Dynamics of Event-Induced Liquidity Changes In the Aftermarket

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Abstract

This paper studies the effects of large price changes on the liquidity measures such as spread and depth, as well as transaction prices immediately following the IPO. In the immediate aftermarket the underwriter is almost always the market maker for NASDAQ stocks, and different sets of incentives are present from the perspectives of the underwriter and market maker. Previous studies have documented that liquidity providers manage additional uncertainty by decreasing liquidity exposure – widening the spread and reducing the depth. In the immediate aftermarket, however, I document that quoted spread is the only dimension along which the liquidity providers manage the additional uncertainty. I also document that the magnitude of the quoted spread increases as the time since the IPO elapses, which supports the hypothesis that the market makers have an incentive to offer additional liquidity to ensure the success of the offering. Surprisingly, the magnitude of spread increases seems to have negligible effect on post-event return predictability on daily basis.

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Introduction

The period immediately following the initial public offering has been the subject of numerous studies. Not only is the IPO one of the most important events in finance, but the immediate aftermarket also presents the researcher with a quite unique setting, characterized by a variety of institutional and statistical features.

The development of the aftermarket liquidity is of particular importance, since an orderly and liquid market is critical to the success of the offering. This paper analyzes the responses of NASDAQ market-makers to significant price changes in terms of adjusting quoted spread and depth. A large body of literature analyzes aftermarket liquidity. Recently, the focus of research has shifted towards the role of the underwriter in the period following the IPO. Nevertheless, most of the existing analysis has been performed in an *unconditional* setting. In other words, no specific information releases are considered in the development of the market liquidity following the IPO. This paper applies some of the existing analysis techniques to a conditional setting, in order to explore the dynamics of aftermarket liquidity measures (spreads and depths) and prices.

The main research question explores the price and liquidity responses of newly issued stocks to information events. Several factors could be at play. On one hand, market makers are faced with an increased adverse information risk following the event. This issue is addressed in Lee et al. (1993). They show that, in general, a release of firm-specific information increases the market-maker’s risk of trading with, and losing to, an informed trader. Providing liquidity on NASDAQ is a competitive business, in which the market makers seek to maximize profits. Therefore, as a rational agent, a market maker will manage additional event-induced risk by decreasing the liquidity s/he provides.

On the other hand, there is a separate set of incentives from the point of view of underwriting and stabilizing the offering. In the case of NASDAQ stocks, the underwriter is always a market maker (and, sometimes, the only market maker). The underwriter seeks to reward informed investors through various stabilization activities, such as price support. It has been shown that price support increases liquidity in the aftermarket. Therefore, it is unclear whether drops in liquidity following information releases will become more, or less, drastic as the time since issue elapses. The main goal of this paper is to determine whether the degree of event-induced information asymmetry from the perspective of the market maker and, therefore, the event-induced changes in liquidity, evolve as stocks season.

The analysis proceeds as follows. First, the effect of significant price changes on liquidity measures is analyzed. Not surprisingly, a significant increase in the quoted spread is documented surrounding a price change. Quoted depth, on the other hand, stays nearly constant, with the exception of a few sub-samples of negative events. Transaction volume dramatically increases around significant price changes. Next, the dynamics of the liquidity measures are explored as the time since the IPO elapses. It is documented that the magnitude of the quoted spread at the event time increases over the first six months after the IPO. This is consistent with the conjecture that market makers have an incentive to provide additional liquidity in the immediate aftermarket through lower spreads, in order to ensure the success of the offering.

The relationship between the magnitude of the information signal and liquidity changes is also explored. The model of Blume et al. (1994) suggests that an event-day price change is a reasonable proxy for a signal's magnitude. The relationship between drops in liquidity, and the speed of incorporation of information into stock prices, is also considered.

The rest of this paper is organized as follows. Section 2 presents a brief review of the literature on aftermarket liquidity and price behavior in the intraday setting. Section 3 describes the data used in the study. Section 4 presents the research hypotheses and the analysis methodology. Section 5 describes the empirical findings, and Section 6 concludes.

Prior Work

Several authors explore the reactions of liquidity (specifically, the bid-ask spread) to firm-specific information signals. Conflicting evidence has been reported following stock splits. Forjan and McCorry (1998) document reductions of the bid-ask spread following such announcements. The authors attribute their finding to reduced information asymmetry. Conroy et al. (1990), on the other hand, document that spreads increase in a sample of NYSE stocks following stock splits.

Similarly contradictory evidence surrounds the dividend announcements. Brooks (1994) documents no significant impact of dividend announcements on the spread. Mitra and Rashid (1997), on the other hand, document significant spread increases on the day prior to the dividend initiation announcements. The authors attribute this to the increased uncertainty from the point of view of a market maker. Howe and Lin (1992) find that stocks which do not pay dividends normally have wider spreads than those which do.

A large body of literature analyzes the development of the aftermarket liquidity. Some papers concentrate on liquidity in general, while others consider the specific actions of underwriters. Corwin et al. (2004) analyze order flow and limit order book characteristics following NYSE-listed IPOs. They document unusually high limit order book depth and low bid-ask spreads. Order depth decreases to stable levels within two to three weeks. Boehmer and Fishe (2006) discuss price support by the underwriter, and its role in the development of aftermarket liquidity. They document that, consistent with information theories, underwriters do compensate informed investors by providing additional liquidity through price support. No such result is documented for seasoned equity offerings. Hanley et al. (1993) find that the spreads are considerably lower when the actual price is close to the offer price. This may indicate a higher probability of price stabilization activities.

Ellis et al. (2000) analyze the role of the underwriter in the aftermarket. They document that the lead underwriter always becomes the lead market maker in the aftermarket. They find that the underwriter is exposed to a substantial inventory risk, which they try to reduce through the exercise of the over-allotment option. Hegde and Miller (1989) examine the behavior of the bid-ask spreads of IPOs in the over-the-counter market. The authors document higher quoted percentage bid-ask spreads for initial public offerings. They find that the significant differences persist for the period of eight weeks.

