O/S: The Relative Trading Activity in Options and Stock

by

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Relatively little is known about the trading volume in derivatives relative to the volume in underlying stocks. We study the time-series properties and the determinants of the options/stock trading volume ratio (O/S) using a comprehensive cross-section and time-series of data on equities and their listed options. O/S is related to many intuitive determinants such as delta and trading costs, and it also varies with institutional holdings, analyst following, and analyst forecast dispersion. O/S is higher around earnings announcements, suggesting increased trading in the options market. Further, post-announcement absolute returns are positively related to pre-announcement O/S, which suggests that at least part of the pre-announcement options trading is informed.

I. Introduction

Where should one trade? The answer depends on liquidity and costs, of course, but also on the strength of a trader's convictions. A buyer believes, correctly or not, that the price is more likely to increase than decrease, and vice versa for a seller. The convinced trader would naturally attempt to execute where the profit potential is highest, in a leveraged market with ample liquidity. Hence, even though options are redundant in the frictionless world of Black and Scholes (1973), trading options could be more attractive than trading stock for an informed agent with borrowing constraints, and it could also be more appealing for any agent with ill-founded but strong beliefs.

Although the theoretical literature about informed trading such as Kyle (1985) or Glosten and Milgrom (1985) emphasizes the distinction between informed and uninformed agents, trading itself is driven by agents with convictions, whether or not they possess valid information. Indeed, one of the great puzzles of finance is the sheer volume of trading, which seems far in excess of what could reasonably be anticipated based on the arrival of new private information. Presumably, some of this seemingly excessive trading is among agents who are not informed at all, but simply believe they are.

There is, nonetheless, recent evidence that at least some traders are truly informed. Easley, Hvidkjaer, and O'Hara (2002) find evidence that informed traders are active in equity markets and that information risk is priced in the cross-section of stock returns. Further, Pan and Poteshman (2006) find that put/call ratios in transactions involving new positions are good predictors of future stock returns. This is consistent with informed traders exploiting the enhanced leverage of the options market to maximize profitability, thus indicating that options are not viewed as redundant securities by agents. Pan and Poteshman (2006) build on earlier theoretical work by Easley, O'Hara, and Srinivas (1998), which suggests that informed traders could use either options or stock and outlines conditions when options would be preferred; e.g., when implicit leverage in options is high and options are relatively liquid. Of course, the same conditions would entice non-informed true believers to trade in options. In addition, options could attract volume as vehicles that can be used to hedge positions in the underlying stock (or indeed in other options).

Despite intimations in the past theoretical and empirical literature about the relative merits of trading in options and stock, there has been virtually no direct work on understanding variation in the actual relative trading volumes in derivatives and their underlying assets. In this paper, we hope to provide some evidence about this important issue by using an extensive cross-sectional and time-series sample of options and their underlying equities over a period spanning almost 3000 trading days.

We first develop a simple empirical construct, the options/stock trading volume ratio (O/S). O/S is the ratio for a given calendar period, usually a day, between the total volume of trading on the listed options market and the corresponding volume of trading on the stock market in options and shares of a given firm. The components of O/S can be measured either in dollars or in shares, given that a typical option contract is for 100 shares of the underlying stock.

We study O/S for a comprehensive sample of equities over 12 years, 1996-2007 inclusive, when daily options trading volumes are readily available. For a given company, O/S swings dramatically from day to day, thereby indicating that on certain days, some traders are attempting to exploit what they believe is privileged information. We find too that O/S cross-sectionally depends on various determinants such as the costs of trading, the size of the firm, the available degree of leverage in options, institutional holdings, and, to some extent, proxies for the likely availability of private information and the diversity of opinions.

To illustrate how committed traders act around news events, we consider a broad sample of earnings announcements for stocks with listed options. We show that O/S increases significantly in the few days around an earnings announcement. Further, high O/S predicts high absolute CARs after the announcement. There is also evidence that some options traders are executing orders in the right direction for the upcoming earnings surprise. These findings are consistent with informed trading in the options market prior to earnings announcements.

To the best of our knowledge, this is the first look at the relative trading activity in options and stock. The empirical patterns are strongly significant, persistent, robust, and generally accord with intuition and received trading theory. Unlike returns generated by a random walk process, there is every reason to think that trading volume could be strongly related to underlying determinants; we find convincing empirical support for such a supposition. Moreover, our work suggests a fertile research agenda that includes looking at O/S around other corporate announcements, as well as O/S for the overall market index.

The remainder of this paper is organized as follows. Section II provides a brief literature review to place our study in the context of existing research. Section III describes the data and provides some summary statistics. Section IV presents the results of the basic regression analysis of O/S determinants. Section V presents time-series properties of some regression coefficients of interest. Section VI and VII analyze respectively the behavior of O/S around earnings announcements and its relation to cumulative abnormal returns. Section VIII concludes.

II. Literature Review

Black and Scholes (1973) treat options as securities that are redundant and can be replicated in continuous time by investments in stocks and bonds. In this paradigm, there is no role for options volume. However, options cannot be dynamically replicated with stocks and bonds when the process for the underlying stock involves features such as stochastic discontinuities (see, for example, Naik and Lee, 1990, and Pan and Liu, 2003).[1] In general, when markets are incomplete, options cannot be replicated by simple securities such as stocks and bonds (see Ross, 1976, Hakansson, 1982, and Detemple and Selden, 1991). Thus, introduction of options may help complete markets and enhance welfare.[2]

[1] Figlewski and Webb (1993), Danielsen and Sorescu (2001), and Ofek, Richardson, and Whitelaw (2004) explore the role of options in alleviating short-selling constraints.
[2] Supporting the notion that options enhance expected utility and asset values, Conrad (1989) documents a positive effect on stock prices following an options listing.

In addition to completing markets, options may also alter the incentives to trade on private information about the underlying asset. For example, Cao (1999) argues that agents with information about future contingencies should be able to trade more effectively on their information in the presence of options, thus improving informational efficiency. In addition, informed traders may prefer to trade options rather than stock, because of increased opportunities for leverage (Back, 1992, Biais and Hillion, 1994).

Consistent with the preceding notions, Cao and Wei (2008) find evidence that information asymmetry is greater for options than for the underlying stock, implying that agents with information find the options market a more efficient venue for trading. This finding is supported by Easley, O'Hara, and Srinivas (1998), Chakravarty, Gulen, and Mayhew (2004), and Pan and Poteshman (2006), who find that options order flows contain information about the future direction of the underlying stock price. This is consistent with informed traders exploiting the enhanced leverage of the options market to maximize profitability. Ni, Pan, and Poteshman (2008) show that options markets attract traders informed about future volatility and also show that options order flows forecast stock volatility. While these authors use microstructure data over a long period, they do not analyze cross-sectional determinants of options trading activity relative to that in the underlying stocks.

The notion that informed agents can trade more effectively in options markets is also supported by Jennings and Starks (1986), who present evidence that options markets allow prices to adjust more quickly after earnings announcements. Further, Mendenhall and Fehrs (1999) argue that options trading increases the speed of adjustment of prices to earnings before, rather than after the earnings announcement, by way of insider trading. Skinner (1990) argues that the information content of earnings releases is smaller after options listing, suggesting more informed trading prior to the earnings release. None of these authors consider options trading activity. However, using data for about two months, Amin and Lee (1997) show that open interest in options rises prior to earnings announcements. Similarly, using a sample of firms that experienced merger activity during the 1986-1994 period, Cao, Chen, and Griffin (2005) show that options volume predicts returns around takeover announcements, suggesting the presence of informed traders in the options market prior to corporate events.

There also have been studies of whether options markets lead stock markets or vice versa. These studies yield somewhat mixed results. For example, Anthony (1988) finds that options lead stocks, while Stephan and Whaley (1990) find the opposite. Chan, Chung, and Johnson (1993) attribute the Stephan and Whaley (1990) results to non-trading in the options market, and find that measuring returns by the midpoint of bid-ask quotes leads to different results. Schlag and Stoll (2005) argue that order flows in the index options market tend to be reversed due to inventory pressures, and thus only have a temporary impact, while De Jong and Donders (1998) argue that there are bivariate leads and lags from options to stock markets and vice versa.

In sum, the literature suggests that options markets stimulate greater informational efficiency by allowing for more informed trading. It also is well-known that options are used for hedging positions in other options as well as the underlying stock.[3] While the existing literature does not separately attempt to disentangle the role of hedging vis-à-vis informed trading in options markets, in this paper we analyze the cross-section of the ratio of options volume to stock volume (i.e., O/S) in order to ascertain whether this ratio varies across stocks in a manner consistent with what proxies for hedging demand and informed trading would suggest.

Earlier cross-sectional studies of volume have focused mainly on individual stocks. There are two main lines of theoretical thought about trading volume. In the first paradigm, trading happens both because of informed and uninformed investors. Such models, represented by Grossman and Stiglitz (1980), or Kyle (1985), generally examine cases where investors try to infer information from trading activity and market prices. Noise trading usually hinders this inference. The second school of thought (e.g., Harris and Raviv, 1993, or Kandel and Pearson, 1995) holds that trading is induced by differences of opinion. This line of research often de-emphasizes the role of information gleaned from market prices and ignores noise traders. Instead, investors share the same public information but interpret it differently, which impels them into transactions.

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[3] Lakonishok, Lee, Pearson, and Poteshman (2007) show that covered call writing, a form of hedging, is one of the most commonly used strategies in options markets.

Testing these lines of thinking, Chordia, Huh, and Subrahmanyam (CHS) (2007) study the cross-section of trading activity and show that dispersion in analysts' opinions is positively related to trading volume, whereas Choy and Wei (2009) demonstrate a similar finding for options volume (though they do not focus on O/S). CHS also use the number of analysts as a proxy for the extent of informed trading and find that this quantity is also positively related to volume. In our paper we use both analyst forecast dispersion as well as the extent of analyst following a stock as explanatory variables for O/S. We also use the option delta as a proxy for hedging-related demand (and enhanced leverage.) A sub-sample of out-of-the-money options is examined separately since they would offer even more anticipated profit for committed agents. In addition, since institutions would be more likely to use options for hedging purposes and would also be more likely to be informed, we use the percentage of stock held by institutions as a potential determinant of O/S. Finally, we analyze trading around earnings announcements to ascertain if O/S increases prior to the announcement and predicts post-announcement returns, as the information paradigm would suggest.

III. Data

A. O/S: The Options/Stock Trading Volume Ratio

The option trading data come from Option Metrics. This database provides the daily number of contracts traded for each individual put and call option on U.S. listed equities along with associated bid and ask prices and other relevant information such as delta and implied volatility. With these data, we can approximate the total daily dollar options volume for each firm by multiplying the total contracts traded in each option by the end-of-day quote midpoints and then aggregating across all options listed on the stock (we account for the fact that each contract is for 100 shares of stock). We can also calculate the total daily number of contracts traded for each stock by adding the contracts traded across all options listed on the stock. The sample includes 2948 trading days over the 12-year period 1996-2007. The cross-section of stocks each day is the sample with listed options that also has data available on all of the explanatory variables, described later.

