Revisiting the Impact of Options Introductions on Stock Market Microstructure

by

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Abstract

We reexamine the impact of option introductions on market microstructure measures of liquidity and on measures of short-sale constraints. Previous research reveals that average stock liquidity shows improvement after the introduction of options, while short-sale constraints are relaxed. However, in contrast to the inferences drawn from these earlier studies, we find that option introductions do not improve the market for the underlying security. Instead, using improved empirical methods, we find that options are listed on securities for which liquidity is already dramatically improving prior to the listing date. In contrast to our microstructure results, we find that the supply of shares that can be borrowed increases around the listing date. This and other evidence suggests that option listings mitigate short-sale constraints.

1. Introduction

Black and Scholes (1973) modeled options as redundant securities. Accordingly, the trading characteristics of the underlying stock determine the value of an option. However, soon after the introduction of exchange-traded options in 1973, several scholars speculated that while stock characteristics clearly impact option trading, the reverse might be true also. Options might impact the trading characteristics of the underlying stock. Ross (1976) and Hakansson (1982) argue the assumption that stock characteristics must govern option prices but that options cannot impact stock prices seems naïve. Instead, where optionless markets are incomplete, improved trading efficiencies should result from option introductions.

Kumar, Sarin and Shastri (1998), examine the impact of option introductions on the microstructure characteristics of securities. They conclude that "option listings improve the quality of the underlying stocks [p.717 abstract]" because bid-ask spreads decrease, volume increases, transaction-sizes increase and volatility declines after options are introduced. These findings largely confirm early studies by Conrad (1989) and Skinner (1989) who also find that the volatility of the underlying stock declines around option introductions.

Sorescu (2000) finds that stock prices also are impacted by option introductions. Like Conrad (1989), Sorescu finds that during the 1970's stock prices rose when options were introduced. However, after the early 1980's option introductions appear to be persistently associated with declines in the price of the underlying stocks; a phenomenon he notes is consistent with a relaxation of short-sale constraints on the underlying security. Figlewski and Webb (1993) also conclude that options relax short-sale constraints. They note that the level of short interest in a firm rises in the month after options begin trading. Also, firms with options have higher short interest than those without options.

A possible problem acknowledged by Figlewski and Webb (1993) was that a selection bias might exist in the data. "If short interest happens to be correlated with characteristics of a stock that make it a good candidate for options trading, there would be an association betweens short interest and options trading, but not one that is due to the causal connection we have suggested." [p. 764]

The possibility of an endogenous correlation between changes in stock trading characteristics and option exchanges' listing decisions is also raised by Conrad (1989) and Skinner (1989).[1] Each noted that option introductions are not random events, and selection biases by the options exchanges could give rise to observed market quality improvements.

Although selection is considered a possible explanation, each of these early studies was primarily concerned with determining whether changes in the underlying security markets even existed around the introduction date. If no changes were detected, the inquiries would have ended there. Concerns voiced about possible endogenous correlations would never have become important.

Recently, concerns have resurfaced about whether option listings produce changes in stock trading behaviors, or whether changes in stock trading behaviors produce option listings. Mayhew and Mihov (2004) find that exchanges appear to treat increased volatility as a selection criterion. Using a control sample methodology, they conclude the declines in volatility observed by previous authors are endogenous to the selection

[1]Kumar, Sarin and Shastri (1998) and Sorescu (2000) note similar concerns.

process – not an outcome of the listing event. Decreased volatility has been the longest-recognized change previously attributed as an "option listing effect". Given Mayhew and Mihov's conclusion that endogenous abnormal volatility actually generates option introductions, other presumed listing effects obviously should be reexamined to determine whether options cause changes in the underlying market or merely flag firms for which changes are already underway. That is the purpose of this study.

The methodology which we adopt is to reexamine many of the changes observed in previous studies using higher-frequency observations. Rather than examining the market merely before and after the option introduction, as others have done, we track changes in stock characteristics on a daily basis to determine whether or not shifts in market microstructure and short-sale constraint measures actually occur around the option introduction date.

We discover that many of the previously documented changes in stock trading characteristics do not result from the option listing. Instead, these characteristics are changing well in advance of exchanges' listing decisions. In general, a "linear drift" model through the option introduction date better fits various microstructure characteristics for both NYSE and NASDAQ firms than does a model which presumes a regime shift occurs on the option introduction date. Previous papers have mistakenly concluded that improvements in market quality occur after the option introduction because the average quality after the listing date shows an improvement relative to the average quality before the date.

Conversations with options exchange personnel confirm that exchanges focus attention on securities that have recently improved stock market quality characteristics.

Greater volume suggests that public demand for options products will be stronger. Moreover, improved stock market liquidity allows options market makers to effectively and profitably make markets in options because they can hedge at lower cost in the underlying security market.

Imposing a less rigid structure on the innovations in market quality metrics, we find that implied regime shifts tend to occur well before the listing date. In fact, the data usually rules out a shift on the listing date with high statistical significance, preferring pre-listing dates as the more likely dates for a shift to have occurred. This result is consistent with the endogeneity of option listing decisions. Given that option introductions are driven by improvements in the quality of the underlying market, the listings occur after the underlying market has improved.

While our findings generally reject the hypothesis that option introductions change the market microstructure of the underlying stocks, our findings regarding the impact of options on short-sale constraints generally support the hypothesis that options relax short-sale constraints. Specifically, although the number of shares being reported as sold short rises over time, the number of shares remaining available to borrow increases. Also, the cost of shorting, as measured by short-stock-rebate rates, decreases around the option listing date. The timing of these changes suggests that the supply of shares available to borrow is greater because options are introduced.

Our paper proceeds as follows; section 2 presents the data and method, section 3 reports the results and analysis and section 4 concludes.

2. Data and Method

Our study uses four different data sets. These are microstructure data extracted from the TAQ database for 1993 to 2002, daily security borrowing and short-stock rebate rates provided by a market maker in the security lending market for 2001 to 2003, monthly short interest data for 1988 to 2002, and daily market adjusted returns for 1988 to 2002. Each of these data sets is merged with the set of option introductions from 1988 to 2003. The variables extracted from these data sources are presented in summary form in the appendix.

The following section will discuss each data source and the relevant variables in detail. We select observation windows for each variable in a manner that is consistent with prior research where applicable. Because Kumar, Sarin and Shastri (1998) examine microstructure variables using a 251 day window centered on the option introduction, we adopt the same observation window for all microstructure variables taken from TAQ. We use the same window (-125,125) for examining market adjusted returns because we observe these values on a daily basis also.

Because we only possess stock borrowing and short-stock rebate rate data beginning in March 2001, we use a shorter window to increase the number of firms that can be observed over the full window. This window begins is 151 days (-75, 75). For monthly short interest, we have a much longer time series of data available, but the data are very coarse relative to the transactional data items, so we extend the window and use a 401 day window (-200, 200) around the option introduction.

2.1. **Microstructure data**

For option introductions from 1993 to 2002, we collect microstructure data from the NYSE TAQ data set. Because we wish to track the microstructure characteristics over a period of time both before and after the option introduction, we require that microstructure data be available on the security for 125 trading days before and after the event date. This produces the 251 day window of trade and quote data, centered on the introduction date.

Between 1993 and 2002 several market changes and reforms were made on both the NYSE and NASDAQ. Tick size reductions or significant rule changes occurred on NASDAQ on June 2, 1997 and March 26, 2001 and on the NYSE on June 24, 1997 and January 29, 2001. A large body of research (see for example Bessembinder, 2003, and Chung, Van Ness, and Van Ness, 2004), finds these changes had a significant impact on market quality metrics, including a narrowing of spreads. To avoid confusing the impact of option introductions with changes in microstructure variables driven by global changes in the stock trading process, we exclude all firms whose 251 day window includes a significant rule change or tick reduction.

We use TAQ data to estimate several microstructure measures of stock liquidity around the options introduction date. These measures are the quoted bid-asked spread, the percentage spread, the percentage effective spread, trading volume, and the standard deviation of the quote midpoint.

To minimize data errors, we precondition the TAQ data in several ways. We omit trades and quotes if they are flagged as out of time sequence or involve either an error or a correction. We omit quotes if either the ask or bid price is zero or less, and we omit trades if the price or volume is not greater than zero. In addition, as in Huang and Stoll

(1996), we omit the following to further minimize data errors: (1) quotes when the spread is greater than \$4 or less than zero; (2) before-the-open and after-the-close trades and quotes; (3) trade price, p_t, when $|(p_t - p_t\text{-}1)/p_t\text{-}1| > 0.10$; (4) ask quote, at, when $|(a_t - a_t\text{-}1)/a_t\text{-}1| > 0.10$; and (5) bid quote, b_t, when $|(b_t - b_t\text{-}1)/b_t\text{-}1| > 0.10$. Because liquidity metrics differ across exchanges, we exclude from our analysis all firms that moved from Nasdaq to the NYSE during the 251 day window. We also exclude any stocks that had stock splits during the window.