Marshall (2004) points out the unique liquidity risk of the IPO because of its implications for bargaining position with the underwriter. The author documents that firms with lower liquidity levels at the IPO are characterized by greater under-pricing. Hegde and Varshney (2003) investigate, among other things, consequences of ownership structure choice on the secondary market liquidity. They document that liquidity is positively related to institutional ownership concentration, and negatively related to ownership retention and underwriter reputation.

Zheng et al. (2005) argue that, in an IPO, owners decide on under-pricing, share retention and the length of the share lockup with a view to maximizing aftermarket liquidity. Similar to Hegde and Varshney (2003), they document a negative relationship between ownership retention and liquidity. Cao et al. (2004) document that, although lockup expirations are associated with considerable insider trading for many IPOs, the effect on the effective spread is insignificant. Quoted depth and trading activity, on the other hand, improve significantly. Li et al. (2005) find that the level of asymmetric information is lower immediately after the IPO, but rises as stocks season. They use the adverse selection component of the bid-ask spread as a measure of information asymmetry.

Lee et al. (1993) study the effects of event-induced information asymmetry in the context of earnings announcements. Using a sample of seasoned NYSE-listed firms, the authors show that spreads widen, and depths fall, in anticipation of earnings announcements. They also find that the depth, rather than the spread, is a more likely dimension along which market makers will manage event-induced uncertainty. Not surprisingly, liquidity effects are more pronounced for signals with higher magnitude. This study adopts some of the analysis techniques of this paper.

Data

The data on transaction prices, quoted spreads and depths are obtained from the NYSE TAQ database. The sample consists of 220 IPOs that went public on NASDAQ in the period between January 1, 1998 and December 31, 2002.[7] Similar to Bossaerts and Hillion (2001), companies for which the CRSP variable SHRCD (share code) is different from 10 or 11 are eliminated from the sample. This eliminates certificates, ADRs, shares of beneficial interest, unit offerings and REITs. Financial institutions are also excluded from the sample, using historical CRSP SIC codes.

[7] The amount of the intraday data that had to be processed was too great to include more firms.

Events which occurred during the first 120 trading days of the aftermarket are examined. Similar to Lee et al. (1993), the trading time is discretized into half-hour increments. For each increment, the quoted bid and ask prices, as well as the depths effective at the end of the increment, are recorded.[8] Using these half-hour increments, the returns are computed using the transaction prices effective at the end of each half-hour increment. The mean and the standard deviation of the returns are computed over the entire sampling window of 120 trading days. A price change is considered to be a candidate for inclusion in the sample, if the return in a given increment falls more than two standard deviations away from the overall mean.

Several restrictions are placed on a price change in order to classify it as an included event. First, events for thinly traded stocks are eliminated. The stock is considered to be thinly traded if it averages less than ten trades per day (Lee et al., 1993, use a similar approach). Next, events for stocks with prices below US$3 per share are eliminated. This restriction drastically reduces the probability that the results are spuriously driven by the discreet nature of prices. The study also excludes events associated with trading halts. Finally, only price changes which occurred during normal trading hours are included.

The resulting sample includes 2524 positive, and 2397 negative, price changes. Some descriptive statistics for the sample of events are reported in Table 1. T = 0 corresponds to the event time. T = -11 is chosen as a point of comparison. Relative liquidity measures are computed as the ratio of the respective variables at t = 0 and t = -11.

Very large values of event-time returns are observed: This is 13% average half-hour return for positive events; and 7% average negative half-hour return for

[8] This methodological issue is addressed later in the paper. The means and medians recorded throughout the half-hour interval are also used.

negative events. The event-time quoted spread is very wide, at more than 30 cents. The mean value of the relative spread is more than 2 for both positive and negative events, implying that the spread more than doubles compared to the benchmark five and a half trading hours prior to the event. The mean value of the 15-period buy-and-hold abnormal return is close to zero for both positive and negative events.

Hypotheses and Methodology

Hypotheses

There are several interesting research hypotheses for the period immediately after the IPO. First, the responses of market makers to the arrival of new information are examined in terms of liquidity. It is hypothesized that the release of new firm-specific information increases the adverse selection risk faced by the market maker, so, in order to reduce the exposure to any additional risk, the market maker will reduce the liquidity.[9] This result has already been established for seasoned stocks by Lee et al. (1993).

It is expected that there will be a sharper drop in liquidity following positive events during the first trading days than for negative events, as many negative events are accompanied by some price support activities which have been shown to increase liquidity. In general, a positive relationship between the absolute value of announcement-period return, and liquidity drops, is expected.

Several interactions could be at play in the aftermarket period. On one hand, the level of uncertainty surrounding most firms should decrease as the time since issue elapses. This theory suggests that the magnitude of post-event abnormal returns following positive information releases diminishes as stocks season. Therefore, it is

[9] By reduction in liquidity a widening of the quoted bid-ask spread and a decrease in the depth is implied.

expected that the sharpest event-induced liquidity drops occur immediately after the offering. On the other hand, the stabilization activities of the underwriter; aimed, in part, at providing additional liquidity; cease after the first few weeks of trading. This suggests that the liquidity responses may become more drastic as the time since IPO elapses. Therefore, the direction of the relationship between the event-day aftermarket length, and event-induced liquidity drops, is unclear.

A positive relationship is expected between the magnitude of event-induced liquidity drops, and post-event return predictability. In other words, it is expected that post-event liquidity will be positively related to the speed of the price revelation. Chapter Two of this dissertation shows that the speed of post-event price revelation (at least, for positive events) increases as the time since the IPO elapses. Thus, it is expected that the magnitude of event-induced liquidity drops, in a negative relationship to the aftermarket length.