Table 1 gives summary statistics for options trading volume by calendar year. Panel A provides the annual summary statistics for the daily cross-sectional average dollars options trading volume and Panel B for the average contract options trading volume. The average number of firms increases from a minimum of 752 firms in 1996 to a maximum of 1290 in 2007, with a slight decrease during the period of decline in tech sector prices (2001-2003). The mean daily dollar options volume also increases from $167,000 in 1996 to $752,000 in 2007, with more dramatic reductions during the period of decline in tech sector prices, whereas the mean daily contract options volume increases from 555 in 1996 to 2530 in 2007.

The stock trading data comes from CRSP. This database provides both the daily dollar volume of trading and the daily number of shares traded for each firm's equity. With both stock and options data on trading activity, we compute every day for every firm in the sample both the dollar options/stock volume ratio ($O/S) and the share options/stock volume ratio (ShO/S). To reduce the influence of possible outliers we use the natural logarithms of these ratios as the dependent variables in the results presented in the next section. For convenience, we will often refer to the logged variables as simply O/S. As an example, Figure 1 plots the natural logarithm of $O/S for IBM over the 1996-2007 sample period. As can be seen from the figure O/S for IBM generally declines from the start of the sample period to about 2005. A specific cause for this is challenging to discern, and is a worthwhile topic for further analysis.

Table 2 provides some summary statistics associated with the various O/S measures. For each firm in the sample with at least fifty time series observations, we compute summary statistics over the firm's time series observations of O/S. Then, cross-sectional statistics are computed using the time series statistics. Overall, the mean and median O/S in dollars are very close to each other and are less than unity. The value of the O/S in shares, however, is larger (much closer to unity). The mean kurtosis is also fairly small. Overall, O/S appears to be well behaved and suitable for the linear regression analysis conducted in the next section.

Since the next section analyses time-series averages of cross-sectional regressions, autocorrelation in the dependent variable (i.e., in O/S) is of particular interest. We therefore provide summary statistics for the partial autocorrelations in O/S. Using the same sample as in Table 2, we provide the cross-sectional summary statistics of the partial autocorrelations up to lag five for the four O/S measures in Table 3. It can be seen that the autocorrelations, on average are positive, but are substantial only for the first two lags and decay from about 19% at the first lag to about 7% by the fifth lag. The positive autocorrelations may arise because informed agents may start trading on information signals a few days in advance of news events, and trade slowly over time to maximize their expected trading profits (Kyle, 1985). We account for the autocorrelations by reporting Newey-West (1987) corrected t-statistics of the coefficients from the regressions to follow.

B. Candidate Determinants of O/S

To explain the daily options/stock volume ratios, we use all the variables for which we have available data and that we believe have some reason to explain the cross-section of these ratios. These variables include firm size, options spreads, implied volatility, option deltas, number of analysts following the firm, analysts' earnings forecast dispersion, and institutional holdings. We provide justifications for each of these variables below.

First, firm size is a standard control variable in finance studies. There is some reason to believe that larger firms would have more liquid options markets allowing more trading, though the stock would also be more liquid so its effect on the options/stock volume ratio is uncertain. We use the log of firm size (market capitalization) as of the previous month as an explanatory variable because the variable is highly skewed.

Options spreads are a direct measure of trading costs in the options markets, so we would expect lower spreads to be associated with higher O/S. For each firm/day we measure the percentage spread as the average bid-ask spread divided by the midpoint over all options traded. This is used as an explanatory variable for O/S. Due to potential endogeneity between trading activity and spreads, we also provide results with an instrumental variable estimate of the spread, described later.

Higher implied volatilities may attract more informed traders because such agents would perceive higher expected profits on their information signal in more volatile companies (Glosten and Milgrom, 1985; Kyle, 1985).[4] There also is reason to expect a relation between O/S and option Delta. A higher call option Delta indicates more sensitivity to changes in the underlying stock price and the same thing is true of put option Deltas after they are reversed in sign (which we do.) Firms whose options have lower Deltas will require more option contracts per underlying share to achieve the same share-equivalent position. (Option hedge ratios are reciprocals of Deltas.) Consequently, there should be a negative relation between Delta and Share O/S. For dollar O/S, though, the effect can be ambiguous because lower Delta options have lower prices, ceteris paribus.

To see this, suppose that we have two firms, L and H, with low Delta and high Delta, respectively, and let the stock prices and shares traded be the same. If N_L and N_H are the option contracts traded concurrently, we would anticipate that $N_L > N_H$. However, the dollar value of options traded would be $P_L N_L$ and $P_H N_H$ where P denotes the option price. So, even though $N_L > N_H$, it is possible that $P_L N_L < P_H N_H$ provided that $P_L < P_H$ and the price difference is large enough. In general, one would expect $P_L < P_H$ for low and high Delta options, respectively; so the dollar O/S should be algebraically larger than the share O/S and the signs could even be reversed.

There also are reasons to believe that explanatory variables outside of the options market may be related to O/S. For example, when more analysts follow a firm, there is, presumably, less potential to uncover private information (Easley, O'Hara, and Paperman, 1998). This suggests that more analysts should be associated with less informed trading in options. On the other hand, agents with ill-founded but strong beliefs might be more tempted to trade in the options of stocks that are more widely followed. In addition, if analysts disseminate valuable private information to favored institutional clients (Green, 2006) then these clients may be tempted to exploit this information in the options market. These arguments indicate that the overall impact of analysts on O/S is ambiguous, and becomes an unresolved empirical issue that

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[4] While, in general, volume and volatility may be jointly determined, note that we use option implied volatility as the explanatory variable for O/S. This measure represents anticipated future volatility which is less likely to be jointly determined with current trading activity.

we address. We use the number of I/B/E/S analysts making one-year forecasts on the firm as of December of each year as a proxy for analyst coverage.

Another potential explanatory variable is the divergence of analysts' opinions. A larger dispersion of analysts' forecasts (measured by the standard deviation across their one-year ahead earnings forecasts) implies more disagreement about the firm, which could lead to more options trading by either informed or convinced agents. So, one might anticipate a positive association with O/S. Note that computation of the dispersion variable requires coverage by at least two analysts. The dispersion variable is computed each month and scaled by the previous month's price.

Larger holdings by institutional investors could reduce or increase options trading. Institutions are attracted to larger and better-known firms and institutions often employ their own buy-side analysts, thereby increasing the potential for uncovering information. Consequently, one might anticipate a positive relation between the proportion of a firm held by institutions and O/S. However, lower institutional holdings suggest greater individual holdings, and because individuals may trade more often than professionals in the mistaken belief that they have information, this may lead to an inverse relation between institutional holdings and O/S. The institutional holdings data, representing the percentage of outstanding shares held by institutions as of December of each year, are obtained from Standard and Poor's for the period 1996 to 2005, and from Thomson Financial for the years 2006 and 2007.[5]

In addition to the above explanatory variables, we also include an "Earnings Date" dummy that takes a value of 1.0 if the trading date or any of the next four trading dates has an earnings announcement for a firm. The idea is to ascertain whether in the five days before an

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[5] We had a choice between using institutional holdings data available directly from Standard and Poor's (S&P) for the period 1996 to 2005, and data extracted from the Thomson s34 database at WRDS (S&P holdings data were not available to us for the last two years of our sample period). The documentation manual on the WRDS website for the Thomson holdings data, http://wrds.wharton.upenn.edu/ds/tfn/manuals/WRDS-TFN200807.pdf), indicates that these data are prone to errors. Hence we use the S&P data for all but the last two years of the sample. The results are not significantly affected if we omit the last two years from our analysis (thus keeping the data source unaltered), indicating that the switch in the data source is not critical to the analysis.

earnings announcement (including the announcement day) there is additional informed option trading volume.[6] If this is the case, this variable should be positively associated with O/S.

Table 4 presents summary statistics for the explanatory variables. A daily cross-sectional mean is computed for each trading day and then various statistics are computed from the daily means across all 2948 trading days in the sample. From the table we can see that the average firm size is close to $18 billion, the average option relative spread is 0.21%, average institutional holdings are 64.2%, and on average 7.9% of the firms have an earnings date dummy on any particular day.

Except for the earnings date dummy, the daily means are quite well-behaved; e.g., the means and medians are close and there is little evidence of skewness or excess kurtosis. All variables are always positive, of course. The maximums and minimums refer to the extremes of the daily means across all sample days.

Table 5 reports the correlations of the explanatory and dependent variables. For each of the 2948 trading days, correlations are computed across firms among all dependent and explanatory variables, and the daily correlations are then averaged across all trading days. Some of the correlations between the explanatory variables are fairly high such as the one between ln(Size) and number of Analysts (0.71).

Correlations between the explanatory variables and the dependent variables are modest, perhaps with the exceptions of the correlations between Ln($O/S) and option spread (-0.30) and between Ln($O/S) and implied volatility (0.33). Correlations between the earnings date dummy and every other variables are uniformly small (less than 0.03 in absolute value). The correlation between the two O/S constructs is high (0.92).

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[6] Bernard and Thomas show (1989) that there are price reactions to earnings releases in advance of the announcements, suggesting that some agents trade on privileged information about earnings prior to the announcements. Also Beaver (1968) and, more recently, Landsman and Maydew (2002) show that stock trading volume is higher prior to earnings announcements. We examine whether the *ratio* of options to stock trading activity increases before earnings news, on the premise that such an increase would be anticipated if informed agents prefer options markets and trade intensively in such markets just prior to the release of the news.

IV. Regression Results

This section examines determinants of O/S. Since we are mainly interested in the cross-sectional effects of the explanatory variables on O/S, we run daily cross-sectional regressions and then test the significance of the time series means of the cross sectional coefficients (as in Fama and MacBeth, 1973). To control for any possible industry effects, we use the 48 Fama and French (1997) industry categorizations. Specifically, we include 47 industry dummies, with financial firms (SIC codes 6200-6299 and 6700-6799) forming our base case. Since the residuals of the cross-sectional regressions may be serially correlated (as pointed out in the previous section), the time series t-statistics are corrected according to the Newey and West (1987) procedure using two lags.

In the tests that follow, we use four different definitions of O/S, two of them based on the dollar volume ratios and the other two based on the share volume ratios. In addition to using all the option contracts available every day, we also consider an alternative O/S measure that only includes the out-of-the-money contracts. The out-of-the-money version of O/S is studied separately because traders who believe themselves in possession of valid information would prefer to trade them since they are cheaper and represent a higher implicit degree of leverage.

The first panel of Table 6 contains correlations among the various definitions of (logged) O/S. Correlations are first computed during each daily cross-section over firms, then the daily correlations are averaged across all sample days. O/S is either in dollars, \$O/S, or in shares, ShO/S. "All" includes all options and OOM includes only out-of-the-money options. The various definitions of O/S are highly correlated, with the correlations between the two versions of O/S within each sample (i.e., the full sample and the OOM sample) being around 0.92 and all the other correlations being above 0.77. The second panel of Table 6 reports the average number of concurrent firms observations used in computing the correlations. The average number of concurrent firm observations is 1065 for definitions that use all options and 974 for OOM definitions, implying that there are some firm-days that do not have any out-of-the-money options.