For the purposes of this portion of the analysis, the quoted bid-ask spread, Spread_i, is defined as the difference in the best ask price and the best bid price, for each firm i:

$$\text{Spread}_i = (\text{Ask Price}_i - \text{Bid Price}_i) \tag{1}$$

The midpoint of the spread is defined as the mean of the best ask price and the best bid price, for each firm i:

$$\text{Midpoint}_i = \frac{(\text{Ask Price}_i + \text{Bid Price}_i)}{2} \tag{2}$$

Percentage Spread_i, is the difference in the best ask and bid price, divided the midpoint of the spread (the ask price plus the bid price divided by two).

$$\text{Percentage Spread}_i = \frac{\text{Spread}_i}{\text{Midpoint}_i} \tag{3}$$

To measure trading costs when trades occur at prices inside the posted bid and ask quotes, we use the Effective Spread_i, which is defined as:

$$\text{Effective Spread}_i = 2D_i(\text{Trade Price}_i - \text{Midpoint}_i) \tag{4}$$

where Trade Price_i is the transaction price for security i, Midpoint_i is the midpoint of the most recently posted bid and ask quotes for security i, and D_i is a binary variable which equals +1 for a customer buy order and -1 for customer sell orders (this is done as in Lee and Ready, 1991).

Panel A of Table 1 presents summary statistics for our basic data set. The impact of the screens we impose is clearly visible in 1997 and in 2000. We observe in panel A that NASDAQ optioned stocks tend to be smaller than the NYSE optioned stocks, and they have lower volume and higher spreads. These characteristics are as expected.

2.2. **Market Adjusted Returns**

We examine market adjusted returns for firm's issuing options using a 125 day window before and after the option introduction date. The market adjusted returns are computed as the daily return reported by CRSP minus the return on the CRSP value weighted index.

2.3. **Monthly short interest data**

We use publicly available monthly short interest data published by the NYSE. These data are for trades which settle by the 15th day of each month. We scale the monthly short interest by CRSP shares outstanding to generate a monthly relative short interest variable we designate as Relative Short Interest.

Although Relative Short Interest is only observed monthly, option introductions occur throughout the month. By reorganizing the short interest in "option introduction time", we are able to populate a daily time series with short interest data. For example, if an option is listed on the 16th of the month, the short interest for that firm will be reported on day t-1. Also, depending on the number of trading days in particular months, we can observe short interest for the firm at earlier and late dates also. For example, if the number of trading days between the previous monthly report and the t-1 report is 22 days, we observe short interest for the firm on day t-23. If 21 days pass between day t-1 and the next monthly report, we observe the short interest on day t+20.

The daily time series of short interest is not as smooth as one would observe if every firm were represented each day. However, we have relatively large number of firms (3233 listings between 1988 and 2003 existed for the full 401 day window), and option introduction dates are dispersed throughout the month (although more firms are listed in the first week than in other weeks of the month. Thus, our daily time-series of Relative Short Interest is distributed fairly evenly throughout the window. Summary statistics for these data are presented in panel B of Table 1.

2.4. **Daily Security Borrowing Data**

We obtain daily stock borrow and short-stock rebate data from a broker who makes markets in securities lending. These market-making activities consist, in part, of borrowing stocks from mutual funds and re-lending the shares to hedge funds which short the stock. The mutual fund cannot lend directly to the hedge fund, which has a C credit rating. Therefore, the broker intermediates such stock loans and earns a spread. The data we are using details the stock borrowing activities of the market maker.

The data begins in March 2001 and provides for each stock on each day the following relevant data:

- the number of shares newly borrowed from the market maker that day,
- the average short-stock rebate and fee associated with the borrowed shares
- the aggregate shares borrowed at day end

- the number of shares reported to be still available for borrowing by approximately 30 large institutions.

In this study, we do not use the data on the number of shares newly borrowed by the market maker each day. However, the other items are used and require additional description.

The variable "Shares Borrowed" represents the share which the market maker has borrowed from mutual funds on the current day or a previous day and has not yet covered. Shares Borrowed is scaled by the number of shares outstanding so that it is comparable to the Relative Short Interest variable. The differences between these two variables are that Relative Short Interest is reported monthly for all short sales that have been reported as of the 15th of the month. Shares Borrowed is reported daily, but only represents the market maker's open positions at the end of the day. These shares are loaned to hedge funds and others who probably sell the securities short. However, we cannot be sure that the sales are reported as short sales in the monthly market summary.

The Shares Borrowed data overlaps the Relative Short Interest data in 2001 and 2002. This allows us to make some direct comparisons of these data. During 2001 and 2002, the Relative Short Interest ranges from 4 to 5%. At the same time, Shares Borrowed ranges from 0.35% to 0.49% of shares outstanding. Thus the market maker's proprietary data equals about 10% of the share lending market. The cross sectional correlation for these two years between Shares Borrowed and Relative Short Interest is 0.7. We conclude that these data sets are capturing similar variation in securites lending and short selling over time.

The "short-stock rebate" is the rate of interest that the borrower earns on his posted cash collateral. Normally this rate is the "general collateral rate" which is close to the short-term treasury rate. Occasionally, a stock becomes hard to borrow and the rebate rate will be lower. This provides additional compensation to the lender for lending hard-to-borrow securities. The "borrowing fee" is the short-term treasury rate net of the rebate. Simply stated, the fee is the amount of interest foregone by the borrower assuming that the collateral is invested in short-term treasury securities. This variable, "Borrowing Fee", is the cost of borrowing shares: the rental price.

Although the Borrowing Fee is not a price determined in a centralized market, the securities lending market is competitive and the market-maker asserts that the rebate rates (Borrowing Fees) would be similar across market makers.

One shortcoming of the Borrowing Fee data is that, although the data is reported daily, the fee is reported only when a transaction has occurred on that day. We cannot impute a fee on the basis of bid-ask prices because we do not have this information. Thus, we have many missing observations in the Borrowing Fee data. For any individual firm, there are discontinuities. Also, the Borrowing Fee data does not reflect all firms in the market, only those firms for which the broker is making a securities-lending market.

Because we are interested in observing changes in the market around the option introduction, we do not "interpolate" data on the basis of nearby trades. This would smooth the data and make regime changes harder to identify.

The final variable in our data is a measure of street availability at the close of trading each day. We refer to this variable which is also scaled by shares outstanding as "Market-Wide Availability," and it is the aggregate shares reported to be available by approximately 30 large institutions. We believe that this is unique measure of the magnitude of short-sale constraints in the market in that it is a measure of supply.

Like the Borrowing Fee data, "Market-Wide Availability" has missing observations. First, the variable was not preserved by the market-maker over the entire history of the lending data. For several months in 2001, the field is missing from the data. Also, the variable is not reported for stocks on any day for which the market maker had neither a new borrowing transaction nor a Shares Borrowed position.

If option introductions relax short-sale constraints, the nature of the relaxation might be evidenced in one or more of the variables discussed above. Relative Short Interest and Shares Borrowed should be higher when short-sale constraints are relaxed. Also, the Market-Wide Availability of shares should be higher when constraints are lessened. Finally, the Borrowing Fee may decline for borrowing shares in the securities lending market.

We should be careful to note that Borrowing Fee may not decline if options relax some non-priced constraint; for example if options can be used to hedge when short-sales are not useful for some reason. In this case, option market makers will convert new synthetic short positions in options into actual short sales as part of their own portfolio balancing efforts. In this case, relaxation of a non-priced constraint could lead to additional short selling and a higher Borrowing Fee across the market. In other words, relaxation of a non-priced constraint may be partially offset by a higher priced constraint in the form of higher Borrowing Fees.

Summary statistics for Shares Borrowed, Borrowing Fee and Market-Wide Availability are presented in panel B of Table 1.

3. Results and Analysis

3.1. **Does liquidity change around option introductions?**

Kumar, Sarin and Shastri (1998) examine 174 option introductions between 1983 and 1989. They report spreads, volume and trading activity both before and after the event date finding that option introductions are associated with an overall improvement in market liquidity. Their primary test examines the means of these variables before and after the option introduction. Table 2 follows this method and seeks to test whether there are any significant changes in market liquidity after option introductions in our later sample.

We divide the sample into NYSE and NASDAQ stocks and examine the difference in means of the various liquidity measures in the window before and after the option introduction. For spread, percentage spread, and percentage effective spread there is a statistically and economically significant decline following the introduction. For volume and the number of trades, there is also a significant increase following the option listing date. These results all conform to those previously observed by Kumar, Sarin and Shastri (1998). Unlike each of the other microstructure measures, changes in average trade size are not consistent between the NYSE and the NASDAQ samples. NYSE trade size increases after the option listing, but NASDAQ trade size decreases.

For reasons best explained later, we do not consider the daily volatility metric used by Kumar, Sarin and Shastri (1998). Instead, we examine the standard deviation of the quote midpoint, a measure of intraday volatility. We find that volatility declines after the option listing. This is consistent with a decline in inter-day volatility observed by Kumar, Sarin and Shastri (1998). In summary, like Kumar, Sarin and Shastri, we find a multi-dimensional improvement in market liquidity after options are introduced. We also find that daily returns on the stock prior to the option introduction are significantly higher than after the option listing.

With regard to short-sale constraint measures, the relative short interest is higher after option listings indicating that more shares are sold short post-event. After the option listing, the number of shares borrowed by the security lender increases, the number of shares reported as still available to borrow in the market increases, and the average cost to borrow decreases. Each of these changes would be consistent with options relaxing short-sale constraints.