It is also expected that the magnitude of post event return predictability (both daily and intraday) will be positively related to the event magnitude measured by the absolute return on the event interval.

Methodology

In this subsection, the methodology of measuring returns and liquidity is described. Two liquidity measures are considered here: Quoted spread; and depth. As noted above, similar to Lee et al. (1993), trading time is discretized into half-hour increments. For each increment, the quoted bid and ask prices, as well as the depths effective at the end of the increment, are recorded. Period $t = 0$ would, therefore, represent the event time.

Both absolute and relative measures of liquidity are used in the study. Relative spread is measured as the ratio of the spread effective at time t to spread effective at t=11:

$$Relspread_t = Spread_t/Spread_{t-11} \qquad (5)$$

Absolute spread is defined in dollars. Relative and absolute depths are defined in a similar way. The benchmark t = -11 is chosen as it is believed here that the liquidity measures from five and a half hours before the event time should not be affected by unanticipated news releases. The use of relative measures allows more accurate aggregation of liquidity measures across stocks with different price levels. Absolute measures allow for an estimation of the potential profits of the market maker.

To appropriately assess event-induced liquidity change the differences between the liquidity measures at t = -11 and t = 0 must be computed:

$$\Delta spread = spread_{t=-11} - spread_{t=0} \qquad (6)$$

$$\Delta depth = depth_{t=-11} - depth_{t=0} \qquad (7)$$

Numerous studies document that the volume of shares traded in a given trading interval is an important control variable. Trading volume is defined here as being the number of shares traded in a given half-hour increment. The relative measure of the volume is defined similarly to spread and relative depth.

As for the price responses, I define the return in period t as:

$$Rt = (Price_t - Price_{t-1})/Price_{t-1} \qquad (8)$$

Several measures of post-event return predictability, which will help to assess the speed of incorporation of information signals into stock prices, are also defined here. A 15-period post-event buy-and-hold abnormal return (BHAR15) is defined as a measure of return predictability. Buy-and-hold rather than cumulative abnormal returns, are used, since it is unrealistic to buy and sell the stock at the end of each half-hour increment. In the later part of the analysis an examination of return predictability on daily basis is carried out. The event sample is sorted by the width of the bid-ask spread at event time, and it is possible to observe the relationship between the post-event abnormal returns and the spread magnitude at the event time.

The sampling window is divided into three subintervals: The first 30 trading days, days 31 - 60, and days 61 – 120. During each of these periods, a comparison is made of the quoted spreads, the quoted depths and the transaction volumes to their respective values at t = -11. The regression analysis is performed over the entire sampling window.

Affleck-Graves et al. (2000) document that the distribution of average standardized abnormal spreads show little deviation from normality. They report that using a standardized raw spread metric and a simple mean-adjusted expectation model result in well-specified test statistics. Heteroskedastically-consistent standard errors are used in testing hypotheses about the spreads, depths and volumes. The null hypothesis states that the liquidity metric at any point in the event time is not significantly different from its value at t = -11. Bootstrapping algorithm described in the appendix to Chapter 3 was employed, but the results were virtually identical. T-statistics using heteroskedastically-consistent standard errors are reported in the paper.

Empirical Findings

The empirical findings of this paper will now be examined. The effects of the significant price changes on quoted spreads, depths and volumes are presented in Tables 2 to 4. As expected, widening of the quoted spread is observed, as the market makers reduce their liquidity exposure. Spreads start to widen as early as two and a half hours prior to the actual price change, and continue to stay abnormally wide for as long as three and a half hours after the price change. This result is consistent with prior literature; namely, Lee et al. (1993).

Surprisingly, the spread appears to be the only dimension along which the market makers control their liquidity exposure. Quoted depths appear to be unaffected by the price changes. Nevertheless, in the two sub-samples of negative events (days 31 – 60 and 61 – 120), the depths decrease significantly *prior* to the price change, but return to their original levels at the moment of a significant price change. This result is in contrast with prior research. Depths have been shown to fall around the releases of company-specific information, as, in such times, the risks of trading with an informed trader are higher. One possible explanation for this phenomenon is that the market makers want to provide additional liquidity.

In most of the sub-samples, a quoted spread widens prior to the price change, which may suggest some anticipation of the event on behalf of the market makers. Trading volume, on the other hand, appears to be triggered by the event. Only in the sub-samples of trading days 61 – 120 is volume abnormally high. Volume remains abnormally high for as long as three and a half hours after the actual price change (negative events, trading days 61 – 102). This is not surprising, since a higher trading activity would be expected around a firm-specific event.

Overall, there are no systematic differences in the patterns of spreads, depths and volumes between positive and negative events. Similarly, there are no significant differences for events which occurred immediately after the IPO, and those that took place several weeks later.

The reference point of t = -11 occurs five and a half hours before the significant price change. Therefore, some reference points occur on the day prior to the event in question. The sample of events is divided into the group for which the reference point occurs on the same trading day, and the group with the reference point occurring on the prior trading day. Generally, similar patterns of spreads and depths are documented around significant price changes. Nevertheless, there are certain differences in spread patterns. The bid-ask spread tends to stay wider for a much longer time (up to 13 increments), whereas the events occurring in the evening tend to be accompanied by less persistent spread widenings. Quoted depths are not affected significantly in either sub-sample.

Another important consideration in the analysis is the possibility of information leakage and/or insider trading prior to the actual price change. One way to control for possible information leakage is to select only those events that have unusually high volume prior to the actual price change. The analysis proceeds in the following way. First, I compute the average trading volume for the increments t = -11 through t = -9. Next, events have been selected that have a trading volume greater than 110% of the average trading volume computed before.