The basic results are presented in Table 7. For each trading day in the sample, a cross-sectional regression with log O/S as dependent variable is computed using the eight explanatory variables and the 47 industry dummies. The table reports the time series statistics for the cross-sectional t-statistics of the explanatory variables (for brevity, we do not report the corresponding statistics for the industry dummies). Panels A-1 and A-2 report results for dollar volume ratios while Panels B-1 and B-2 report results for share volume ratios. Panels A-1 and B-1 include all available options. Panels A-2 and B-2 include only options on each day that are out-of-the-money for each firm. There were 2948 trading days in the 1996-2007 sample but a few cross-sections are dropped because the Earnings Date dummy is entirely zero for all firms or there is a singularity between the Earnings Date dummy and one or more of the industry dummies. The number of days on which this occurred was smaller for the out of the money sample, which consists of a fewer number of firms per day, so that there is less likelihood of this linear dependence between two variables in the cross-section.

We find that the size variable is positive and strongly significant in the four panels. Thus, larger, more visible firms have higher O/S. The option spread is strongly negative; in all cases, the mean t-statistics are large. For the dollar O/S, 100% of the daily t-statistics are negative and for the share O/S over 98% are negative. This implies that the liquidity of the option market is associated with greater trading, whether the agents are informed or they think they are informed.

The results also indicate that the implied volatility variable is strongly positive in all cases (and over 99% of the time.) More volatile stocks attract more options trading. Notice that the mean t-statistics are larger for dollar O/S than for share O/S; this might be attributed to close connection between implied volatility and option prices.

The option Delta is strongly negative in the share O/S regressions; this is the result we anticipated above. That is, lower deltas imply higher hedge ratios, and hence are associated with higher O/S. Also as anticipated, the impact of option delta on dollar O/S is algebraically larger and even turns positive in Panel A-1 when all options are included. For out-of-the-money options, (Panel A-2), delta is negative on average but is not very significant.

The number of analysts and the dispersion of analysts' forecasts have relatively small t-statistics on average over the time series of cross sections. This might be explained by the coarseness of these variables, which change in value only once a year. However, the Newey-West t-statistics for the mean do indicate some power from Analysts for dollar O/S and from Analysts' Dispersion for share O/S, the latter being negative. Neither of these results accords with intuition. One might have thought that more analysts would lessen the incentive to produce private information (but perhaps naïve traders are swayed by analyst opinions that may frequently be uninformative). Analysts' dispersion seems intuitively associated with divergence of opinion, which should be associated with more options trading rather than less. However, it may be that dispersion affects both stock and option volume, so that the net effect on O/S is ambiguous.

The institutional holdings variable is strongly negatively associated with O/S. The mean t-statistics are large and in all cases are overwhelmingly negative. This result accords with the view that a lower level of holdings by sophisticated institutions implies a higher level of unsophisticated individual investors, and hence more options trading on mistaken beliefs that one possesses private information.

Of special interest for our study is the Earnings Date variable. It is positive and highly significant in all cases, implying that during the five days culminating in a firm's earnings announcement there is an increase in options trading activity. Informed agents (or those who think they are informed) trade in the options markets in anticipation of the earnings announcement to profit from their views about the unanticipated earnings surprise.

From the perspective of economic significance, the coefficient of 1.0 on the earnings dummy in Panel A-1 of Table 7 may be compared with the mean O/S value of –4 within our sample. This comparison implies that the implied increase in O/S around earnings announcements is substantial (25%) relative to the mean O/S. Turning to other explanatory variables, the numbers in Tables 4 and 7 imply that a one standard deviation decrease in spreads and institutional holdings is associated with increases in the dollar version of O/S by 1.53 and

0.3, respectively. Finally, a one standard deviation increase in the size variable increases dollar O/S by 0.57. Similar calculations can be performed for the other coefficients.

The results indicate that O/S is strongly predictable by its cross-sectional determinants; the mean adjusted R-squares are over 25% for dollar O/S and over 15% for share O/S.[7] In the next sections, we shed further light on these results, by analyzing a few coefficients in detail, and performing robustness checks.

V. The Time Series of Cross-Sectional R-squares and of Interesting Coefficients Plus Robustness Checks

This section considers the time-series behavior of goodness-of-fit and some other interesting time patterns in the results, and also considers some robustness checks. The behavior of the earnings announcement dummy is discussed in a section by itself (Section VI to follow).

A. Goodness-of-Fit and Coefficient Behavior Over Time

First, Figure 2 plots the R-squares from the cross-sectional regressions using the log share O/S as dependent variable. It is evident that the R-squares are much larger in the second half of the sample period; they increase from an average of around 0.1 in the first half to around 0.3 in the second half and they stand at 0.5 around the beginning of 2005. The time-series behavior of two of the most significant coefficients in Table 7, namely those of the spread and institutional holdings, are of special interest. Coefficients of the spread (see Figure 3) become more negative over the sample. Further, the coefficients of institutional holdings (Figure 4) increase from a negative level at the beginning to almost zero during the second half of the sample. It would be interesting to study these phenomena in more depth in an effort to uncover an explanation.

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[7] To analyze the impact of outliers, we considered a version of the regressions in Table 7 with the most significant variables, namely, size, options spread, implied volatility, and institutional holdings trimmed at the 0.5^{th} and 99.5^{th} percentiles. The results are robust to the trimming, and are available from the authors.

B. Endogeneity of Spreads and Trading Activity

The basic results from the time series of cross-sectional regressions reported above in Table 7 are possibly subject to several issues of interpretation, particularly with regard to a few of the explanatory variables. In particular, what we have surmised is a measure of trading costs, the options percentage spread, might be subject to an endogeneity bias. In many past studies starting with Benston and Hagerman (1974), spreads have been the dependent variable in models that contains the volume of trading as an independent variable. Presumably, higher volume leads to lower spreads on average; of course there is also reverse causality since lower spreads encourage more trading.

In our case, the suspicion of endogeneity for spreads seems intuitively less because the dependent variable in the cross-sectional regression each day is the (log of) the ratio of trading volume in options relative to stock, not the absolute level of options trading. Nonetheless, it seems worthwhile to investigate whether endogeneity might be a cause for concern.

To address this issue, we perform two additional complete estimations with alternative specifications. Since Table 5 shows that the spread is not very correlated with other explanatory variables, a straightforward approach is to simply delete it and look at the impact on the remaining explanatory variables. We do not report these results for brevity, but none of the coefficients on the other explanatory variables are materially affected in the absence of the spread variable, though size actually becomes a bit stronger and the earnings announcement dummy slightly weaker. Implied volatility and institutional holdings are virtually unchanged and remain highly significant and Delta displays the same pattern as before. Analysts and Analysts' dispersion are also similar; they are not very significant. The one difference is that the explanatory power (R-square) declines to some extent, between two and four percentage points on average. This is not a surprise, of course, because spreads were significant in the previous specification.

In an effort to preserve the explanatory power of trading costs while correcting for potential endogeneity, we next resort to an instrumental variable approach for spreads. There are few obvious good instruments and we follow common practice in simply using a one-day lagged value; this has the virtue of being unrelated cross-sectionally to the regression disturbances on the next trading day.

Table 8 presents results with the instrumented version of the options spread. Thus, the specification is the same as in Table 7 with the exception that the one-day lagged percentage spread is used as an instrument for the same variable the next day. (This changes the sample size slightly because the first day of each stock's history must be dropped and there are other missing data on occasion.)

The instrumented spread variable is also strongly significant, which indicates that endogeneity is not the complete explanation of its power. However, it is weakened relative to the non-instrumented version in Table 7, so there might be some reason to suspect a degree of feedback from O/S to spreads.

As for the other variables, most are similar. Size weakens slightly but the earnings announcement dummy actually strengthens (relative to Table 7). Including instrumented spreads does not, however, bring back the same explanatory power as in Table 7. The R-squares are somewhat smaller on average.

Another issue concerns whether traders are inhibited from options trading by options spreads alone or instead by option trading costs relative to stock trading costs. To investigate this issue, we replace the percentage spreads in options alone with the ratio of percentage spreads in options versus stock, where the stock percentage spread is obtained from CRSP. We use the log ratio, options/stock, as the new spread variable. In addition, we add a dummy variable for NASDAQ stocks simply to ascertain whether the different protocols on NASDAQ versus the NYSE and AMEX affect the average level of O/S after accounting for the relative spreads. While these results are not reported for brevity, we find that the relative options/stock percentage spread, is negative and strongly significant. However, it is less significant than the options spread alone. This supports the notion that an informed trader, attracted by the leverage afforded by options, is encouraged more by low costs in the options market alone, as opposed to lower costs in options versus stock. The NASDAQ dummy is weak. Its average t-statistic in the cross-section never exceeds 0.3 for any definition of O/S and it reverses sign from all options to out-of-the-money options for the dollar version of O/S.

VI. Time Series Behavior of the Earnings Announcement Date Dummy

The previous sections report that the earnings announcement date dummies are positive and strongly significant. This implies that in the five-day period ending on an earnings announcement date there is a significant increase in O/S. Since the earnings announcement dummy is the key to providing clues on privately informed trading, in this section we investigate the time series properties of the earnings date coefficient for possible trends or seasonality.

Using the series of 2879 cross-sectional regressions summarized in Panel B-1 of Table 7, (Share O/S, All options),[8] the earnings announcement dummy coefficient variable is fit to a linear time trend and monthly seasonal dummies and the results are given in Table 9. The time trend increases by one unit per calendar year, so its coefficient gives the annual estimated increase in the impact of an earnings announcement (including the four days preceding the announcement) on share O/S. The left panel reports a simple OLS fit and the right panel reports a fit after adjusting for autocorrelation in the residuals using a Cochrane and Orcutt (1949) transformation that is described in the Appendix.

The table shows that there is a positive trend of over 3% per year in the coefficient of the earnings announcement dummy. This implies that the option trading activity (relative to the underlying stock trading activity) prior to earnings announcements has been increasing substantially over the 1996-2007 sample period. If such a trend reveals increased informed trading before earnings releases, the result has regulatory policy implications; insiders may have become increasingly active within options markets during later sample years.[9] Alternatively, the

[8] The other time series of cross-sections from Table 7 give similar results.

[9] Arnold, Erwin, Nail, and Bos (2000) present evidence that insiders have become increasingly more active in options markets around merger announcements in recent years. Launois and van Oppens (2003) find in the European context that informed traders prefer to trade in options markets rather than those for individual stocks

trend might reveal nothing more than growing differences of opinion among convinced traders who are aware of an upcoming earnings announcement date but really do not have any firm information about its content. We will shed more light on these alternative possibilities in the next section.

The table also shows that the seasonal dummies for March, June, September and December have the largest positive coefficients and t-statistics. This is consistent with the quarterly earnings announcement calendar typical of U.S. firms, the months mentioned above being the most popular. Figure 5 plots the coefficient of the earnings announcement dummy over the sample period 1996-2007. The figure shows the high time series variability of this coefficient and the clear trend over the period.