3.2. **Shift or Drift?**

The key potential shortcoming of the difference-in-means tests performed in Table 2 is that they explicitly assume a shift in the means around the option date and stationarity at all other times. An alternative explanation for each of these results could be that the liquidity measures improve gradually over time. In other words, perhaps liquidity changes "drift through", rather than "shift on" the event date A drift toward improving liquidity would be consistent with option exchanges' deciding to introduce options on stocks that have become sufficiently liquid for effective market-making activities on the options exchange.

To see whether the data is better fitted with a shift model as previously tested or a linear drift model (which would suggest an endogenous option listing decision) we estimate a shifting means model and a linear drift model and examine which is preferred by the data using a J-test as discussed in Davidson and MacKinnon (1981).

The shifting means model is a simple OLS regression of the daily liquidity measure (spread, volume etc) on dummy variables for before and after the option introduction without an intercept i.e.:

$$\text{depvar}_{i,t} = \alpha_1 predummy_i + \alpha_2 postdummy_i + \varepsilon_{i,t} \quad (5)$$

where depvar is one of the variables of interest for each firm (i) on day (t). Predummy is equal to one if the date is before the option introduction, zero otherwise. Postdummy is equal to one if the date is after the option introduction, zero otherwise.

The linear drift model is an OLS regression of the daily liquidity measure on the day, where day spans from -125 to +125. Day zero is the option introduction day.

$$\text{depvar}_{i,t} = \beta_0 + \beta_1 relativeday_{i,t} + \varepsilon_{i,t} \quad (6)$$

where relativeday takes the value of -125 through +125.

Table 3 presents the results of these regressions in panel A (linear drift model) and panel B (shifting means model).

As these models are non-nested, we cannot simply determine which better specifies the relationship by examining the likelihood ratio or adjusted R-squared. Therefore we employ the J-test, as developed by Davidson and MacKinnon (1981) and more recently use by Sorescu and Boehme (2002).

The J-test requires estimating each model independently and capturing the fitted values. We refer to the fitted values as $\text{depvar}_{\text{shift}}^{\text{predicted}}$ for the predicted values from the shift model (equation 5) and $\text{depvar}_{\text{drift}}^{\text{predicted}}$ when they are taken from the linear drift model (equation 6). These fitted values are then inserted in a hybrid model of each, producing two competing models:

$$\text{depvar}_{\text{i,t}} = \gamma_{\text{drift}}\left[\text{depvar}_{\text{drift}}^{\text{predicted}}\right] + \left(1-\gamma_{\text{drift}}\right)\left[\alpha_1\text{predummy}_{\text{i}} + \alpha_2\text{postdummy}_{\text{i}}\right] + \varepsilon_{\text{i,t}} \quad (7A)$$

$$\text{depvar}_{i,t} = \gamma_{shift}\left[\text{depvar}_{shift}^{predicted}\right] + \left(1-\gamma_{shift}\right)\left[\beta_0 + \beta_1 \text{relativeday}_{i,t}\right] + \varepsilon_{i,t} \qquad (7B)$$

Model 7A tests whether the predicted values of the drift model are preferred to the shifting means model, if $\gamma_{drift} = 1$ and $\gamma_{drift} \neq 0$ in a statistical sense. Model 7B tests whether the predicted values of the shift model are preferred to the linear drift model if $\gamma_{shift} = 1$ and $\gamma_{shift} \neq 0$ in a statistical sense. To find support for the linear drift model we should find $\gamma_{drift} = 1$, $\gamma_{drift} \neq 0$, $\gamma_{shift} \neq 1$ and $\gamma_{shift} = 0$, in other words that the linear drift model is favored in both model 7A and 7B. The key drawback of the J-test is that it can produce inconclusive results, such as rejecting neither model.

For the microstructure data, the results of the J-test are presented in Panel A of Table 3. The J-test results are shown at the bottom of the Panel. For the percentage spread for NYSE firms we find the $\gamma_{shift} = 0.249$. This value is significantly different from 1 and not distinguishable from 0. On the other hand, $\gamma_{drift} = 0.80$ which is not significantly different from 1 but significantly different from zero. Therefore for the NYSE stocks, where percentage spread is the dependant variable, we are able to reject the shifting means model in favor of the linear drift model.

For percentage spread for NASDAQ stocks, we find that $\gamma_{shift} = -0.26$ while $\gamma_{drift} = 1.18$. This result is very surprising because while the shift variable is significantly different from 1, it is also different from zero in that it is significantly *less than* zero. Likewise, the drift variable is significantly greater than both 0 and 1. In other words, the J-test favors over-weighting the drift model and placing a negative weighting on the shift model. This appears to be a strong rejection of the shift model.

Similar results are found for standardized daily volume – in that the linear drift model is favored to such a degree that the J-test results suggest a negative weighting on the shift model. In other words, volume appears to be better explained as a long-term upward drift than as a shift around the listing date.

The J-test result for the standard deviation of the quote midpoint in the NYSE sample exemplifies the potential shortcoming of the J-test. Results here are inconclusive, and neither model can be rejected in favor of the other. However, for the NASDAQ firms, the shift model is preferred to the drift model. At least for NASDAQ firms, the volatility changes that occur are better specified by a shifting means model than by a linear drift model.

Panel B reports j-test results for short selling metrics (and for the daily market adjusted return measure). The results for these short-sale market metrics are mixed. The data on the number of shares actually borrowed by our data supplier is better described by the linear drift model, but changes in market-wide availability of shares is better described by the shifting means model. As if to highlight the inconsistency observed between the test results for these two measures, the J-test to distinguish the better specification describing the borrowing fee paid proves to be inconclusive because the F-tests for the γ_{drift} cannot be distinguished from either zero or one at the ten percent significance level.

The Relative Short Interest J-test is also inconclusive because neither model is strictly preferred. But the decline in firms' market-adjusted returns is better described by a regime shift than by a gradual downward drift.

3.3. **A less restrictive model**

The previous sub-section demonstrates that changes in market microstructure measures which have previously been ascribed to regime shifts generated by option introductions are often better described as a gradual drift that coincides with option introductions. Of course, the linear drift model which we have considered is, in a real sense, just as restrictive as the model which built on a regime-shift paradigm. The J-test conducted above were required because the shifting-mean model and the linear-drift model are non-nested. We should obviously consider the possibility that an underlying drift in the trading characteristics of the firm have occurred while a shift due to option-introduction impacts may also exist.

Taking an agnostic approach, we consider a model which allows for both a drift and a shift in the data. Moreover, we allow the data to select an optimal regime change date rather than impose an assumption that any observed shift must occur on the option introduction date.

Discussions with option market makers reveal that the decision to option a stock is usually made a week to a month before the option is introduced. If this is the case, and if the liquidity effects are endogenous to the introduction decision, the true regime change probably will not occur on the introduction date but on some prior date (the decision date). This is because inclusion in our sample is path dependent only up to the date that an affirmative option listing decision is made by an exchange.

Using the method of Sorescu (2000), we search for the best switch date for each dependent variable and generate a confidence interval in dates around this most likely switch date. To do this specify the following model:

$$\begin{aligned} \text{depvar}_{i,t} = {} & \alpha_0 \text{preswitch} + \alpha_1 \text{relativeday} \times \text{preswitch} + \\ & b_0 \text{postswitch}_i + b_1 \text{postswitch}_i \times \text{relativeday} + \varepsilon_{i,t} \end{aligned} \tag{8}$$

where preswitch takes values (-125,+125) and postswitch = 125-preswitch.[2] We then run this model for on the full data set 250 times, each time moving the switch date forward 1 day. We capture the log likelihood ratios for each regression and select the highest ratio as the optimal switch date. The results are presented in table 4.

To test whether the switch date is different from the option listing date we estimate the following statistic: $2*(LR_{\text{switch date}}-LR_{\text{option date}}) \sim \chi^2(1\text{ df})$, where LR is the likelihood ratio on the switch or option date. The lower and upper confidence intervals around the optimal switch date T* are based on a Chi Square test with one degree of freedom of $2*(LR_{T*}-LR_{\text{lower date}})$ and $2*(LR_{T*}-LR_{\text{upper date}})$. Note that both the linear-drift and the means-shift models previously discussed are restricted versions of this more general model.

For the NYSE stocks, all of the optimal regime-change dates for the microstructure variables occur before the option listing date. Volume, raw spread, mid-point volatility, and trade size regime changes occur before the option listing date with high statistical significance. For the percent quoted spread and percent effective spread, optimal change dates occur very near the listing date. In fact, the listing date cannot be statistically ruled out as the date of the regime change.

For NASDAQ stocks, none of the microstructure optimal change dates suggest a switch on the listing date. The Chi-Square test rules out the list date as a switch date in each case. Except for trade size, which identifies a preferred regime change long after the listing date, each of the microstructure measures identifies the optimal shift as occurring before the listing date occurs with 95% significance.

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[2] For the daily short data we use the (-75, 75) window and for the monthly short data we use the (-200, 200) day window.

In contrast with the results one might expect based on Sorescu (2000), regression results for market adjusted returns designate a preferred regime change 17 to 19 days before the listing date. Average daily market-adjusted returns before this date are positive, but market-adjusted returns after the optimal regime-change date are not, on average, different from zero.[3]

Taken as a whole, the change-date tests on market liquidity measures and the tests for a regime change in market-adjusted returns suggest that improvements in liquidity and market value do not result from option listings. These changes precede option listings. In fact, a stock's improved liquidity is probably, at least in part, one of the selection criteria for option listing. Improvements in liquidity generally are not coincident with the listing as has previously been concluded.