It is expected that the events which are accompanied by abnormally high volume are also accompanied by liquidity drops (wider spreads and lower quoted depths) prior to the actual event, as higher volume could signal some information leakage to the market makers. Their risks in trading with informed traders will increase, and they will attempt to reduce the risk exposure. Surprisingly, the results are not consistent with this hypothesis. The behavior of quoted bid-ask spreads for the events with preceding volume spikes is not different from the overall sample. Depth remains unaffected by the price changes.

Furthermore, the exercise of the overallotment (*green shoe*) option by the underwriters is controlled for in this analysis. The first quarterly report (form 10-Q), or the first annual report (form 10-K), from the IPO date is used to check for the exercise of the over-allotment option. One hundred and ten companies in the sample exercised the overallotment option in part, or in full. No significant differences in the patterns of bid-ask spreads, depths, and volumes were detected for those companies that exercised the option and those that did not. This leads to the conclusion that the exercise of the overallotment option is not a significant factor in determining market-makers' liquidity responses to significant price changes.

Next, the dynamics of liquidity at the event time, as the time since the IPO elapses, is analyzed. The following regression equations are employed:

$$SPREAD_0 = \beta_0 + \beta_1 TRADEINT \quad (9)$$

$$DEPTH_0 = \beta_0 + \beta_1 TRADEINT \quad (10)$$

$$VOL_0 = \beta_0 + \beta_1 TRADEIN \quad (11)$$

where $SPREAD_0$, $DEPTH_0$ and VOL_0 represent the liquidity measures at the event time, and TRADEINT represents the number of half-hour trading intervals elapsed since the IPO.

The results for positive and negative events are presented in tables 5 and 6. For both types of events, a significantly positive relationship is observed between the magnitude of the quoted spread and the time elapsed since the offering. This important result is consistent with the hypothesis that market makers, who are often employed by the underwriting firm, provide additional liquidity in the immediate aftermarket to ensure the success of the offering.

It could be argued that this result is driven solely by the underwriter's price support activities, which, as discussed above, have been shown to increase liquidity. It is notable, however, that the result is even more prevalent in the sample of positive events, which should be much less affected by price support activities.

Trading volumes during the event interval are negatively related to the time elapsed since the IPO (in the case of negative events, however, the significance is only at the 10% level). This is expected since it has been shown that the maximum aftermarket trading activity takes place immediately after the offering. Depths remain unaffected by the aftermarket length.

Next, the relationship between the magnitude of the event and the liquidity measures is examined. The following regression equations are employed:

$$SPREAD_0 = \beta_0 + \beta_1 RET_0 \qquad (12)$$

$$DEPTH_0 = \beta_0 + \beta_1 RET_0 \qquad (13)$$

$$VOL_0 = \beta_0 + \beta_1 RET_0 \qquad (14)$$

where RET_0 represents the event-period return. The model of Blume et al. (1994) suggests that the event-period return could be used as a proxy for the magnitude of the event. Quite surprisingly, this study does not document a significant relationship between the event-period return and the quoted spreads and depths. Also, there is a significantly positive relationship between the transaction volume and event magnitude in the sample of negative events.

This study also analyzes the relationship between post-event returns, prices and liquidity measures. On the intraday level, a 15-period buy and hold return is chosen as the measure of post-event return predictability. As discussed before, a slower price adjustment is expected for the events which are characterized by lower liquidity. Therefore, a positive relationship is anticipated between the post-event return magnitude and the event-induced changes in spread and depth.

Indeed, for both positive and negative events, a positive relationship exists between the event-induced change in spread and the 15-period BHAR. Again, quoted depth turns out to be unimportant in predicting post-event returns. Also, in the sample of negative events, volume is an important predictor of post-event returns.

Finally, an examination is carried out regarding the effects of event-induced liquidity changes on the post-event return predictability on a daily level. For both positive and negative events, this study defines 5, 10, 30 and 60-day post-event market-adjusted buy and hold returns. First, an estimate is made of the abnormal returns over the entire sample. The results are presented in Tables 7 and 8. Negative abnormal returns are observed in both samples.

As observed earlier, depth is a relatively unimportant avenue through which market makers adjust their liquidity exposure. Therefore, the file is sorted in ascending order according to the event-induced change in the quoted spread. Five hundred events with the lowest spread change are labeled *high liquidity*. Five hundred events with the highest spread change are labeled *low liquidity*.

On one hand, the only statistically significant post-event abnormal returns are observed in the *low liquidity* sub-sample. On the other hand, the magnitude of these returns is very similar for both subsamples, which leads to the conclusion that the event-day liquidity, surprisingly, turns out to be a relatively unimportant control variable in the daily analysis post-event return predictability.

Conclusions

This paper explores the prices and liquidity measures immediately following the IPO. This period presents the researcher with a unique setting, characterized by a variety of institutional and statistical features, with interesting implications for market microstructure and stock returns. Some of these features are explored in this work.

The arrival of new information has been shown to affect the behavior of the market maker, as the adverse information risk increases. In the immediate aftermarket, however, the degree of information asymmetry between the market maker and the investors is different from that of seasoned stocks.

In contrast with the previous literature, this study shows that the bid-ask spread is the only dimension along which market makers reduce their exposure to event-induced risk in the immediate aftermarket. Quoted spreads increase prior to the event and stay elevated for as long as four hours following the price change.

Another important result concerns the evolution of the quoted spread at the event time as the time since the IPO elapses. This study shows that the magnitude of the bid-ask spread increases over the first 120 trading days, which is consistent with the hypothesis that the market makers have an incentive to provide additional liquidity in the immediate aftermarket.

A significant positive relationship is documented between event-induced changes in spread and post-event abnormal returns on an intraday level. On a daily level, however, event-induced changes in the spread turn out to be a relatively unimportant predictor of the post-event abnormal return magnitude.

Some directions for future research may include analysis of NYSE-listed securities, and the effects of events occurring during the nontrading hours.