VII. Cumulative Abnormal Returns Around Earnings Announcements and O/S

This section assesses whether the increase in O/S just before earnings announcements is due to increased trading in options by informed agents attempting to exploit their knowledge of the upcoming unanticipated earnings surprise. Cumulative abnormal returns (CARs) are computed for all sample firms just before and just after every earnings announcement. The CARs are estimated using a market model over a period ending 30 days prior to the announcement, and the CRSP equally-weighted index is used as the market proxy. The estimation period varied between 255 days and three days (depending on the number of observations available for each stock-announcement pair).

If the pre-announcement O/S is due to informed trading, it should predict the post-announcement CAR. Moreover, the relation between O/S and the post-announcement CAR could depend on the size of the pre-announcement CAR. Profit-taking by informed traders before the announcement could induce larger (absolute) pre-CARs and imply less informative

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around corporate announcements. Cleeton (1987) discusses various options strategies that would make insider trading in options trading difficult to detect from a regulatory standpoint.

(more noisy) post-CARs. This suggests that the relation between post-CARs and O/S could be attenuated when pre-CARs are large.

Since earnings surprises can be either disappointing or exhilarating and signed options volume is unavailable over our sample period, we examine absolute pre- and post- CARs in 48,243 earnings announcements by all firms from 1996 through 2007. In Table 10, the first regression relates the absolute value of the CAR on days zero through +2 relative to the announcement day, zero, (the post-CAR), to the O/S averaged over the pre-announcement window (days -3 to -1) and this same variable interacted with the absolute value of CAR during days -3 to -1, (the Pre-CAR.) T-statistics are in parentheses below the coefficients.

O/S in the pre-announcement period is positive and strongly significant by itself. This indicates that more options trading relative to stock trading prior to an earnings announcement is, *ceteris paribus*, associated with a bigger absolute price movement after the announcement. The interaction coefficient of O/S with the pre-earnings CAR is negative and significant, thereby indicating that the relation between pre-announcement O/S and post-announcement CARs tends to be attenuated when the pre-announcement absolute CAR is high. This is consistent with the notion that informed investors capture some trading gains and move prices toward their full information values prior to the announcement, thus rendering post-CARs less sensitive to pre-O/S.

The above absolute return regressions do not reveal whether options investors are trading in the right direction. To address this issue, we run bivariate regressions of signed post-CARs on O/S for two separate cases, one for positive post-CAR and one for negative post-CAR. The coefficient of O/S is negative and significant (t-statistic = −4.57) when the post-CAR is negative, and positive and significant (t-statistic = +2.48) when the post-CAR is positive. Thus high O/S prior to a positive announcement implies a bigger positive post-CAR, and high O/S prior to a negative announcement implies a larger negative post-CAR. This suggests that informed options traders are acting in the right direction, i.e., trading actively prior to either large negative or large positive earnings surprises. The coefficient is bigger in absolute terms prior to negative announcements. This suggests that options investors are particularly active (relative to stock investors) prior to negative announcements, which is what one would expect if options investors trade in part to avoid short-selling constraints in the stock market. Further light may be shed on these phenomena in future research, especially if a long time-series of *signed* options volume becomes available.

It seems reasonable to think that the empirical patterns in the first regression in Table 10 might be different for firms followed by numerous analysts, owned by many institutions, or that are simply small rather than large. For example, analysts may acquire information which crowds out private information gathering by outside agents (Easley, O'Hara, and Paperman, 1998). Alternatively, analysts may disseminate salient information to favored institutional clients (Green, 2006; Irvine, Lipson, and Puckett, 2007). Institutions might also acquire information on their own, though the quality of their information is open to question. Large and small firms too might simply have more or fewer investors devoted to securing privileged information and insiders might be more reluctant to trade depending on their perceptions of being detected, which may relate to firm size.

Consequently, we add further interaction terms for analysts, institutional holdings, and firm size; each of these variables are interacted with the interactive variable given by O/S times pre-event CAR. The results appear in the second regression of Table 10. The sample size reductions are induced mainly by firms followed by no analysts on the day just before an earnings announcement along with some missing data for institutional holdings and size. First note that the signs and significance of O/S and O/S interacted with the Pre-CAR remain qualitatively unchanged relative to those in the first regression, though the significance levels decline moderately. The Analysts interaction term is negative and significant, suggesting that analyst following bolsters the impact of pre-announcement informed traders, i.e., some investors may be trading on information disseminated by analysts prior to the earnings announcement. Institutional holdings display a pattern similar to analysts, though the effect is less significant.

Firm size has a positive and very significant impact. Thus, the activities of informed traders in moving pre-announcement prices to their full information values appear to be more effective for smaller firms, but the effect is not dramatic. As an example, the interaction coefficient in the regression for absolute values of CARs is -.1780, which is moved closer to zero by .001781 for every increase in ln(Size) of one unit. From Table 4, the mean ln(Size) is 9.79, or about $17.8 billion, and the standard deviation of ln(Size) is .176. Hence an increase in firm size from the mean, $17.8 billion, to one standard deviation above the mean, $21.3 billion, would raise the interaction coefficient from -.1780 to only -.1777. Taken in total, the results in this section support the notion that at least some of the agents that trade actively in the options markets in anticipation of earnings announcements are informed.

VIII. Conclusion

Volume is an integral part of financial markets and deserves a full understanding by finance scholars. While many papers have focused on the time-series and cross-section of equity market volume, little is known about what drives volume in derivatives relative to their underlying equities. We view our paper as the first attempt to address this issue. We consider the relative trading volume in options and stock as measured by the daily ratio O/S of total listed options trading divided by concurrent stock trading. Our cross-section is comprehensive and our time series covers twelve years, corresponding to almost 3000 trading days. We find that O/S is quite variable over time and it is strongly related in the cross-section to size, trading costs, implied volatility, option delta (which is an indicator of leverage), and institutional holdings. It is also related less strongly to the number of analysts following a stock (an inverse measure of the potential for private information) and analysts' forecast dispersion (a measure of disagreement.)

O/S rises sharply in the period culminating in an earnings announcement, thereby revealing the some traders believe they possess relevant information about the upcoming event. They appear to affect prices, in that high O/S in conjunction with high CARs before earnings announcements imply smaller CARs following the announcements. Moreover, at least some options traders seem to be successfully predicting the direction of the earnings surprise. There also is evidence that O/S before earnings announcements has generally increased over the 1996-2007 period. Such increased trading may reflect more successful trading on information in recent years.

Our central results are robust across a variety of specifications and are not due to potential endogeneity between options spreads and trading activity. Our work suggests many areas of further research. First, given that trading activity predicts returns (Brennan, Chordia, and Subrahmanyam, 1998), it remains to be seen if O/S is a better predictor of returns than stock volume itself, given that agents care about liquidity in equities as well as their underlying derivatives. Second, the O/S concept could be extended to index options, and the time-series relation between index returns and the index O/S would be interesting to examine. Finally, O/S could be examined around specific corporate announcements such as mergers, repurchases, or equity offerings to obtain further evidence on informed trading in the options market. These and other issues are left for future research.

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Appendix: Application of the Cochrane-Orcutt Estimator in Table 9

This appendix discusses the analysis in Table 9 involving the time-series of the coefficient for the earnings announcement dummy in daily cross-sectional regressions explaining O/S. The Cochrane/Orcutt method is used to correct for autocorrelation in the residuals. Details are as follows.

In the standard model,

$$Y_t = a_0 + a_1 X_{1t} + a_2 X_{2t} + a_3 X_{3t} + ... + a_k X_{kt} + \varepsilon_t, \tag{1}$$

first-order residual autocorrelation, ρ, can be estimated by regressing ε_t on ε_{t-1},

$$\varepsilon_t = \rho\varepsilon_{t-1} + u_t \tag{2}$$

where u_t is approximately white noise when there is no second- or higher-order autocorrelation.

Multiplying both sides of (1) for t-1 by the estimated ρ,

$$\rho Y_{t-1} = \rho(a_0 + a_1 X_{1,t-1} + a_2 X_{2,t-1} + ... + a_k X_{k,t-1} + \varepsilon_{t-1}) \tag{3}$$

and subtracting (3) from (1) and substituting from (2) results in

$$Y_t - \rho Y_{t-1} = (1-\rho)\, b_0 + b_1(X_{1t} - \rho X_{1,t-1}) + \dots + u_t \tag{4}$$

Note that the error term in (4) is less serially correlated. Thus, transforming each variable as follows

$$Y_t^* = Y_t - \rho Y_{t-1}$$

$$X_{it}^* = X_{it} - \rho X_{i,t-1},\ i=1,\dots,k$$

and running OLS with the transformed variables,

$$Y_t^* = a_0(1-\rho) + a_1 X_{1t}^* + a_2 X_{2t}^* + \dots a_k X_{k,t-1}^* + u_t, \tag{5}$$

reduces the autocorrelation problem (for first-order autocorrelation in the original equation.)

Using the coefficients from (5), the residual autocorrelation can then be re-estimated. These steps can be repeated until ρ converges to a fixed value. In our case, the first iteration of Cochrane/Orcutt reduced the residual serial correlation from 0.346 to –0.029, so no further iterations were required. Table 10 reports coefficients from regressions involving both the untransformed and transformed versions of the variables [i.e., Equations (1) and (5)] for completeness.

Table 1
Summary Statistics for Options Volume by Calendar Year

Using dollar options volume in hundreds aggregated over all options for a given firm (Panel A) and aggregated options contract volume (Panel B) in hundreds of shares of the underlying stock, a mean over all firms for each calendar day during a year is calculated first, then a grand mean over all days in the year is computed along with various statistics for the daily means. "Sigma" is the standard deviation across time in the daily means. "Firms" is the number of firms with options volume averaged across days within the year.

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Firms	752	858	916	1140	1130	1050	1050	1050	1120	1170	1270	1290
Panel A. Annual Summary Statistics for Daily Cross-Sectional Average Dollar Options Volume												
Mean	1670	2460	2460	4550	7380	4460	2530	2380	3060	3610	4970	7520
Median	1660	2410	2310	3990	6760	3870	2510	2360	2980	3460	4830	6730
Sigma	486	660	697	1710	3190	1960	611	566	669	869	1110	4240
Panel B. Annual Summary Statistics for Daily Cross-Sectional Average Contract Options Volume												
Mean	555	675	674	796	1110	1200	1050	1210	1570	1770	2170	2530
Median	556	673	671	760	1090	1180	1040	1220	1570	1720	2190	2430
Sigma	126	122	111	162	202	281	200	231	283	325	390	535

Table 2

Time Series Summary Statistics for Options/Stock Volume Ratios

For each firm in the sample with at least fifty time series observations, (3,114 firms), summary statistics were computed over the firm's time series observations of the log options/stock trading volume ratio, O/S. Then, cross-sectional statistics were computed using the time series statistics. "Mean" is the sample mean. "Sigma" is the standard deviation. The fraction greater than zero is given by "%>0." "N" is the time series sample size in trading days. Panels A report dollar volume ratios while Panels B report share volume ratios. Panels A-1 and B-1 include all available options. Panels A-2 and B-2 include only out-of-the-money options.