Turning our attention to changes in short-sale constraints, we find results that differ markedly from the timing of microstructure changes observed above. First, observe that the 95% confidence interval for each constraint measure spans the introduction date.[4] However, the breadth of the confidence intervals for these variables, is much wider than those observed in the tests of market liquidity measures. Recall that the horizon for Relative Short Interest is (-200, 200), but the optimal change date is day 180 which cannot be distinguished from numerous dates over a 223 day long window beginning 41 days before the option introduction.

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[3] We observe that while the market-adjusted returns are not different from zero after the optimal change date, because the average beta for firms with new option listings is significantly greater than one, market-model abnormal returns for a narrow window around the listing would report negative abnormal returns. Our results suggest that previously observed negative market-model returns probably result from abnormal pre-event beta estimation rather than abnormal event-window stock returns.

[4] Although the confidence interval spans the listing date for Borrowing Fee and Shares Borrowed %, the actual listing date is not significant at the 5% level. This reflects the fact that while the optimal change date is preferred to the listing date with 95% confidence, other dates near the listing are not significantly distinguished from the optimal date.

The event window for the other short-sale constraint measures is (-75, 75). Observe that Shares Borrowed and Borrowing Fee optimal switch dates cannot be distinguished from dates over almost all of the sample period. In other words, the data has chosen an optimal date that is hardly distinguishable from most of the sample.

Market-Wide Availability provides a tighter confidence interval. Here the data chooses a switch date two days before the option introduction. The date is not distinguishable from the list date.

Taken as a whole, the data suggests that for most of the short-sale constraint proxies, the optimal regime-change dates cannot be differentiated from the listing date, or any other date for that matter. Only the "Market-Wide Availability" metric has a reasonably tight confidence interval.

We note that the quality of the Market-Wide Availability data is almost certainly higher in quality than the other three constraint proxies. Because Market-Wide Availability is a daily aggregate of approximately 30 securities lenders, the idiosyncratic volatility in the data will be less than that for a single firm's "Shares Borrowed" or for Relative Short Interest, which is observed for each firm only monthly.

3.4. **Visual depictions of the results.**

To give the reader a better understanding of the time series of the data, we provide several graphs of the "optimal regression" results shown in Table 4. Figures 1 – 11 show the fitted values for several of the variables using the regression results from Equation 8. In each case, the optimal Switch Date reported in Table 4 is used. In addition to the fitted values, each figure shows the mean value of the variable on every day in the window of observation.

Figures 1 and 2 show the Percentage Spread for NYSE and NASDAQ stocks respectively. The results here are obvious. Spreads are declining before the option introduction. Options clearly don't cause the spreads to fall. If anything, spreads actually rise after the option introduction.

Likewise, in Figures 3 and 4, Daily trading Volume peaks before options are introduced. While average volume is higher after the option is introduced, it should be clear that increased volume precedes the listing rather than being caused by the listing.

NASDAQ Volatility (Figure 6) is the single microstructure measure where a regime shift seems to occur near the listing date. Recall that the optimal shift date for this variable is 4 days before the listing. Mayhew and Mihov (2004) observe that volatility is a selection criteria for the exchanges, and we clearly observe increased volatility shortly before the option listing. Nevertheless, a substantial break in the data points in the week prior to the option listing, but undoubtedly after to listing announcement seems quite suspect. Frankly, of all the liquidity measures considered, the volatility of NASDAQ stocks is the only variable where we might reasonably infer that the announcement or listing seems to have an impact.

Figure 7 shows daily Market Adjusted Returns. Prior to the option listing, the returns are positive with high statistical significance, but these abnormal returns cease well before the listing date and cannot be distinguished from zero later. Using betas from the early part of the sample period to estimate abnormal returns late in the sample will force a conclusion that the firms earn negative abnormal returns after the option listing date.

Figures 8 through 11 depict short-sale constraint proxies. As noted earlier, each of these proxies suggest that constraints are relaxing over the window, but there is no obvious shift occurring near the option introduction date. A possible exception to that assertion is for Market-Wide Availability (figure 10). An upward spike appears to coincide with a relatively narrow window around the option introduction, and the data points become much tighter on or around that date also.

4. Conclusion

This paper reexamines the impact to of option introductions on the market quality of the underlying stock. We find that the post-option market quality, measured as spreads or volume does show an improvement over the pre-option market quality; however we find that this improvement is not due to the option introduction. Our findings support the hypothesis that option introductions are largely endogenous events that occur because of improvements in the liquidity of the underlying stocks. Furthermore, we find that market quality, as measured by bid-ask spreads and trading volume, peaks before the option listing date in most cases. Volatility also peaks well before the listing date.

There is some evidence that options do impact proxies for short-sale constraints. The availability of shares rises around the listing. But other constraint level measures, such as shares shorted and short-stock rebate rates, do not show much evidence of relaxation in short-sale constraints.

Finally, we find that daily market-adjusted returns are significantly positive prior to the option introductions but shift to a level not different from zero around 19 to 17 days prior to the introduction. This finding is consistent with positive stock performance being a selection factor for option introductions.

Appendix: Descriptions of data.

All variables are measured daily relative to the option introduction date, t=0. For variables with daily observations, all the variables were aligned and grouped according to the day relative to the option introduction. For the non-daily observations we followed the same procedure but recognize that firms will effectively come in and out of the data set depending on what day it is relative to the option introduction. For the monthly Relative Short Interest data, this data only occurs monthly, but we aggregate it daily again relative to the option date. Therefore there is about a 1 in 20 chance that any single firm will be in the sample for a given relative day. Because the option dates are broadly distributed throughout the month we have RSI observations for each relative day.

Variables that do not necessarily have daily data points.

Variable Name	**Description**	**Time Period and Source**	**Window**	**Computation**	**Daily Frequency**
Borrowing Fee	Fee paid for borrowing securities from Mutual Funds to lend to Hedge Funds.	2001 – 2003 Proprietary	+/- 75 days	No adjustments.	Varies
Shares Borrowed	Shares currently borrowed from Mutual Funds.	2001 – 2002 Proprietary & CRSP	+/- 75 days	Divided by current shares outstanding from crsp.	Varies
Market Availability	Shares currently available to be lent	2001 – 2002 Proprietary & CRSP	+/- 75 days	Divided by current shares outstanding from crsp.	Varies
Relative Short Interest (RSI)	Monthly short interest reported.	1988 – 2002 NYSE & CRSP	+/- 200 days	Divided by current shares outstanding from crsp	Monthly reported on the 15th

Variables with daily observations

Market Adjusted Return	Market Adjusted Return: RET-VWRETD	1988 – 2002 CRSP	+/- 125 days	No adjustment	Daily
Percent Spread	Average daily Bid Asked Spread divided by quote midpoint	1993 – 2000 TAQ	+/- 125 days	No adjustment	Daily
Volume	Average daily volume divided by aggregate market volume on CRSP for that day	1993 – 2000 TAQ & CRSP	+/- 125 days	Divided by CRSP market volume	Daily
SDMID	Standard Deviation of the quote midpoint	1993 – 2000 TAQ	+/- 125 days	No adjustment	Daily

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Table 1 Summary Statistics

This table presents the number of options listings per year that pass the screens discussed in the text. Averages of percentage spread, the bid-asked spread divided by price, volume and market value on the listing day are also presented.

Panel A Market microstructure variables

	NYSE				NASDAQ			
Year	N	Percentage Spread	Volume	Market Value	N	Percentage Spread	Volume	Market Value
1993	30	0.01282	141,120	564,123	28	0.01757	196,157	379,415
1994	44	0.01062	134,075	1,369,668	68	0.02156	160,449	346,623
1995	56	0.00934	84,134	850,738	46	0.01902	170,765	419,515
1996	49	0.00907	75,471	1,063,309	127	0.02037	202,851	396,637
1997	3	0.00794	91,233	781,831	18	0.01732	81,067	331,086
1998	81	0.00696	118,481	922,230	183	0.01396	195,446	426,933
1999	35	0.00860	109,329	843,387	150	0.01073	382,594	729,913
2000	0	-	-	-	144	0.00970	576,603	1,173,779
All Years	298	0.00909	108,187	951,333	764	0.01478	297,992	610,555

Table 1 Summary Statistics continued

This table presents the number of option introductions that have full data from the two short interest data sets. Relative short interest is monthly short interest divided by shares outstanding. Borrowing fee is the real fee charged to borrowers of shares, it is equal to the Treasury Bill rate less the rebate rate. Shares borrowed are the number of shares borrowed as a percentage of the shares outstanding for one bank in the share lending market. Market wide availability is the number of shares available to loan divided by shares outstanding for the top 30 firms in the share lending market.