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Table1. Descriptive Statistics of the Event Sample

This table presents some descriptive statistics of the events included in the sample. All statistics are computed over the half-hour increment in which the price change has taken place. *T = 0* represents the event time. Relative spread is computed as $Spread_0/Spread_{-11}$. Relative depth is computed in a similar way. BHAR15 represents 15-period post-event buy and hold return.

	Positive Events		Negative Events	
Statistic	Mean	Standard deviation	Mean	Standard deviation
Sample size	2524		2397	
Return	0.13	1.94	-0.07	0.039
Volume	28551	85106	27443	104966
Bid-ask spread	0.34	0.27	.035	0.27
Relative spread	2.08	2.71	2.05	2.55
Depth	12.14	14.65	10.94	13.29
Relative depth	1.81	3.07	1.61	2.69
BHAR 15	-0.01	0.19	0.02	0.08

Table 2. Changes in Quoted Spread in Event Time

This table presents the changes in quoted spread at various intervals in event time. Spread-11 represents the quoted spread 11 half-hour intervals prior to the event. Spread0 represents the spread at the event time. The hypothesis tested is that the specified difference in spreads is equal to zero. T-statistics are given in parentheses.

		Event					
		Positive			Negative		
Trading day		1 – 30	31 – 60	61 – 120	1 – 30	31 – 60	61 – 120
Pair 1	Spread-11 to Spread-10	0.003 (0.399)	0.003 (0.492)	-0.001 (-0.176)	-0.002 (-0.271)	0.009 (1.459)	0.009 (1.666)
Pair 2	Spread-11 to Spread-9	-0.003 (-0.340)	-0.001 (-0.672)	0.001 (0.112)	0.008 (0.908)	0.003 (0.422)	0.007 (1.130)
Pair 3	Spread-11 to Spread-8	-0.008 (-0.868)	-0.004 (-0.426)	-0.004 (-0.775)	-0.004 (-0.410)	-0.004 (-0.518)	-0.009 (-1.307)
Pair 4	Spread-11 to Spread-7	-0.014 (-1.284)	0.001 (0.126)	-0.002 (-0.417)	-0.002 (-0.250)	-0.016 (-1.783)	-0.001 (-1.121)
Pair 5	Spread-11 to Spread-6	-0.011 (-1.217)	-.007 (-0.764)	-0.012 (-1.916)	-0.005 (-0.518)	-0.002 (-0.234)	-0.004 (-0.592)
Pair 6	Spread-11 to Spread-5	-0.020 (-1.831)	-0.009 (-0.987)	-0.021* (-3.197)	-0.017 (-1.736)	-0.007 (-0.715)	-0.012 (-1.580)
Pair 7	Spread-11 to Spread-4	-0.001 (-0.022)	-0.015 (-1.569)	-0.024* (-3.697)	-0.022* (-2.064)	-0.024* (-2.340)	-0.009 (-1.164)
Pair 8	Spread-11 to Spread-3	-0.039* (-3.227)	-0.023* (-2.224)	-0.027* (-4.046)	-0.018 (-1.542)	-0.036* (-2.994)	-0.018* (-2.313)
Pair 9	Spread-11 to Spread-2	-0.034* (-2.803)	-0.021 (-1.805)	-0.048* (-5.684)	-0.015 (-1.126)	-0.049* (-3.886)	-0.036* (-4.052)
Pair 10	Spread-11 to Spread-1	-0.045* (-3.962)	-0.037* (-3.513)	-0.052* (-7.734)	-0.012 (-1.142)	-0.034* (3.416)	-0.033* (-4.175)
Pair 11	Spread-11 to Spread0	-0.081* (-7.337)	-0.086* (-7.093)	-0.104* (-13.41)	-.0109 (-7.831)	-0.102* (-8.898)	-0.086* (-9.937)
Pair 12	Spread-11 to Spread1	-0.053* (-4.347)	-0.025* (-2.202)	-0.050* (-6.647)	-0.074* (-5.639)	-0.059 (-4.661)	-0.052* (-6.597)
Pair 13	Spread-11 to Spread2	-0.059* (-4.296)	-0.029* (-2.721)	-0.047* (-6.304)	-0.049* (-3.981)	-0.054* (-4.913)	-0.049 (-6.096)
Pair 14	Spread-11 to Spread3	-0.040* (-3.393)	-0.024* (-2.365)	-0.041* (-5.820)	-0.043* (-3.600)	-0.042* (-4.198)	-0.037* (-4.790)

(continued from Table 2)