Cross-Sectional Statistic for Time Series Statistic ↓	Mean	Median	Sigma	Skewness	Kurtosis	Maximum	Minimum	% > 0	N
Panel A-1. Dollar Options/Stock Volume Ratio, Ln($O/S), All Options									
Mean	-4.00	-3.93	1.45	-0.33	0.64	0.31	-9.36	0.59	1053
Median	-3.96	-3.87	1.48	-0.31	0.39	0.26	-9.41	0.12	782
Sigma	0.96	0.98	0.27	0.33	1.17	1.10	1.51	1.99	872
Skewness	-0.11	-0.14	-0.32	-0.47	6.68	0.47	0.24	12.45	0.88
Kurtosis	0.03	-0.02	0.73	2.69	103.	2.66	0.15	224.73	-0.41
Maximum	-0.02	-0.01	2.64	1.66	26.8	10.08	-2.09	49.61	3013
Minimum	-8.19	-8.14	0.42	-2.2	-1.08	-4.8	-14.57	0	50
% > 0	0	0	100	12.78	77.1	60.63	0	60.63	100
Panel A-2. Dollar Options/Stock Volume Ratio, Ln($O/S), Out-of-the-Money Options									
Mean	-4.80	-4.74	1.47	-0.25	0.43	-0.45	-10.00	0.19	1053
Median	-4.77	-4.70	1.48	-0.22	0.25	-0.52	-10.04	0.00	782
Sigma	0.94	0.96	0.24	0.31	0.95	1.00	1.48	1.17	872
Skewness	-0.05	-0.07	-0.37	-0.71	9.76	0.63	0.16	26.71	0.88
Kurtosis	-0.02	-0.07	1.14	3.27	223.	4.04	0.03	971.62	-0.41
Maximum	-0.08	-0.04	2.57	1.69	27.6	9.27	-2.62	48.3	3013
Minimum	-8.25	-8.19	0.47	-2.09	-1.09	-4.8	-15.04	0	50
% > 0	0	0	100	18.66	72.9	28.97	0	28.97	100

Table 2 (Continued)

Cross-Sectional Statistic for Time Series Statistic ↓	Mean	Median	Sigma	Skewness	Kurtosis	Maximum	Minimum	% > 0	N
Panel B-1. Share Options/Stock Volume Ratio, Ln(ShO/S), All Options									
Mean	-1.30	-1.25	1.30	-0.26	0.41	2.53	-5.80	19.94	1053
Median	-1.33	-1.28	1.32	-0.23	0.24	2.50	-5.90	14.81	782
Sigma	0.77	0.80	0.22	0.34	0.99	0.94	1.09	16.62	872
Skewness	0.18	0.16	-0.27	-0.71	13.31	0.58	0.47	1.61	0.88
Kurtosis	0.01	-0.03	1.28	3.51	387.46	4.22	1.03	2.89	-0.41
Maximum	1.37	1.36	2.38	2.01	32.96	12.2	-0.36	99.27	3013
Minimum	-4.1	-3.98	0.35	-2.27	-1.03	-1.16	-9.97	0	50
% > 0	5.39	6.42	100	18.91	71.84	99.68	0	99.68	100
Panel B-2. Share Options/Stock Volume Ratio, Ln(ShO/S), Out-of-the-Money Options									
Mean	-1.74	-1.69	1.37	-0.21	0.29	2.31	-6.26	13.17	1053
Median	-1.77	-1.71	1.39	-0.18	0.14	2.30	-6.34	9.09	782
Sigma	0.77	0.80	0.21	0.33	0.91	0.92	1.07	12.55	872
Skewness	0.23	0.21	-0.36	-0.83	11.92	0.51	0.36	2.2	0.88
Kurtosis	0.02	-0.03	1.62	4.11	308.66	4.06	1.08	6.48	-0.41
Maximum	0.99	0.99	2.38	2	28.34	11.65	-0.64	95.32	3013
Minimum	-4.13	-4.09	0.39	-2.44	-1.01	-1.16	-10.66	0	50
% > 0	1.64	2.25	100	24.98	63.84	99.26	0	99.26	100

Table 3
Summary Statistics for Options/Stock Volume Ratio Partial Autocorrelations

For each firm in the sample with at least fifty time series observations, (3,114 firms), partial autocorrelations using five lags were computed over the firm's time series observations of the log options/stock trading volume ratio, O/S. Then, cross-sectional statistics were computed using the partial autocorrelations. "Mean" is the cross-sectional sample mean. "Sigma" is the standard deviation. The fraction greater than zero is given by "%>0." Panels A report dollar volume ratios while Panels B report share volume ratios. Panels A-1 and B-1 include all available options. Panels A-2 and B-2 include only out-of-the-money options.

	Lag (Trading Days)				
	1	2	3	4	5
Panel A-1. Dollar Options/Stock Volume Ratio, Ln($O/S), All Options					
Mean	0.1944	0.1101	0.0867	0.0727	0.0754
Median	0.2005	0.1175	0.0926	0.0794	0.082
Sigma	0.0698	0.0664	0.0636	0.0625	0.0629
% > 0	98.8	94.4	92.0	89.3	89.8
Panel A-2. Dollar Options/Stock Volume Ratio, Ln($O/S), Out-of-the-Money Options					
Mean	0.1882	0.1062	0.0826	0.0695	0.0716
Median	0.192	0.1127	0.0875	0.076	0.0775
Sigma	0.069	0.064	0.0646	0.063	0.0626
% > 0	98.8	94.5	91.3	89.1	89.7
Panel B-1. Share Options/Stock Volume Ratio, Ln(ShO/S), All Options					
Mean	0.1993	0.111	0.0866	0.0732	0.0763
Median	0.2065	0.1188	0.0924	0.0802	0.0824
Sigma	0.0717	0.0665	0.0654	0.0649	0.0639
% > 0	98.8	94.2	91.9	89.0	89.9
Panel B-2. Share Options/Stock Volume Ratio, Ln(ShO/S), Out-of-the-Money Options					
Mean	0.1859	0.1044	0.0818	0.0695	0.0715
Median	0.1911	0.1108	0.0878	0.0764	0.0766
Sigma	0.0709	0.0652	0.0656	0.0646	0.0645
% > 0	98.6	94.1	91.3	88.7	88.9

Table 4
Summary Statistics for Explanatory Variables

For each of nine variables used later to explain the options/stock volume ratios, a daily cross-sectional mean is computed for each trading day and then various statistics are computed from the daily means across all 2948 trading days in the sample, 1996-2007 inclusive. "Size" is the firm's size in $millions. "% Spread" is 100(Ask-Bid)/[(Ask+Bid)/2]. "Implied volatility" and "Delta" pertain to the options traded (with put deltas being reversed in sign.) "Analysts" is the number of analysts for a firm and "Analysts' Dispersion" is the standard deviation across their earnings forecasts. "Institutional Holdings" is the fraction of the firm's shares held by institutions (in percent.) "Earnings Date" is a dummy variable that is 1.0 if the trading date or any of the next four trading dates has an earnings announcement for a firm; (so about 7.9% of firms on average satisfy this condition on a given trading day.) "Sigma" is the standard deviation in daily means. NWT-Stat is the Newey-West corrected t-statistic for the mean using two lags. "MAD" is the mean absolute deviation. The fraction greater than zero over all sample days is given by "%>0."

	ln(Size)	% Spread	Implied Volatility	Delta	Analysts	Analysts' Dispersion	Institutional Holdings	Earnings Date
Mean	9.79	0.210%	0.499	0.480	10.9	0.505%	64.2%	0.079
Median	9.78	0.210%	0.455	0.480	10.9	0.491%	62.3%	0.038
Sigma	0.176	0.022%	0.124	0.019	0.595	0.129%	9.4%	0.087
NWT-Stat	1360	244	98	652	450	97	166	22
MAD	0.152	0.017%	0.104	0.016	0.505	0.099%	8.4%	0.068
Skewness	0.084	0.366	0.845	0.045	-0.260	0.773	0.357	1.510
Kurtosis	-1.150	1.410	-0.242	-0.289	0.887	1.260	-1.480	1.250
Maximum	10.20	0.353%	0.910	0.541	12.3	1.020%	80.1%	0.394
Minimum	9.35	0.142%	0.328	0.426	9.5	0.221%	52.7%	0
% > 0	100	100	100	100	100	100	100	99.4

Table 5

Average Correlations of Explanatory and Dependent Variables

For each of 2948 trading day cross-sections from 1996 through 2007 inclusive, correlations are computed among all dependent and explanatory variables. The correlations are then averaged across all trading days and reported below. "Size" is the firm's size in $millions. "% Spread" is 100(Ask-Bid)/[(Ask+Bid)/2]. "Implied volatility" and "Delta" pertain to the options traded (with put deltas being reversed in sign.) "Analysts" is the number of analysts for a firm and "Analysts' Dispersion" is the standard deviation across their earnings forecasts. "Institutional Holdings" is the fraction of the firm's shares held by institutions (in percent.) "Earnings Date" is a dummy variable that is 1.0 if the trading date or any of the next four trading dates has an earnings announcement for a firm. The two dependent variable are Ln($O/S) and Ln(ShO/S), which are the logs of the options/stock trading volume ratios in dollars and shares, respectively.

	ln(Size)	% Spread	Implied Volatility	Delta	Analysts	Analysts' Dispersion	Institutional Holdings	Earnings Date	Ln($O/S)
% Spread	-0.2672								
Implied Volatility	-0.5714	0.0376							
Delta	-0.0591	-0.4466	0.0259						
Analysts	0.7085	-0.2000	-0.3062	-0.0462					
Analysts' Dispersion	-0.2018	0.0647	0.2685	0.0061	-0.0903				
Institutional Holdings	0.1423	-0.0788	-0.2021	-0.0198	0.1496	-0.1388			
Earnings Date	-0.0103	0.0193	0.0308	-0.0032	-0.0042	0.0019	0.0080		
Ln($O/S)	-0.0211	-0.2953	0.3327	0.1641	0.0410	0.0895	-0.1407	0.0322	
Ln(ShO/S)	0.1333	-0.1728	0.1346	-0.0682	0.1198	0.0134	-0.0895	0.0414	0.915

Table 6
Average Correlations and Observations for Ln(O/S) of Various Definitions

The first panel contains correlations among the various definitions of the log options/stock trading volume ratio (O/S). Correlations are first computed during each daily cross-section across firms, then the daily correlations are averaged across available days. The second panel reports the average number of firms observations used in computing the correlations. O/S is either in dollars, $O/S, or in shares, ShO/S. "All" includes all options and OOM includes only out-of-the-money options.