Panel B Short interest data

	Monthly short data		Daily short data					
	Relative Short Interest		Borrowing Fee		Shares Borrowed		Market Wide Availability	
Year	N	Mean	N	Mean	N	Mean	N	Mean
1988	110	0.0112656	-	-	-	-	-	-
1989	115	0.0125749	-	-	-	-	-	-
1990	86	0.017659	-	-	-	-	-	-
1991	153	0.0254489	-	-	-	-	-	-
1992	158	0.0293333	-	-	-	-	-	-
1993	171	0.0300431	-	-	-	-	-	-
1994	223	0.0311905	-	-	-	-	-	-
1995	251	0.0256616	-	-	-	-	-	-
1996	389	0.0228212	-	-	-	-	-	-
1997	370	0.0230857	-	-	-	-	-	-
1998	287	0.0241583	-	-	-	-	-	-
1999	291	0.026688	-	-	-	-	-	-
2000	364	0.0271232	-	-	-	-	-	-
2001	206	0.0399073	297	1.478312	293	0.003503	293	0.0446348
2002	59	0.0508129	165	1.106793	100	0.004858	100	0.0493163
2003	-	-	31	1.201276	-	-	-	-
All Years	3233	0.02613	493	1.3365498	393	0.0038479	393	0.045826

Table 2 Changes in the Means of Variables Around the Options Listing Day

This table presents tests of the changes in microstructure variables around the option listing day. The variables are measured as the average for all stocks over all days before and after option introduction date. All numbers reported to 6 significant figures. Standardized volume is daily share volume divided by total volume for the exchange for that day, i.e. total NASDAQ volume for NASDAQ stocks, total NYSE volume for NYSE stocks. The window before and after the option day is 125 days.

Panel A Microstructure Variables

Variable	NYSE			NASDAQ		
	Mean t < -5	Mean t > 5	Difference	Mean t <- 5	Mean t > 5	Difference
Spread	0.20149	0.19004	-0.01146***	0.37086	0.30172	-0.06914***
Percent spread	0.00982	0.00944	-0.00038***	0.01758	0.01542	-0.00216***
Effective spread	0.00608	0.00587	-0.00021***	0.01336	0.01168	-0.00168***
Standardized volume	0.0001743	0.0001804	0.0000061**	0.0003013	0.0003594	0.0000581***
Trade size	1780.67	1788.27	7.59664	1274.52	1169.21	-105.309***
Number of trades	43.9932	52.3985	8.40529***	320.741	434.109	113.368***
Standard deviation of quote midpoint	0.08231	0.07939	-0.00292***	0.08231	0.07939	-0.07939***

Table 2 continued

Borrowing fee is the Treasury Bill rate less the rebate rate paid to customers who borrow shares. It is a measure of the real cost of borrowing. Shares borrowed are the number of shares borrowed by the bank's customers as a percentage of the shares outstanding from CRSP. Market wide availability is the total shares available to be loaned from about 30 major share lending institutions, scaled by shares outstanding. Relative short interest is short interest reported by the NYSE scaled by shares outstanding. Market adjusted returns are CRSP daily returns less the CRSP value weighted index return. Borrowing fee, shares borrowed and market wide availability are all measured on a 75 window before and after the option date. Relative short interest, which is reported monthly is measured on a 200 day window before and after the option date. Market adjusted returns are measure on a 125 window before and after the option date.

Panel B Short Interest and Return Variables

	Time Period and Sample Size	Mean t<0	Mean t>0	Difference
Market adjusted returns (value weighted)	1988 – 2002, N=36197	0.0028211	-0.0003105	-0.0031317***
Relative short interest	1988 – 2002, N=36177	0.0217163	0.0326932	0.0109769***
Borrowing fee	2001 – 2003, N=15405	1.339068	1.192506	-0.1465622***
Shares borrowed	2001 – 2002, N=53139	0.0036815	0.0045503	0.0008688***
Market wide availability	2001 – 2002, N=27486	0.0447427	0.0492474	0.0045047***

***Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 3. A Comparison of the Shifting Means and Linear Drift Models.

The linear drift model in section 1 is $\text{depvar}_{i,t} = \beta_0 + \beta_1 relativeday_{i,t} + \varepsilon_{i,t}$ where depvar is the daily liquidity measure on the day (0 to 250). Day 125 is the option introduction day. The shifting means model (section 2 is $\text{depvar}_{i,t} = \alpha_1 predummy_i + \alpha_2 postdummy_i + \varepsilon_{i,t}$ where depvar is the daily liquidity measure on dummy variables for before and after the option introduction without an intercept, predummy is equal to one if the date is before the option introduction, zero otherwise, and postdummy is equal to one if the date is after the option introduction, zero otherwise. Section 3 presents the J-test, as developed by Davidson and MacKinnon (1981) i.e.

$$\text{depvar}_{i,t} = \gamma_{drift}\left[\text{depvar}^{predicted}_{drift}\right] + (1-\gamma_{drift})\left[\alpha_1 \text{predummy}_i + \alpha_2 \text{postdummy}_i\right] + \varepsilon_{i,t}$$ and

$$\text{depvar}_{i,t} = \gamma_{shift}\left[\text{depvar}^{predicted}_{shift}\right] + (1-\gamma_{shift})\left[\beta_0 + \beta_1 \text{relativeday}_{i,t}\right] + \varepsilon_{i,t}.$$ To find support for the linear drift model we should find $\gamma_{drift} = 1$, $\gamma_{drift} \neq 0$, $\gamma_{shift} \neq 1$ and $\gamma_{shift} = 0$.

***Significant at 1%, ** Significant at 5%, * Significant at 10%

Panel A Microstructure variables						
	NYSE N=74798			NASDAQ N=191764		
	Percent Spread	Volume	Std Dev Quote Mid	Percent Spread	Volume	Std Dev Quote Mid
1. Linear Drift Model: $\text{depvar}_{i,t} = \beta_0 + \beta_1 relativeday_{i,t} + \varepsilon_{i,t}$						
Constant	0.00995	0.00017	0.0832628	0.01861	0.00027	0.4591609
	(236.43)***	(69.46)***	(266.58)***	(390.17)***	(82.99)	(132.14)***
Relative Day (x10k for spread)	-0.02754	1.04e-07	-0.0000198	-0.17386	5.26e-07	-0.0001151
	(-9.45)***	(6.29)***	(-9.15)***	(-52.68)***	(23.69)	(-4.80)***
2. Shifting Means Model: $\text{depvar}_{i,t} = \alpha_1 predummy_i + \alpha_2 postdummy_i + \varepsilon_{i,t}$						
Pre Option	0.00979	0.00018	0.0821954	0.01745	0.00031	0.4591749
	(328.61)***	(104.37)***	(371.80)***	(515.79)***	(134.30)***	(187.01)***
Post Option	0.00942	0.00018	0.0793715	0.01540	0.00036	0.4303073
	(314.98)***	(106.80)***	(357.62)***	(453.47)***	(157.38)***	(175.66)***
3. J-Test for Drift vs. Shift Models (Davidson and MacKinnon (1981))						
Linear Drift: $\text{depvar}_{i,t} = \gamma_{drift}\left[\text{depvar}^{predicted}_{drift}\right] + (1-\gamma_{drift})\left[\alpha_1 \text{predummy}_i + \alpha_2 \text{postdummy}_i\right] + \varepsilon_{i,t}$						
γ drift	0.80027	2.89197	0.5887645	1.184899	1.55175	-1.993148
F-test γ drift = 1	0.89	35.41***	3.54*	23.72***	42.72***	51.84***
F-test γ drift = 0	14.31***	82.73***	7.26***	974.14***	337.91***	22.99***
Shift: $\text{depvar}_{i,t} = \gamma_{shift}\left[\text{depvar}^{predicted}_{shift}\right] + (1-\gamma_{shift})\left[\beta_0 + \beta_1 \text{relativeday}_{i,t}\right] + \varepsilon_{i,t}$						
γ shift	0.24968	-6.83000	0.4822123	-0.26272	-0.90146	1.994903
F-test γ shift = 1	10.73***	62.05***	5.45***	730.60***	253.44***	17.22***
F-test γ shift = 0	1.19	47.21***	4.72**	31.63***	56.96***	69.22***
Favored Model	Drift	Drift	Inconclusive	Drift	Drift	Shift

Panel B. Short interest and return variables

	Borrowing fee	Shares borrowed	Market wide availability	Relative short interest	Market adjusted returns (value weighted)
Time Period	2001-2003	2001-2002	2001-2002	1988-2002	1988-2002
1. Linear Drift Model: $\text{depvar}_{i,t} = \beta_0 + \beta_1 relativeday_{i,t} + \varepsilon_{i,t}$					
Constant	1.268661 (76.90)	0.004107 (60.76)	0.0470071 (100.70)	0.0270952 (149.56)	0.0012688 (5.35)
Relative Day	-0.0018337 (-4.72)	0.0000131 (8.25)	0.0000436 (4.02)	0.0000532 (33.04)	-0.0000212 (-6.36)
2. Shifting Means Model: $\text{depvar}_{i,t} = \alpha_1 predummy_i + \alpha_2 postdummy_i + \varepsilon_{i,t}$					
Pre Option	1.339411 (54.68)	0.0037138 (37.34)	0.0447839 (62.46)	00217466 (81.84)	0.0028239 (8.26)
Post Option	1.192506 (54.36)	0.0045503 (49.92)	0.0492474 (84.52)	0.0326932 (132.62)	-0.0003105 (-0.95)
3. J-Test for Drift vs. Shift Models (Davidson and MacKinnon (1981))					
Linear Drift: $\text{depvar}_{i,t} = \gamma_{drift}\left[\text{depvar}_{drift}^{predicted}\right] + \left(1-\gamma_{drift}\right)\left[\alpha_1 \text{predummy}_i + \alpha_2 \text{postdummy}_i\right] + \varepsilon_{i,t}$					
γ drift	0.7131471 . (1.74)	1.349786 (5.71)***	-0.0996203 (-0.21)	0.8117461 (13.82)	0.4052955 (1.31)
F-test γ drift = 1	0.49	2.19	5.26**	10.27***	3.72*
F-test γ drift = 0	3.01*	32.62***	0.04	190.98***	1.73
Shift: $\text{depvar}_{i,t} = \gamma_{shift}\left[\text{depvar}_{shift}^{predicted}\right] + \left(1-\gamma_{shift}\right)\left[\beta_0 + \beta_1 \text{relativeday}_{i,t}\right] + \varepsilon_{i,t}$					
γ shift	0.353887 (0.81)	-0.5421037 (-1.72)*	1.070974 (2.68)***	0.2399414 (3.74)	0.664615 (2.24)**
F-test γ shift = 1	2.21	24.04***	0.03	140.30***	1.28
F-test γ shift = 0	0.66	2.97*	7.19***	13.98***	5.02**
Favored Model	Inconclusive	Drift	Shift	Inconclusive	Shift

Table 4. Tests for most likely switch date for regimes in switching regression model.