Pair 15	Spread-11 to Spread4	-0.033* (-3.094)	-0.029* (-2.732)	-0.033* (-4.922)	-0.034* (-3.062)	-0.044* (-4.426)	-0.023* (-3.102)
Pair 16	Spread-11 to Spread5	-0.018 (-1.665)	-0.012 (-1.168)	-0.022* (-3.363)	-0.041* (-3.424)	-0.034* (-3.600)	-0.022* (-2.871)
(coPair 17	Spread-11 to Spread6	-0.017 (-1.615)	-0.019 (-1.930)	-0.023* (-3.199)	-0.023 (-2.148)	-0.020* (-2.078)	-0.012* (-1.486)
Pair 18	Spread-11 to Spread7	-0.016 (-1.497)	-0.018 (-1.844)	-0.021* (-3.003)	-0.023* (-2.187)	-0.019 (-1.890)	-0.016 (-1.908)
Pair 19	Spread-11 to Spread8	-0.025 (-2.193)	-0.008 (-0.823)	-0.014 (-1.866)	-0.027 (-2.325)	-0.016 (-1.495)	-0.006 (-0.818)
Pair 20	Spread-11 to Spread9	-0.022 (-1.834)	-0.005 (-0.514)	0.007 (0.929)	-0.017 (-1.532)	-0.015 (-1.423)	-0.004 (-0.477)
Pair 21	Spread-11 to Spread10	-0.024 (-2.057)	-0.014 (-1.361)	0.008 (1.162)	-0.025* (-2.185)	-0.008 (-0.781)	-0.010 (-1.177)
Pair 22	Spread-11 to Spread11	-0.011 (-1.000)	-0.003 (-0.286)	0.008 (1.045)	-0.026* (-2.233)	-0.002 (-0.150)	-0.008* (-1.033)
Pair 23	Spread-11 to Spread12	-0.023 (-1.738)	-0.008 (-0.711)	0.005 (0.664)	-0.023 (-1.738)	0.017 (1.722)	-0.017 (-1.936)
Pair 24	Spread-11 to Spread13	-0.025 (-1.810)	-0.006 (-0.492)	0.005 (0.720)	-0.021 (-1.431)	-0.009 (-0.702)	-0.029* (-2.994)
Pair 25	Spread-11 to Spread14	-0.017 (-1.644)	0.000 (0.002)	0.005 (0.716)	-0.011 (-1.003)	0.006 (-0.619)	-0.015* (-1.994)
Pair 26	Spread-11 to Spread15	-0.022* (-2.151)	0.007 (0.760)	0.003 (0.381)	-0.024 (-1.937)	-0.015 (-1.469)	-0.017* (-2.158)

* Significant at the 5% level.

Table 3. Changes in Quoted Depth in Event Time

This table presents the changes in quoted depth at various intervals in event time. Depth-11 represents the quoted depth 11 intervals prior to the event. Depth0 represents the spread at the event time. The hypothesis tested is that the specified difference in depths is equal to zero. T-statistics are given in parentheses.

		Event					
		Positive			Negative		
Trading day		1 – 30	31 – 60	61 – 120	1 – 30	31 – 60	61 – 120
Pair 1	Depth-11 to Depth-10	1.33 (1.11)	0.89 (1.68)	0.19 (0.46)	0.49 (0.75)	-0.37 (-0.75)	-0.49 (-1.48)
Pair 2	Depth-11 to Depth-9	0.80 (.53)	1.32* (2.36)	1.11* (2.425)	0.47 (0.72)	-0.58 (-1.05)	-0.46 (-1.09)
Pair 3	Depth-11 to Depth-8	0.52 (0.68)	1.48* (2.69)	0.54 (1.10)	-0.89 (-0.99)	0.01 (0.02)	0.22 (0.56)
Pair 4	Depth-11 to Depth-7	-0.01 (-0.01)	0.64 (1.07)	0.48 (0.91)	0.09 (0.12)	-0.03 (-0.06)	-0.18 (-0.42)
Pair 5	Depth-11 to Depth-6	0.21 (0.15)	0.48 (0.82)	0.62 (1.17)	0.02 (0.02)	0.65 (1.09)	-0.17 (-0.38)
Pair 6	Depth-11 to Depth-5	0.18 (0.13)	0.04 (0.05)	0.18 (0.34)	-0.93 (-0.97)	1.26* (2.10)	0.21 (0.46)
Pair 7	Depth-11 to Depth-4	1.68 (1.209)	-0.10 (-0.14)	-0.06 (-0.11)	-0.66 (-0.65)	0.48 (0.77)	-0.44 (-0.73)
Pair 8	Depth-11 to Depth-3	0.57 (0.37)	0.00 (0.01)	0.43 (0.81)	-1.02 (-0.89)	1.51* (2.68)	0.00 (0.00)
Pair 9	Depth-11 to Depth-2	1.39 (0.95)	1.23 (1.78)	1.39* (2.58)	1.81 (1.82)	2.31* (4.02)	1.30* (2.98)
Pair 10	Depth-11 to Depth-1	2.20 (1.51)	0.95 (1.37)	0.96 (1.38)	1.91 (1.96)	1.51* (2.48)	1.01* (2.35)
Pair 11	Depth-11 to Depth0	0.62 (0.44)	0.96 (1.54)	0.17 (0.31)	1.88 (1.87)	0.95 (1.56)	0.31 (0.74)
Pair 12	Depth-11 to Depth1	1.64 (1.18)	1.36* (2.17)	0.63 (1.13)	0.61 (0.58)	0.41 (0.65)	-0.52 (-1.15)
Pair 13	Depth-11 to Depth2	2.18 (1.58)	0.87 (1.32)	0.87 (1.68)	0.51 (0.51)	0.75 (1.21)	-0.29 (-0.62)
Pair 14	Depth-11 to Depth3	1.63 (1.27)	1.28* (2.01)	0.28 (0.49)	1.37 (1.47)	0.06 (0.10)	-0.11 (-0.23)
Pair 15	Depth-11 to Depth4	1.41 (1.08)	0.54 (0.77)	0.03 (0.05)	0.41 (0.42)	-0.47 (-0.71)	-0.86* (-1.97)

(continued from Table 3)