	$O/S All	$O/S OOM	ShO/S All
Average correlation			
$O/S OOM	0.8257		
ShO/S All	0.9150	0.8327	
ShO/S OOM	0.7717	0.9207	0.9050
Average number of concurrent firm observations			
$O/S OOM	974		
ShO/S All	1065	974	
ShO/S OOM	974	974	974

Table 7

Cross-Sectional Regressions of Options/Stock Volume Ratios on Proximate Determinants

For each trading day in the sample, a cross-sectional regression with the log of an options/stock volume ratio as dependent variable is computed using nine explanatory variables plus 47 unreported industry dummies. This table reports time series statistics for the cross-sectional t-statistics of the explanatory variables. "Size" is the firm's size in $millions. "% Spread" is 100(Ask-Bid)/[(Ask+Bid)/2]. "Implied volatility" and "Delta" pertain to the options traded (with put deltas being reversed in sign.) "Analysts" is the number of analysts for a firm and "Analysts' Dispersion" is the standard deviation across their earnings forecasts. "Institutional Holdings" is the fraction of the firm's shares held by institutions (in percent.) "Earnings Date" is a dummy variable that is 1.0 if the trading date or any of the next four trading dates has an earnings announcement for a firm. "Mean" is the time series average of the cross-sectional t-statistic. "Sigma" is the time series standard deviation. NWT-Stat is the Newey-West corrected t-statistic for the mean t-statistic using two lags. "MAD" is the mean absolute deviation. The fraction greater than zero over all sample days is given by "%>0." "R-Square" is adjusted from the cross-sectional daily regressions. There were 2948 trading days in the 1996-2007 sample but a few cross-sections are dropped because the Earnings Date dummy is entirely zero for all firms or there is a singularity between the Earnings Date dummy and one or more of the industry dummies. Panels A-1 and A-2 report dollar volume ratios while Panels B-1 and B-2 report share volume ratios. Panels A-1 and B-1 include all available options. Panels A-2 and B-2 include only out-of-the-money options.

Table 7 (Continued)

	R-square	ln(Size)	% Spread	Implied Volatility	Delta	Analysts	Analysts' Dispersion	Institutional Holdings	Earnings Date
Panel A-1. Dollar Options/Stock Volume Ratio; N: 2879									
Mean	0.271	3.25	-7.30	10.20	1.72	0.90	0.08	-3.16	1.02
Median	0.275	3.14	-6.64	9.75	2.03	1.01	0.18	-3.10	1.04
Sigma	0.050	2.17	3.21	2.82	2.85	1.38	1.23	1.90	1.12
NWT-Stat	148.0	39.0	-58.3	92.4	15.7	18.2	2.2	-43.8	31.3
MAD	0.041	1.84	2.72	2.40	2.43	1.12	0.97	1.62	0.88
Skewness	-0.209	0.145	-0.407	0.271	-0.211	-0.258	-0.392	-0.029	0.177
Kurtosis	-0.325	-0.739	-0.787	-0.825	-0.791	-0.262	0.340	-0.788	0.492
Maximum	0.418	9.27	-0.25	18.3	10.7	5.06	3.62	2.60	7.09
Minimum	0.102	-2.90	-16.9	2.76	-6.26	-3.57	-4.75	-8.16	-2.90
% > 0	100	95	0	100	69.5	74.3	56.2	3.16	82.1
Panel A-2. Dollar Options/Stock Volume Ratio, Out-of-the-Money Options; N: 2905									
Mean	0.252	1.80	-7.55	9.01	-0.70	0.67	0.16	-3.34	0.94
Median	0.255	1.73	-7.08	8.61	-0.77	0.75	0.27	-3.32	0.93
Sigma	0.051	1.78	3.07	2.81	2.49	1.42	1.23	2.02	1.14
NWT-Stat	136.0	27.7	-63.8	82.0	-7.5	13.5	4.3	-43.4	28.4
MAD	0.042	1.46	2.62	2.38	2.12	1.15	0.96	1.75	0.90
Skewness	-0.107	0.174	-0.302	0.296	-0.001	-0.155	-0.392	0.003	0.175
Kurtosis	-0.346	-0.473	-0.829	-0.757	-0.731	-0.354	0.586	-1.000	0.475
Maximum	0.424	7.39	-0.36	17.7	8.19	5.05	4.88	2.16	6.36
Minimum	0.089	-3.18	-17.9	1.41	-8.07	-4.32	-4.86	-8.73	-2.53
% > 0	100	83	0	100	42.5	68.8	58.4	3.61	80.6

Table 7 (Continued)

	R-square	ln(Size)	% Spread	Implied Volatility	Delta	Analysts	Analysts' Dispersion	Institutional Holdings	Earnings Date
Panel B-1. Share Options/Stock Volume Ratio; N: 2879									
Mean	0.166	4.71	-5.18	6.11	-4.29	0.25	-0.66	-2.59	1.42
Median	0.149	4.62	-4.35	5.95	-3.58	0.35	-0.54	-2.42	1.38
Sigma	0.065	2.08	3.41	2.42	3.12	1.38	1.25	2.01	1.23
NWT-Stat	64.4	60.1	-38.5	65.2	-35.3	5.0	-16.2	-33.7	37.6
MAD	0.056	1.73	2.90	2.02	2.67	1.11	0.99	1.72	0.96
Skewness	0.479	0.156	-0.487	0.121	-0.439	-0.297	-0.403	-0.083	0.277
Kurtosis	-0.764	-0.581	-0.776	-0.611	-0.800	-0.136	0.507	-0.839	0.581
Maximum	0.356	11.00	2.01	14.1	2.52	4.02	3.43	2.90	7.79
Minimum	0.020	-1.07	-15.6	-1.06	-13.8	-4.96	-6.59	-8.20	-2.55
% > 0	100	99.5	1.88	99.9	4.1	59.3	31	9.59	88
Panel B-2. Share Options/Stock Volume Ratio, Out-of-the-Money Options; N: 2905									
Mean	0.161	2.85	-5.29	5.29	-5.57	0.03	-0.44	-2.83	1.28
Median	0.143	2.78	-4.75	5.09	-5.41	0.11	-0.36	-2.71	1.22
Sigma	0.063	1.65	3.18	2.30	2.79	1.37	1.23	2.05	1.25
NWT-Stat	65.6	49.4	-42.7	60.1	-52.0	0.6	-11.4	-36.2	33.6
MAD	0.053	1.33	2.71	1.90	2.36	1.11	0.96	1.77	0.98
Skewness	0.571	0.209	-0.365	0.240	-0.244	-0.197	-0.398	-0.036	0.279
Kurtosis	-0.568	-0.228	-0.779	-0.492	-0.703	-0.259	0.589	-0.982	0.509
Maximum	0.379	7.97	2.00	13.8	1.65	4.03	3.96	2.50	7.06
Minimum	0.016	-1.58	-15.5	-1.38	-13.7	-4.83	-5.28	-8.23	-2.35
% > 0	100	96.8	1.45	99.8	0.31	52.9	38.1	7.85	85.5

Table 8
Cross-Sectional Regressions of Options/Stock Volume Ratios on Proximate Determinants
With an Instrumental Variable for Percentage Spread

For each trading day in the sample, a cross-sectional regression with the log of an options/stock volume ratio as dependent variable is computed using nine explanatory variables plus 47 unreported industry dummies. This table reports time series statistics for the cross-sectional t-statistics of the explanatory variables. "Size" is the firm's size in $millions. "% Spread" is 100(Ask-Bid)/[(Ask+Bid)/2]. The one-day lagged value of % Spread is used as an Instrument for this variable. "Implied volatility" and "Delta" pertain to the options traded (with put deltas being reversed in sign.) "Analysts" is the number of analysts for a firm and "Analysts' Dispersion" is the standard deviation across their earnings forecasts. "Institutional Holdings" is the fraction of the firm's shares held by institutions (in percent.) "Earnings Date" is a dummy variable that is 1.0 if the trading date or any of the next four trading dates has an earnings announcement for a firm. "Mean" is the time series average of the cross-sectional t-statistic. NWT-Stat is the Newey-West corrected t-statistic for the mean t-statistic using two lags. The fraction greater than zero over all sample days is given by "%>0." "R-Square" is adjusted from the cross-sectional daily regressions. There were 2948 trading days in the 1996-2007 sample but a few cross-sections are dropped because the Earnings Date dummy is entirely zero for all firms or there is a singularity between the Earnings Date dummy and one or more of the industry dummies. Panels A-1 and A-2 report dollar volume ratios while Panels B-1 and B-2 report share volume ratios. Panels A-1 and B-1 include all available options. Panels A-2 and B-2 include only out-of-the-money options.

Table 8 (Continued).

	R-square	ln(Size)	% Spread IV	Implied Volatility	Delta	Analysts	Analysts' Dispersion	Institutional Holdings	Earnings Date
Panel A-1. Dollar Options/Stock Volume Ratio; N: 2891									
Mean	0.209	1.13	-3.95	7.65	-1.10	0.64	0.32	-3.30	1.10
Median	0.228	1.01	-3.55	7.23	-0.93	0.74	0.43	-3.31	1.07
NWT-Stat	85.4	24.7	-46.2	74.0	-14.6	12.8	8.0	-57.5	33.6
% > 0	96.7	77.9	1.4	100.0	33.3	67.5	63.5	0.9	83.6
Panel A-2. Dollar Options/Stock Volume Ratio, Out-of-the-Money Options; N: 2902									
Mean	0.218	0.53	-3.44	7.10	-1.80	0.46	0.42	-3.27	0.98
Median	0.227	0.54	-3.10	6.78	-1.63	0.52	0.48	-3.22	0.94
NWT-Stat	109.0	16.3	-44.3	77.0	-23.7	9.3	11.4	-50.1	28.8
% > 0	98.6	65.7	2.2	100.0	21.4	62.9	65.3	1.9	80.8
Panel B-1. Share Options/Stock Volume Ratio; N: 2769									
Mean	0.080	1.77	-3.98	4.15	-4.38	0.11	-0.29	-2.93	1.51
Median	0.089	1.67	-3.61	3.90	-3.75	0.19	-0.18	-2.86	1.44
NWT-Stat	26.6	36.3	-47.1	49.0	-42.1	2.2	-6.7	-48.2	38.5
% > 0	79.6	88.3	1.1	98.6	1.1	55.4	44.3	2.7	89.5
Panel B-2. Share Options/Stock Volume Ratio, Out-of-the-Money Options; N: 2848									
Mean	0.108	0.70	-3.48	3.77	-4.72	-0.08	-0.03	-2.98	1.33
Median	0.113	0.68	-3.18	3.56	-4.22	-0.01	0.05	-2.90	1.28
NWT-Stat	43.0	20.9	-45.8	54.9	-45.8	-1.8	-0.8	-47.0	33.6
% > 0	89.9	70.5	1.6	98.6	0.7	49.6	51.6	2.8	85.6

Table 9
Earnings Announcement Trend and Seasonals

Using the regressions reported in Panel B-1 of Table 5 (All options, Share Options/Stock Volume Ratio, O/S), the coefficient of the earnings announcement dummy variable is fit to a linear time trend and monthly seasonal dummies over the 2879 sequential cross-sections. The time trend increases by one unit per calendar year, so its coefficient gives the annual estimated increase in the impact of an earnings announcement (including the four days preceding an announcement) on O/S. The left panel reports a simple OLS fit and the right panel reports a fit after adjusting for autocorrelation in the residuals using a Cochrane/Orcutt transformation.