The switch date is estimated as the date that results in the highest log-likelihood ratio from a switching regression model that allows the data to fit to lines with different slopes and intercepts. The lines are not required to connect at a spline node. The P value is for a Chi Square test with one degree of freedom of $2*(LR_{T*} – LR_{125})$ where T* is the switch date. This test is testing whether the LR on the switch date is significantly different from that on day 0, the option introduction date. The lower and upper confidence intervals are based on the Chi Square test with one df of $2*(LR_{T*}-LR_{lower\ date})$ and $2*(LR_{T*}-LR_{upper\ date})$ and measure the range for the switch date.

	Switch Date	P value diff from day 0	Lower 95% CI	Upper 95% CI
NYSE percent spread	-1	0.899343	-34	24
NYSE volume	-33***	0.000038	-36	-32
NYSE raw spread	-31***	0.000004	-39	-30
NYSE percentage effective spread	-2	0.803362	-20	28
NYSE std dev quote mid point	-56***	0.004451	-57	-54
NYSE trade size	-75*	0.074911	-85	-74
NYSE number of trades	-33***	0.000020	-36	-28
NASDAQ percent spread	-12***	0.000018	-20	-4
NASDAQ volume	-37***	<0.000001	-44	-36
NASDAQ raw spread	-10***	<0.000001	-12	-6
NASDAQ percentage effective spread	-10***	0.000482	-20	-3
NASDAQ std dev quote mid point	-4***	0.000054	-12	-2
NASDAQ trade size	101***	0.000148	73	106
NASDAQ number of trades	-42***	0.000051	-50	-31
Market adjusted return (Value weighted)	-19***	<0.000001	-19	-17
Relative short interest	180**	0.334344	-41	+182
Borrowing fee	+26**	0.036448	-74	+72
Shares borrowed %	-34*	0.071685	-72	+74
Market wide availability %	+2	0.300044	-32	+13

***Significant at 1%, ** Significant at 5%, * Significant at 10%

Figures showing mean daily values around the option introduction. Fitted lines represent a switching regime model using the optimal switch date presented in table 4.