Pair 16	Depth-11 to Depth5	2.62* (2.05)	0.39 (0.54)	0.22 (0.39)	-0.04 (-0.04)	-0.31 (-0.50)	-0.94 (-1.88)
Pair 17	Depth-11 to Depth6	2.55* (1.96)	1.04 (1.47)	0.45 (0.80)	-0.62 (-0.58)	-1.04 (-1.51)	-0.67 (-1.35)
Pair 18	Depth-11 to Depth7	1.59 (1.20)	0.38 (0.54)	-0.17 (-0.30)	0.95 (0.97)	-1.03 (-1.51)	-0.90 (-1.72)
Pair 19	Depth-11 to Depth8	2.06 (1.51)	0.30 (0.44)	-0.51 (-0.84)	0.68 (0.72)	-0.45 (-0.67)	-0.61 (-1.21)
Pair 20	Depth-11 to Depth9	2.24 (1.73)	-0.39 (-0.57)	-0.44 (-0.69)	1.34 (1.44)	-0.53 (-0.76)	-0.64 (-1.28)
Pair 21	Depth-11 to Depth10	1.99 (1.54)	0.26 (0.40)	-0.19 (-0.32)	1.32 (1.43)	-0.72 (-0.89)	-0.85 (-1.56)
Pair 22	Depth-11 to Depth11	-0.53 (-0.22)	0.45 (0.66)	-0.22 (-0.36)	1.01 (1.11)	0.13 (0.20)	-0.96 (-1.61)
Pair 23	Depth-11 to Depth12	0.58 (0.26)	0.14 (0.19)	-0.18 (-0.30)	1.05 (1.17)	0.30 (0.47)	-0.39 (-0.78)
Pair 24	Depth-11 to Depth13	2.20 (1.67)	1.00 (1.52)	0.94 (1.66)	2.41 (2.73)	1.10 (1.63)	0.61 (1.17)
Pair 25	Depth-11 to Depth14	2.71 (2.08)	1.05 (1.54)	1.24 (2.22)	2.81 (3.37)	-0.18 (-0.26)	1.03 (2.17)
Pair 26	Depth-11 to Depth15	1.16 (0.87)	0.01 (0.01)	-0.51 (-0.87)	1.21 (1.35)	-1.65 (-2.46)	-0.35 (-0.71)

* Significant at the 5% level.

Table 4. Changes in Volume in Event Time

This table presents the changes in volume at various intervals in event time. Vol-11 represents the volume 11 intervals prior to the event. Vol0 represents the volume at the event time. The hypothesis tested is that the specified difference in volumes is equal to zero. T-statistics are given in parentheses.

		Event					
		Positive			Negative		
Trading day		1 – 30	31 – 60	61 – 120	1 – 30	31 – 60	61 – 120
Pair 1	Vol-11 to Vol-10	2430 (2.141)	-329 (-0.285)	-840 (-1.384)	-1919 (-0.911)	928 (1.287)	130 (0.275)
Pair 2	Vol-11 to Vol-9	-685 (-0.357)	864 (0.783)	-27 (-0.046)	267 (0.163)	-217 (-0.211)	151 (0.293)
Pair 3	Vol-11 to Vol-8	-442 (-0.193)	303 (0.296)	-154 (-0.266)	334 (0.188)	686 (0.707)	24 (0.048)
Pair 4	Vol-11 to Vol-7	-32 (-0.019)	-2034 (-1.514)	-408 (-0.583)	-417 (-0.224)	920 (0.969)	-543 (-0.837)
Pair 5	Vol-11 to Vol-6	407 (0.278)	-401 (-0.402)	-1699 (-2.277)	270 (0.174)	800 (0.911)	-209 (-0.250)
Pair 6	Vol-11 to Vol-5	1044 (0.770)	-778 (-0.597)	-172 (-0.278)	321 (0.193)	-2596 (-1.162)	-277 (-0.476)
Pair 7	Vol-11 to Vol-4	-3084 (-1.636)	-3140* (-2.189)	-1133 (-1.737)	-921 (-0.589)	-3374 (-1.102)	-2603* (-2.745)
Pair 8	Vol-11 to Vol-3	-1606 (-1.134)	-2841* (-1.982)	-1525* (-2.374)	-3508* (-2.145)	-1796 (-1.536)	-2458* (-2.936)
Pair 9	Vol-11 to Vol-2	-693 (-0.361)	-2153 (-1.002)	-1473 (-1.168)	2356 (0.932)	-3603 (-1.479)	-1351 (-1.130)
Pair 10	Vol-11 to Vol-1	797 (0.542)	-9461* (-2.618)	-3668* (-2.892)	1975 (0.939)	-1796 (-1.248)	-4160* (-2.695)
Pair 11	Vol-11 to Vol0	-26239* (-8.363)	-19617* (-8.073)	-16305* (-6.502)	-22075* (-8.052)	-15582* (-5.842)	-18368* (-5.151)
Pair 12	Vol-11 to Vol1	-10752* (-4.436)	-9444* (-4.506)	-7426* (-6.623)	-8914* (-4.400)	-6276* (-3.303)	-9541* (-3.577)
Pair 13	Vol-11 to Vol2	-3046 (-1.456)	-5559* (-3.173)	-3956* (-3.856)	-2512 (-1.361)	-4176* (-2.444)	-6010* (-3.846)
Pair 14	Vol-11 to Vol3	-5570* (-2.249)	-3535* (-2.650)	-4092* (-4.433)	-1885 (-0.917)	-3452* (-2.589)	-3541* (-4.023)
Pair 15	Vol-11 to Vol4	-4959* (-2.452)	-4245* (-2.932)	-2613* (-3.366)	-3406 (-1.647)	-1215 (-1.413)	-2329* (-2.680)

(continued from Table 4)