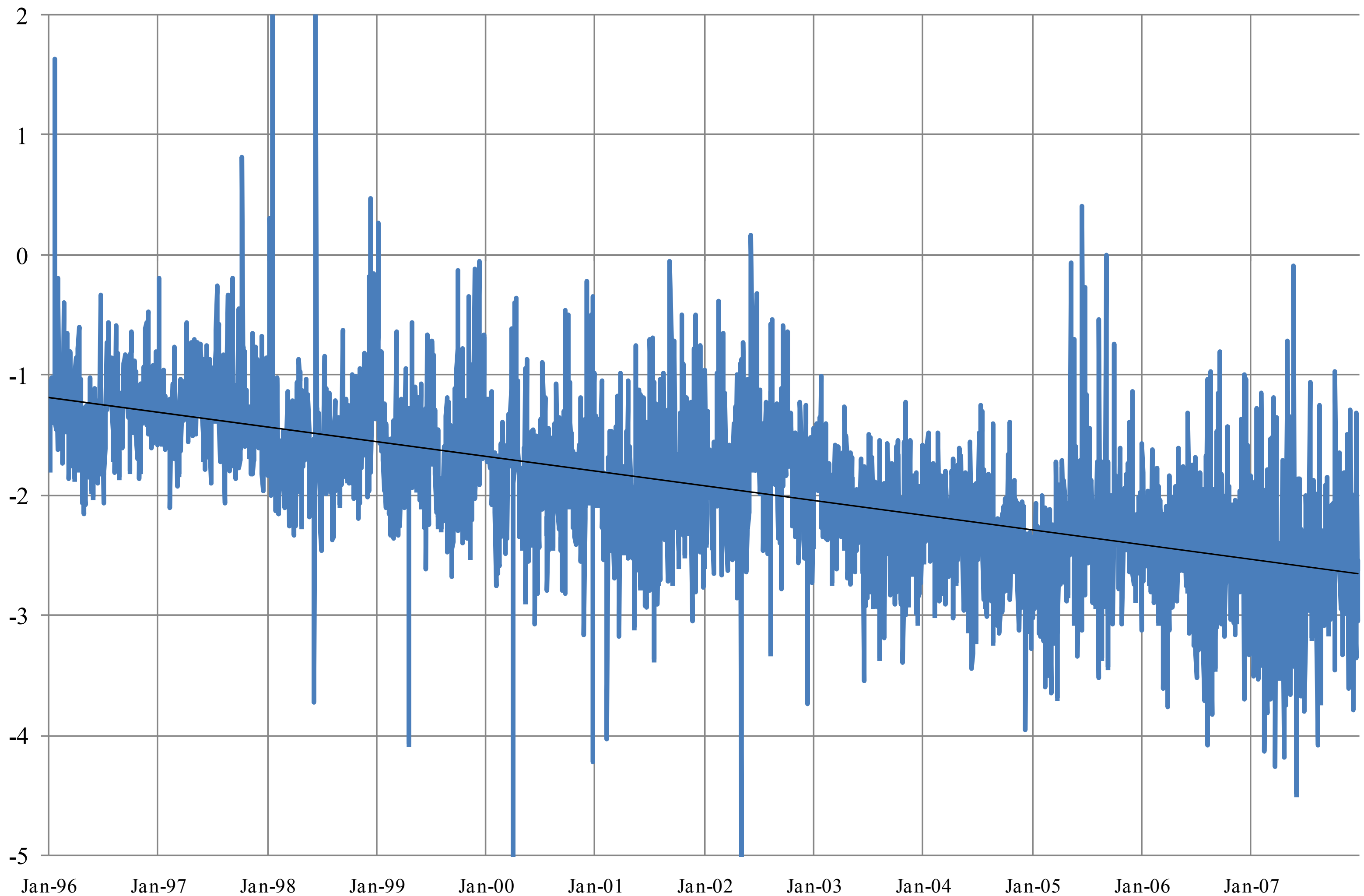
	Coefficient	T-Statistic	Coefficient	T-Statistic
	OLS		Cochrane/Orcutt	
Time	0.0313	19.75	0.0313	13.75
February	0.0427	1.534	0.0360	0.955
March	0.1314	4.862	0.1229	3.288
April	-0.0371	-1.327	-0.0384	-0.995
May	0.0982	3.622	0.0910	2.426
June	0.1385	4.882	0.1258	3.205
July	-0.0040	-0.146	0.0003	0.007
August	0.1062	3.932	0.0917	2.452
September	0.1404	5.087	0.1266	3.320
October	-0.0101	-0.376	-0.0068	-0.183
November	0.0904	3.297	0.0843	2.225
December	0.1910	6.894	0.1752	4.657
Intercept	0.0607	2.786	0.0441	2.218
Adjusted R-Square	0.162		0.0819	
Residual Autocorrelation	0.346		-0.029	

Table 10
Cumulative Abnormal Returns and Options/Stock Volume Ratios

Using all earnings announcements in the sample from 1996 through 2007 inclusive, cumulative abnormal returns (CARs) on and after the announcement are related to the share options/stock volume ratio (O/S) during a period immediately preceding the announcement, using all options. The first regression relates the absolute values of CAR on days zero through +2 relative to the announcement day (day zero), the Post-CAR, to the log of O/S averaged over days -3 to -1 and to this log average O/S interacted with the absolute values of CAR on days -3 to -1, the Pre-CAR. The second regression further interacts the latter variable with three other variables measured just prior to the earnings announcement; the number of analysts, the percentage of the firm held by institutions, and the log market capitalization (size) of the equity. T-statistics are in parentheses below the coefficients.

Dependent variable: Absolute Value of Post-CAR		
Explanatory variable	Basic regression	Augmented regression
Ln(O/S)	$2.001*10^{-3}$ (20.29)	$1.495*10^{-3}$ (13.74)
Ln(O/S)*Pre-CAR	$-4.461*10^{-2}$ (-29.99)	-0.1780 (-18.75)
Ln(O/S)*Pre-CAR* Analysts	-	$-1.110*10^{-3}$ (-4.51)
Ln(O/S)*Pre-CAR* Institutional Holdings	-	$-1.750*10^{-4}$ (-3.52)
Ln(O/S)*Pre-CAR* Ln(Size)	-	$1.781*10^{-2}$ (14.18)
Adjusted R-square	0.0188	0.0243
Sample Size	48,243	42,964

Figure 1. IBM Ln($O/S), Options/Stock Dollar Volume Ratio
All IBM Options, 1996-2007



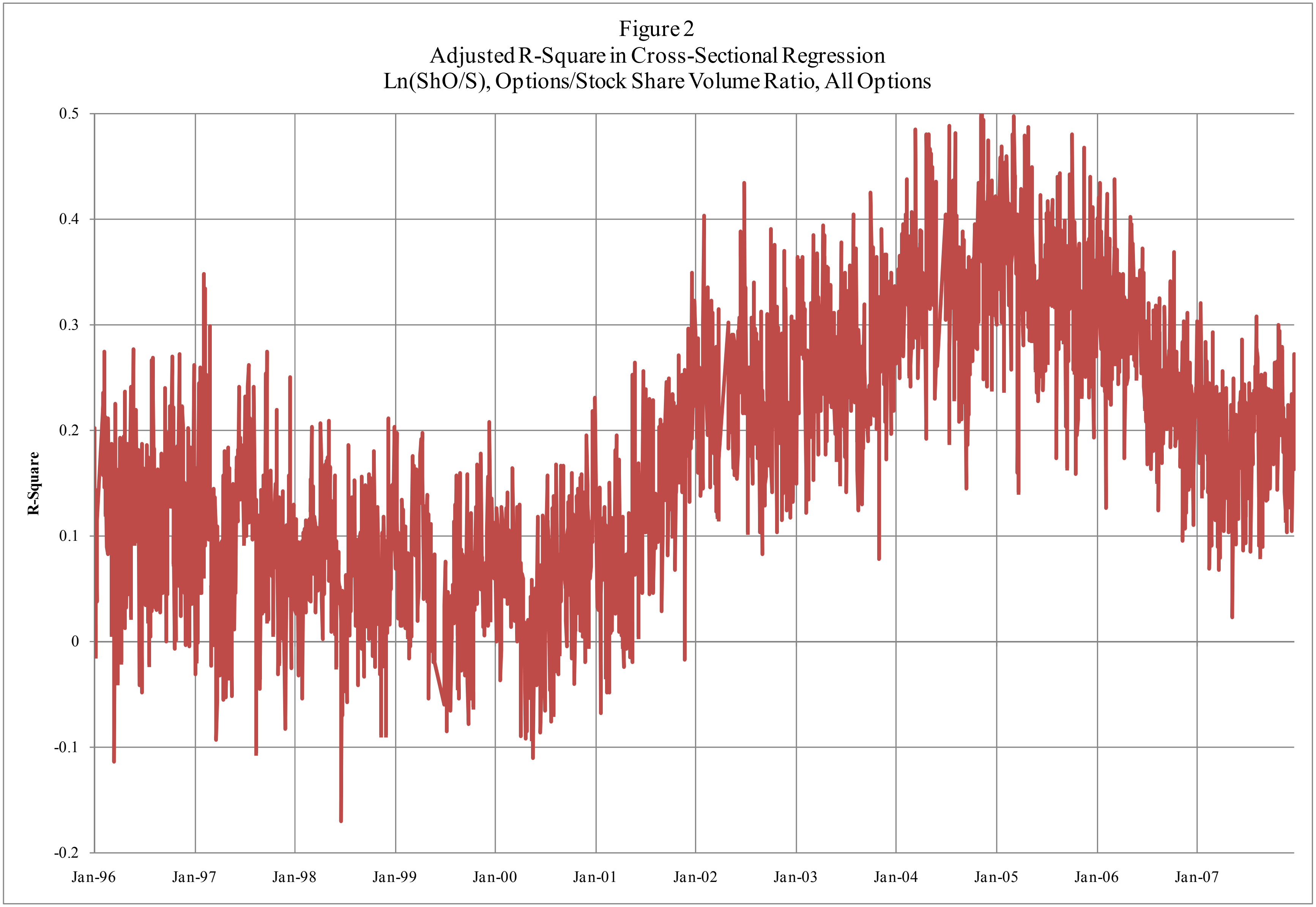


Figure 2
Adjusted R-Square in Cross-Sectional Regression
Ln(ShO/S), Options/Stock Share Volume Ratio, All Options
R-Square
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07