Figure 1. NYSE Percentage spread

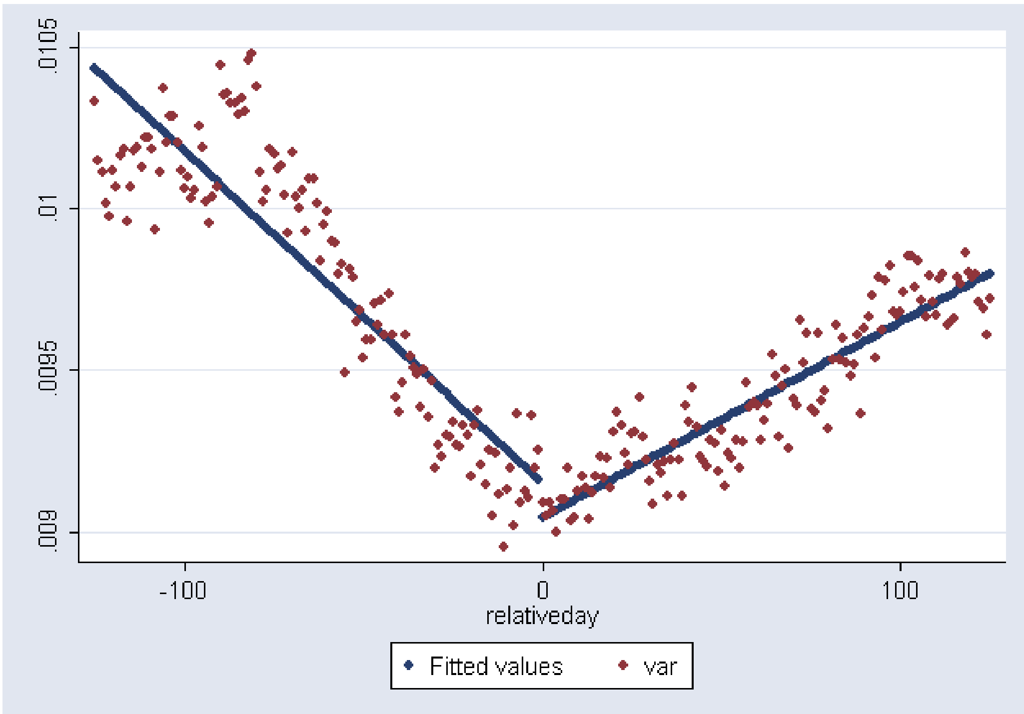

Figure 2. NASDAQ Percentage spread

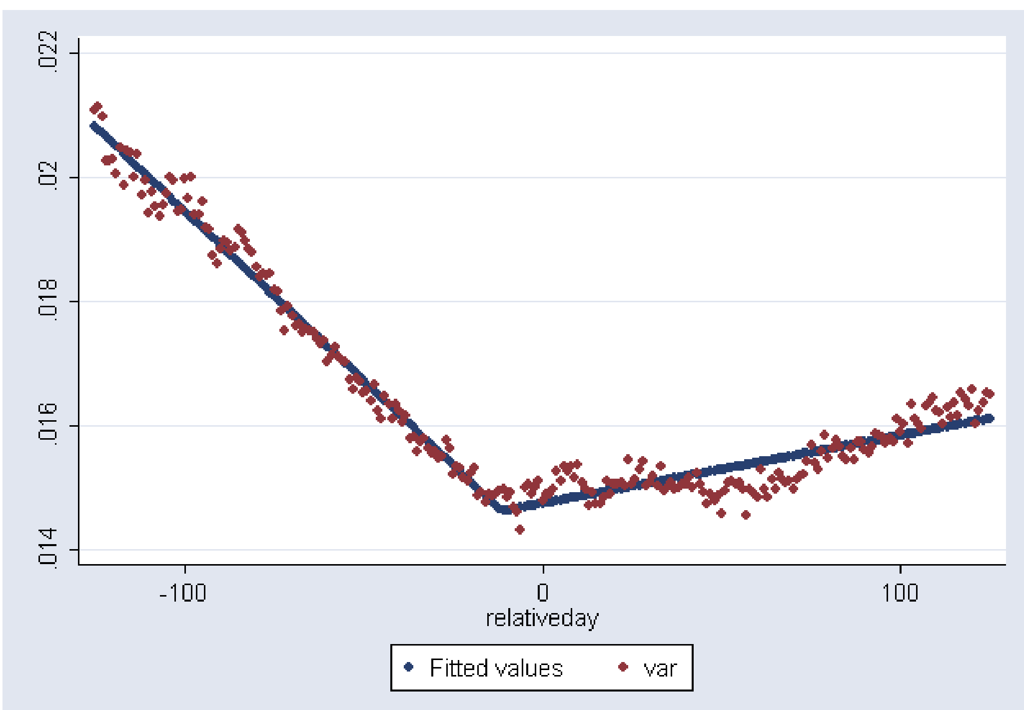

Figure 3. NYSE Volume

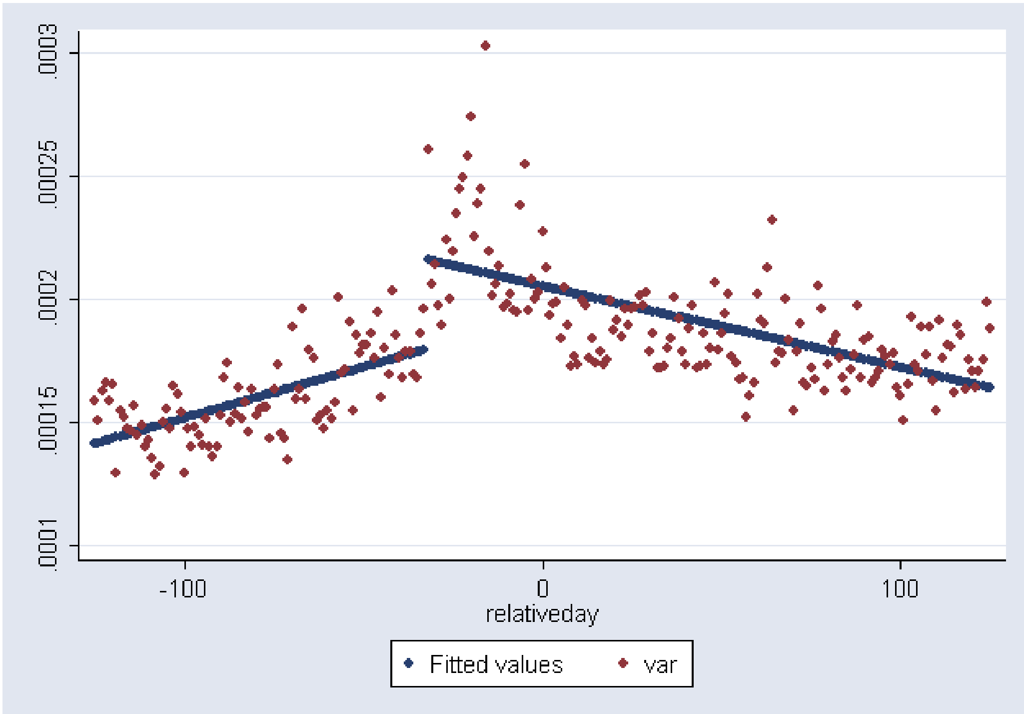

Figure 4. NASDAQ Volume

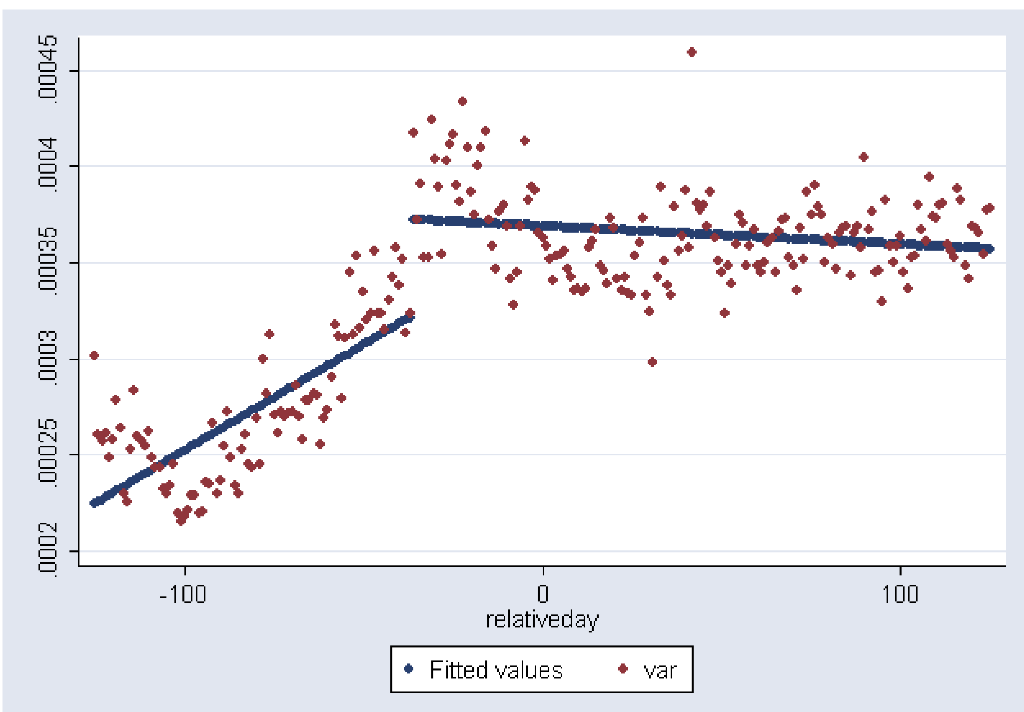

Figure 5. NYSE Standard deviation of quote midpoint

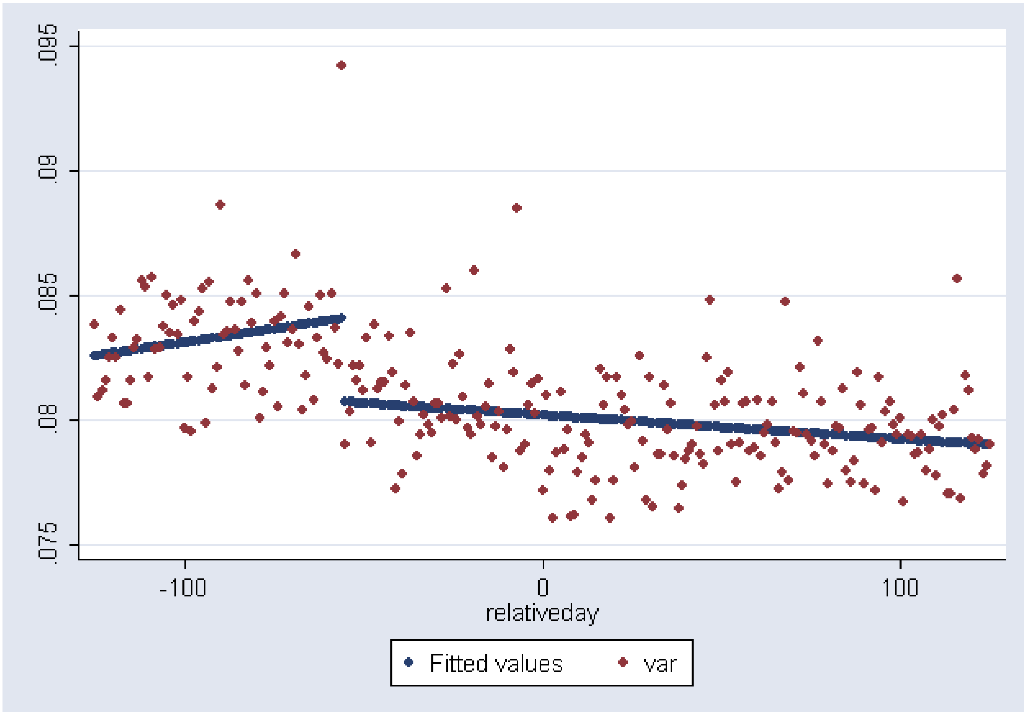

Figure 6. NASDAQ Standard deviation of quote midpoint

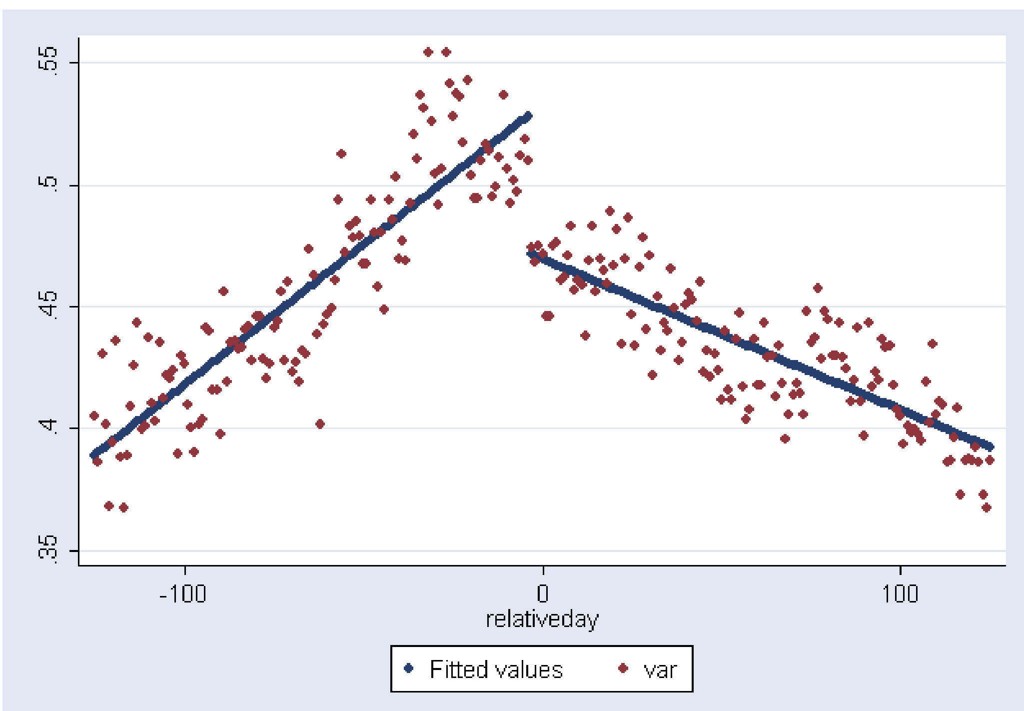

