0.32*
						(23.74)
Panel C: Spread						
Fleeting Orders	4,230.20	5,519.33	6,170.89	3,956.25	1,209.83	-3,020.40*
						(16.72)
Static Orders	3,940.37	4,486.12	4,335.04	2,190.98	819.21	-3,121.20*
						(41.44)
Fleeting/Static Orders	0.68	0.81	0.99	1.38	1.42	-0.74*
						(38.69)
Panel C: Market Cap						
Fleeting Orders	443.91	6,147.00	588.55	5,780.57	384.56	59.35
						(0.37)
Static Orders	364.99	2,060.17	602.54	1,959.65	365.00	0.01
						(0.00)
Fleeting/Static Orders	1.74	2.93	1.53	2.93	1.63	0.11
						(0.40)

Table 7
Are fleeting orders only submitted within the spread?

This table reports the aggressiveness of orders submitted in the limit order book. Order aggressiveness is separated into one of three categories, orders that improve the BBO, orders that match the BBO, and orders that are placed behind the best bid and offer. The best bid and offer are computed from the limit order book using Nasdaq Total-View Itch data. * indicates statistical significance at the 1% level.

	Improve BBO	Match BBO	Behind BBO	Difference	Test-statistic
	[1]	[2]	[3]	[1] – [3]	
# Fleeting Orders	1,490.47	9,306.68	8,515.15	-7,024.70*	37.63
# of Static Orders	879.54	4,204.02	9,481.69	-5,602.15*	56.98
# of All Orders	2,370.00	13,511.71	17,999.08	-15,629.10*	48.46
% Fleeting Orders	0.15	0.38	0.48	-0.33*	148.99
% Static Orders	0.10	0.32	0.58	-0.470*	275.26
% All Orders	0.12	0.35	0.53	-0.41*	222.38
%Fleeting – % Static	0.05*	0.06*	0.10*		
Test-statistic	29.89	20.20	41.48		

Table 8
Do fleeting orders create constant forecastable depth?

This table reports the volatility of the best bid and offer for the fleeting limit order book, static limit order book, and fleeting limit order book. Terciles are formed within each stock, where low days experiencing low fleeting order activity are in the first tercile, and days experiencing high fleeting order activity are in the third tercile. For consistency, ranks are formed within stocks and not cross-sectionally. * indicates significance at the 1% level.

	Low Fleeting Orders	Medium Fleeting Orders	High Fleeting Orders	Difference	Test-statistic
	[1]	[2]	[3]	[1] – [3]	
Total BBO Std. Dev	0.0065	0.0141	0.0317	-0.0252*	37.86
Static BBO Std. Dev	0.0067	0.0147	0.0335	-0.0268*	40.63
Fleeting BBO Std. Dev	0.0907	0.0939	0.1201	-0.0294*	6.70
Fleeting – Static	0.0840*	0.0792*	0.0865*		
Test-statistic	28.54	32.47	29.03		