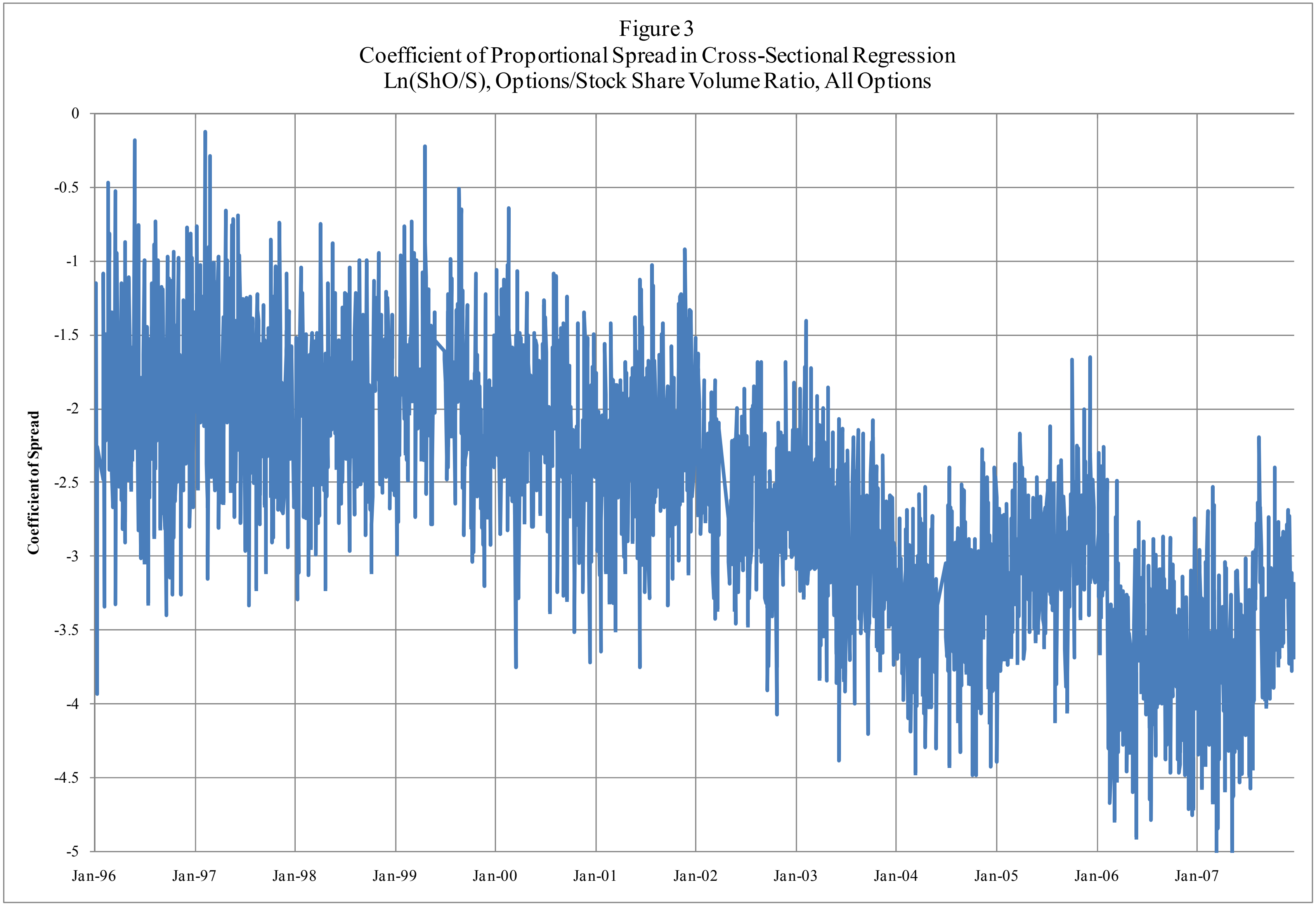
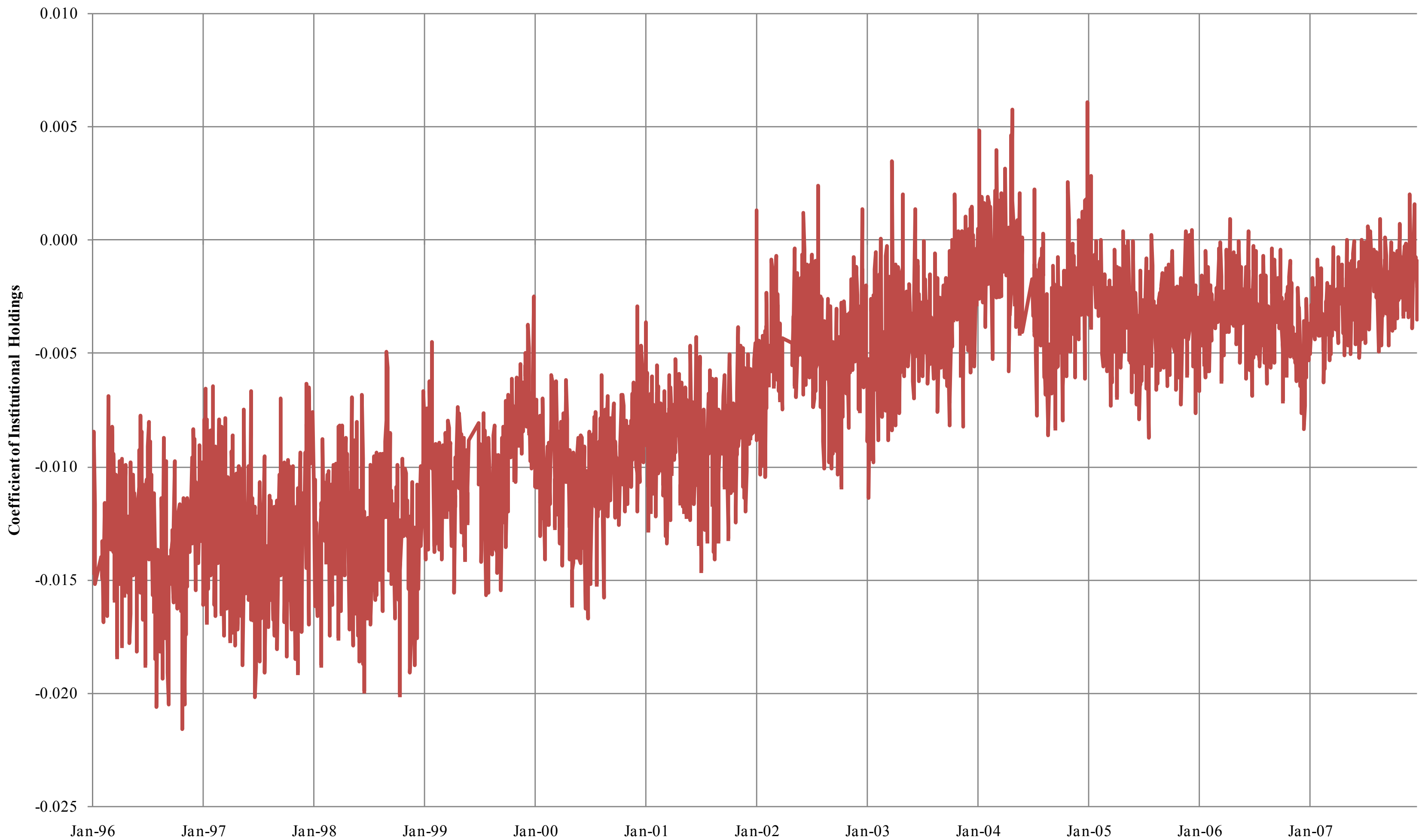


Figure 3
Coefficient of Proportional Spread in Cross-Sectional Regression
Ln(ShO/S), Options/Stock Share Volume Ratio, All Options
Coefficient of Spread
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07

Figure 4
Coefficient of Institutional Holdings in Cross-Sectional Regression
Ln(ShO/S), Options/Stock Share Volume Ratio, All Options



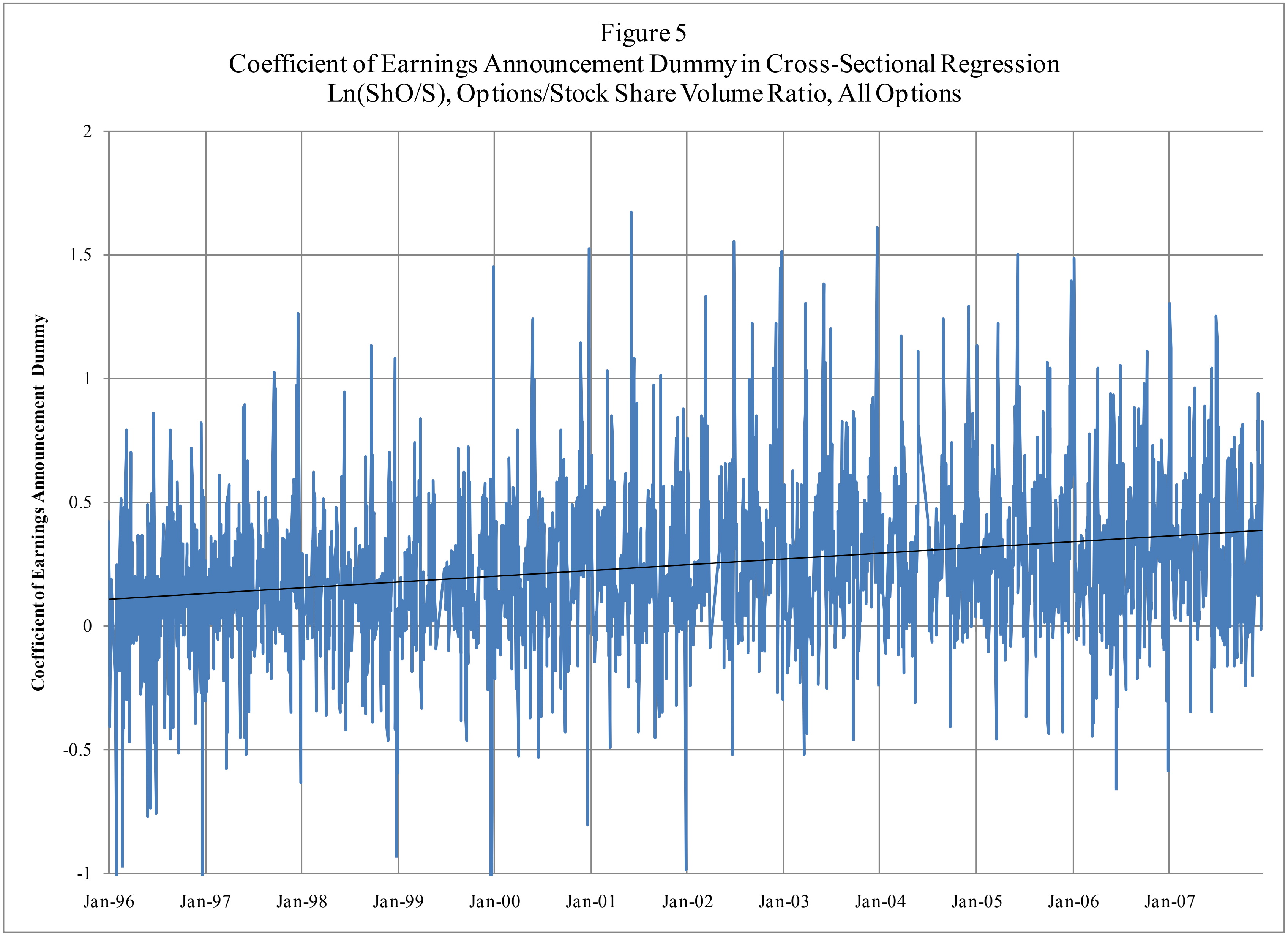


Figure 5
Coefficient of Earnings Announcement Dummy in Cross-Sectional Regression
Ln(ShO/S), Options/Stock Share Volume Ratio, All Options
Coefficient of Earnings Announcement Dummy
2
1.5
1
0.5
0
-0.5
-1
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07