Figure 7. Daily market adjusted returns using value weighted returns

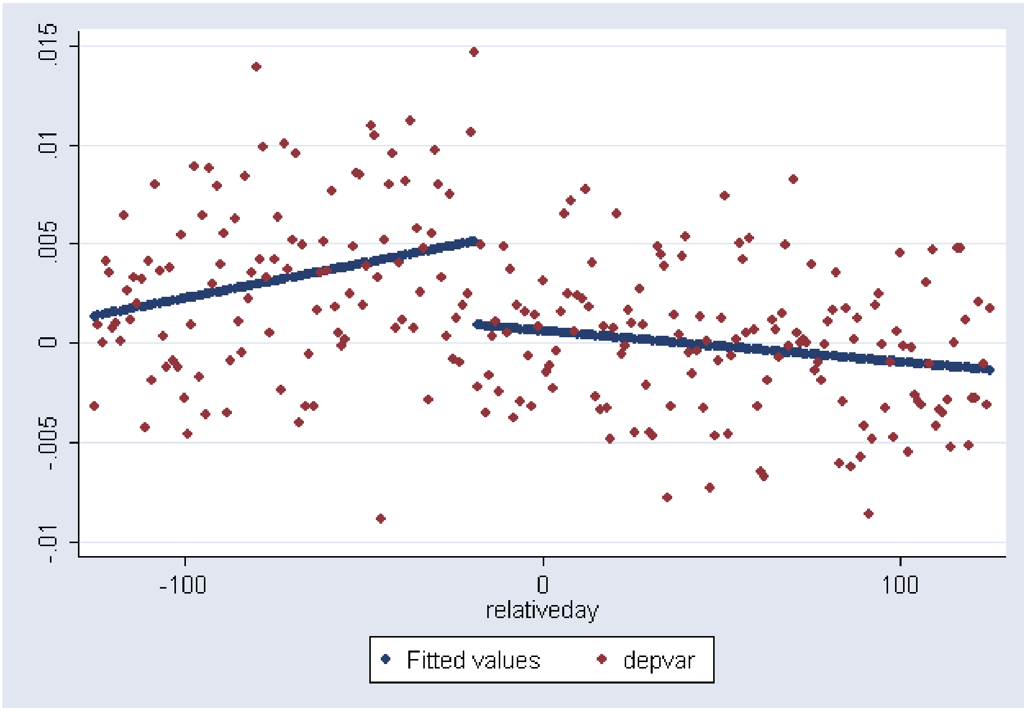

Figure 8. Borrowing fee

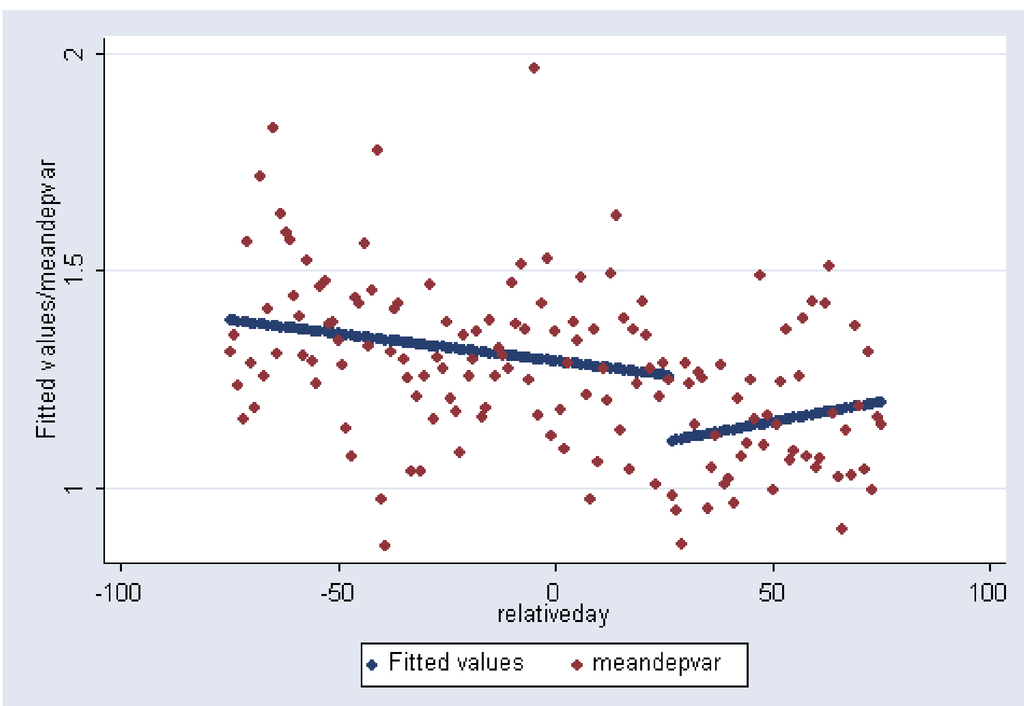

Figure 9 Shares borrowed as a percentage of shares outstanding

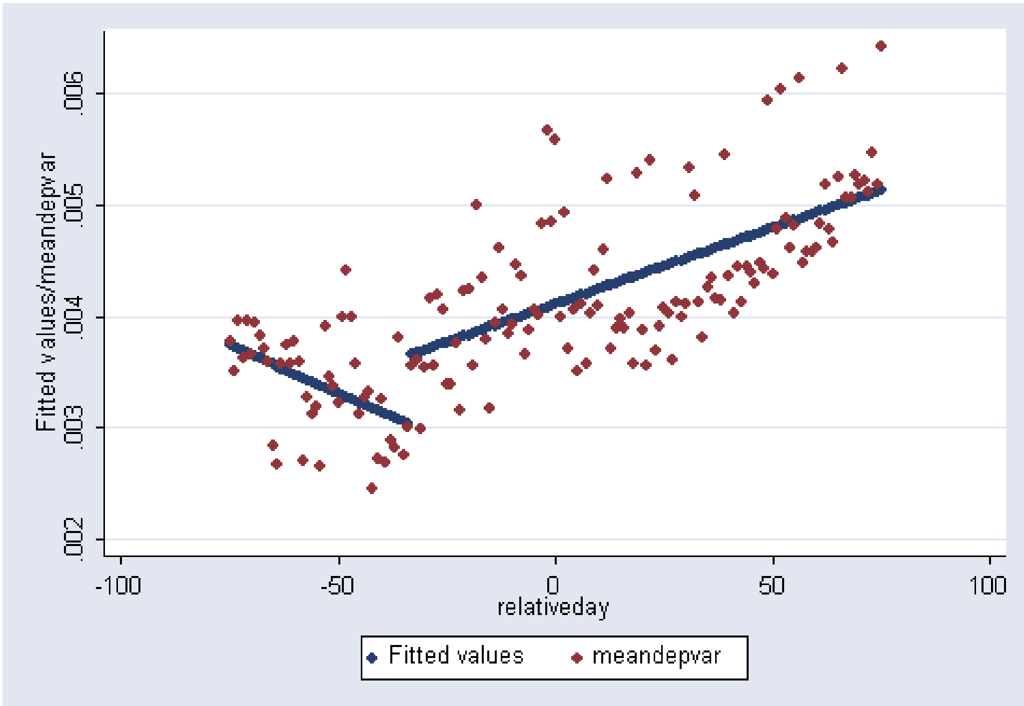

Figure 10. Market wide share availability as a percentage of shares outstanding

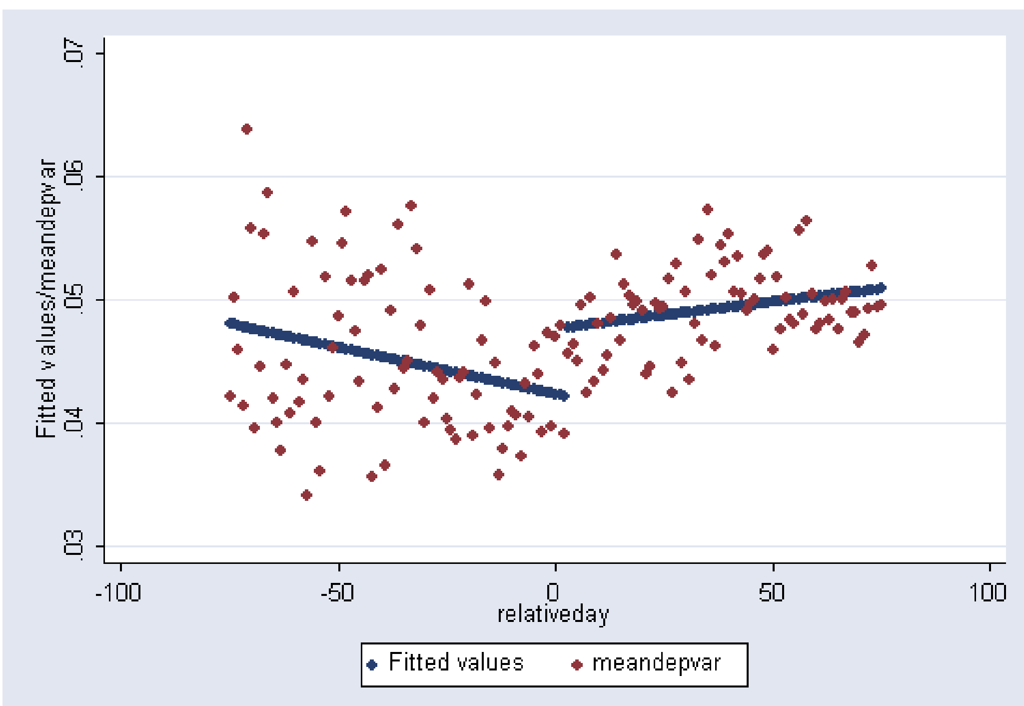

Figure 11. Relative short interest