Pair 16	Vol-11 to Vol5	-4690 (-1.643)	-5382* (-2.508)	-2137* (-2.705)	-810 (-0.423)	-2247 (-1.785)	-3237* (-2.783)
Pair 17	Vol-11 to Vol6	-2131 (-1.016)	-3365 (-1.569)	-1444* (-2.147)	365 (0.185)	-943 (-0.863)	-3805* (-3.469)
Pair 18	Vol-11 to Vol7	-212 (-0.135)	-1710 (-1.400)	-4839 (-1.310)	1699 (0.820)	-819 (-0.860)	-2947* (-3.100)
Pair 19	Vol-11 to Vol8	-827 (-0.419)	-3759* (-2.149)	-8290 (-1.931)	2515 (1.421)	-1843 (-1.284)	-1304* (-1.745)
Pair 20	Vol-11 to Vol9	2283 (1.584)	-2886* (-2.127)	-3298 (-1.765)	-7882 (-0.986)	-540 (-0.581)	-3045* (-3.372)
Pair 21	Vol-11 to Vol10	1329 (0.843)	-1081 (-0.898)	-3314* (-2.218)	1239 (0.658)	-1695 (-1.277)	-3419* (-3.084)
Pair 22	Vol-11 to Vol11	509 (0.328)	-3270 (-1.938)	-2433* (-2.476)	-614 (-0.273)	-2419 (-2.057)	-2795* (-2.700)
Pair 23	Vol-11 to Vol12	-3072 (-0.839)	-2675 (-1.797)	-3448* (-3.768)	-947 (-0.530)	-2172 (-1.765)	-5285* (-2.872)
Pair 24	Vol-11 to Vol13	-806 (-0.331)	-1467 (-0.892)	-1101 (-0.858)	5914* (3.487)	-1218 (-0.927)	-2418 (-1.653)
Pair 25	Vol-11 to Vol14	1461 (0.758)	-3317 (-1.857)	-2038 (-1.476)	4717* (2.476)	757 (0.786)	-1074 (-1.261)
Pair 26	Vol-11 to Vol15	-6931* (-2.300)	-4961* (-2.164)	-7973* (-2.402)	-2900 (-1.430)	-3395* (-2.891)	-4699* (-4.090)

* Significant at the 5% level.

Table 5. Regression Coefficients in the Subsample of Positive Events

This table presents the regression coefficients estimated in the sample of positive events. SPREAD0, DEPTH0, VOL0 and RET0 represent the event-period quoted spread, depth, volume and return. TRADEINT represents the number of half-hour increments elapsed since the IPO date. BHAR15 represents 15-period post-event buy-and-hold return. CHSPRD represents the difference between SPREAD0 and SPREAD-11. CHDPTH is measured in a similar way.

Model	Dependent variable	Independent variable	Standardized coefficient	T-statistic	Significance
1	SPREAD0	TRADEINT	.067	3.377	.001
2	DEPTH0	TRADEINT	.025	1.244	.214
3	VOL0	TRADEINT	-.068	-3.426	.001
4	SPREAD0	RET0	-.014	-.718	.473
5	DEPTH0	RET0	.017	.158	.567
6	VOL0	RET0	.019	.968	.333
7	BHAR15	RET0	.007	.354	.723
8	BHAR15	SPREAD0	-.032	-1.564	.118
		DEPTH0	-.008	-.398	.691
		VOL0	.054	2.701	.007
9	BHAR15	CHSPRD	-.090	-3.107	.002
		CHDPTH	-.015	-.529	.597

Table 6. Regression Coefficients in the Subsample of Negative Events

This table presents the regression coefficients estimated in the sample of negative events. SPREAD0, DEPTH0, VOL0 and RET0 represent the event-period quoted spread, depth, volume and return. TRADEINT represents the number of half-hour increments elapsed since the IPO date. BHAR15 represents 15-period post-event buy-and-hold return. CHSPRD represents the difference between SPREAD0 and SPREAD-11. CHDPTH is measured in a similar way.

Model	Dependent variable	Independent variable	Standardized coefficient	T-statistic	Significance
1	SPREAD0	TRADEINT	.043	2.093	.036
2	DEPTH0	TRADEINT	.028	1.390	.165
3	VOL0	TRADEINT	-.035	-1.728	.084
4	SPREAD0	RET0	-.014	-.704	.481
5	DEPTH0	RET0	.006	.273	.785
6	VOL0	RET0	-.179	-8.883	.000
7	BHAR15	RET0	-.120	-5.936	.000
8	BHAR15	SPREAD0	.069	3.371	.001
		DEPTH0	.007	.339	.735
		VOL0	-.011	-.528	.598
9	BHAR15	CHSPRD	.075	3.685	.000
		CHDPTH	.001	.061	.952

Table 7. Post-Event Market Adjusted Buy and Hold Abnormal Returns Computed on a Daily Basis in the Subsample of Positive Events

This table presents buy and hold post-event abnormal returns computed over the 5-day, 10-day, 30-day and 60-day post-event windows. The returns are estimated for the entire sample, and then for the subsamples of 500 events with the lowest/highest bid-ask spread at the time of the event. T-statistics are given in parentheses.

Post-event window	Abnormal Returns		
	Entire sample	Lowest spread	Highest spread
1 – 5	-0.06%	-0.57%	-1.21%*
	(-0.07)	(-0.33)	(-1.99)
1 – 10	-1.00%	-1.64%	-2.40%
	(-0.80)	(-0.68)	(-1.76)
1 – 30	-5.75%*	-5.94%	-7.77%*
	(-2.66)	(-1.42)	(-3.30)
1 – 60	-10.54%*	-9.62%	-13.92%*
	(-3.45)	(-1.62)	(-4.18)

* Significant at the 5% level.

Table 8. Post-Event Market Adjusted Buy and Hold Abnormal Returns Computed on a Daily Basis in the Subsample of Negative Events

This table presents buy and hold post-event abnormal returns computed over the 5-day, 10-day, 30-day and 60-day post-event windows. The returns are estimated for the entire sample, and then for the subsamples of 500 events with the lowest/highest bid-ask spread at the time of the event. T-statistics are given in parentheses.

Post-event window	Abnormal Returns		
	Entire sample	Lowest spread	Highest spread
1 – 5	-0.35%	-0.44%	-0.12%
	(-0.29)	(-0.29)	(-0.08)
1 – 10	-1.46%	-1.86%	-1.83%
	(-0.88)	(-0.87)	(-0.84)
1 – 30	-5.51%	-6.50%	-6.68%
	(-1.92)	(-1.76)	(-1.75)
1 – 60	-9.67%*	-9.21%	-11.11%*
	(-2.38)	(-1.76)	(-2.07)

* Significant at the 5% level.