Unusual Option Market Activity and the Terrorist Attacks of September 11, 2001

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ABSTRACT

After the terrorist attacks of September 11, 2001 there was a great deal of speculation that the terrorists or their associates had traded in the option market on advanced knowledge of the impending events. It is nearly impossible, however, to assess the option market trading leading up to this or any other event in the absence of systematic information about the characteristics of option market activity. This paper provides this information by computing the distributions of option market volume statistics both unconditionally and when conditioning on the overall level of option activity, the return and trading volume on the underlying stocks, and the return on the overall market. When the option market activity in the days leading up to the terrorist attacks is compared to the benchmark distributions, volume ratio statistics are seen to be at typical levels. An indicator of long put volume, however, appears to be unusually high which is consistent with informed investors having traded in the option market in advance of the attacks.

I. Introduction

In the aftermath of the terrorist attacks on the World Trade Center and the Pentagon on September 11, there was widespread speculation that the terrorists or their associates had used advanced knowledge of the attacks to profit in the financial markets.[1] Much of the attention focused on the trading in the days leading up to September 11 in options written on American Airlines (AMR) and United Airlines (UAL), the two companies whose planes were hijacked and crashed by the terrorists. Since the value of a put (call) option is decreasing (increasing) in the price of the underlying stock, the put-call volume ratio is a common measure of the extent to which positions established by option market trading will profit from the underlying stock price falling rather than rising. It is commonly believed that a typical put-call ratio is in the neighborhood of one,[2] and according to the Options Clearing Corporation (OCC) website (http://www.theocc.com) the September 10 put-call ratio for AMR options was 6.09, and the September 6 put-call ratio for UAL options was 25.4.

Many observers maintained that the AMR and UAL option activity leading up to September 11 constitutes strong evidence that there had been trading on advanced knowledge of the attacks. For example, on September 19 the CBS Evening News reported that the September 10 AMR put trading exceeded the call trading to such an extent that their sources had "never seen that kind of imbalance before" while the September 6 put and call trading on UAL was "extremely imbalanced." The report closed by saying that "Now US investigators want to know whether Osama bin Laden was the ultimate inside trader; profiting from a tragedy he's suspected of masterminding to finance his operations." (Attkisson, 2001) University of Chicago finance professor George Constantinides said that the option market trading was "so striking that it's

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[1] All dates in this paper that do not include a year occur in 2001.
[2] It will be seen below that, in fact, the put-call ratio is usually less than one.

hard to attribute it to chance. So something is definitely going on." (Roeder, 2001) Other well-known academic experts such as Columbia University law professor John Coffee and Duke University law professor James Cox likewise suspected that some investors traded in the option market on foreknowledge of the attacks. (Mathewson and Nol, 2001) In addition, sophisticated option market participants like Jon Najarian, founder of option specialist Mercury Trading, also concluded from the trading that somebody knew ahead of time that the attacks would occur. (Atkinson and Fluendy, 2001)

Despite the views expressed by the popular media, leading academics, and option market professionals, there is reason to question the decisiveness of the evidence that terrorists traded in the option market ahead of the September 11 attacks. One event that casts doubt on the evidence is the crash of an American Airlines plane in New York City on November 12. According to the OCC website, three trading days before on November 7, the put-call ratio for options on AMR stock was 7.74. Based on the statements made about the links between option market activity and terrorism shortly after September 11, it would have been tempting to infer from this put-call ratio that terrorism probably was the cause of the November 12 crash. Subsequently, however, terrorism was all but ruled out. While it might be the case that an abnormally large AMR put-call ratio was observed by chance on November 7, this event certainly raises the question of whether put-call ratios as large as 7.74 are, in fact, unusual. Beyond the November 12 plane crash, an article published in *Barron's* on October 8 (Arvedlund, 2001) offers several additional grounds for being skeptical about the claims that it is likely that terrorists or their associates traded AMR and UAL options ahead of the September 11 attacks. For starters, the article notes that the heaviest trading in the AMR options was not in the cheapest, shortest-dated puts which would have provided the largest profits to someone who knew of the coming attacks.

Furthermore, an analyst had issued a "sell" recommendation on AMR during the previous week, which may have lead investors to buy AMR puts. Similarly, the stock price of UAL had recently declined enough to concern technical traders who may have increased their put buying, and UAL options are heavily traded by institutions hedging their stock positions. Finally, traders making markets in the options did not raise the ask price at the time the orders arrived as they would have if they believed the orders were based on adverse non-public information – the market makers did not appear to find the trading to be out of the ordinary at the time that it occurred.

It is clear both that there is a good deal of *prima facie* evidence that the terrorists or their associates traded in the option market ahead of the September 11 attacks but at the same time that there are a number of reasons to suspect its probative value. Consideration of the option market activity leading up to September 11 suggests that, in general, it is difficult to make reasonable judgments about whether unusual option trading has occurred in the absence of detailed knowledge about the distribution of option market activity. The goals of this paper are twofold. The first is to compute the historical distribution of several option market volume statistics both unconditionally and when conditioning on the overall level of option activity, the return and trading volume on the underlying stocks, and the return on the overall market. These distributions can be used as benchmarks to determine whether the option market trading associated with any event of interest is unusual. The second goal of the paper is to use these distributions to assess the extent to which the option market trading leading up to September 11 was out of the ordinary.

The paper's first set of results characterizes the unconditional and conditional historical distribution of option market activity. I begin by computing quantiles of the daily values of three option market volume statistics: two volume ratio measures and a measure of abnormal long put

volume. The quantiles are computed over the January 2, 1990 through September 4, 2001 period for options listed at the Chicago Board Options Exchange (CBOE) on the 1000 largest market capitalization firms, for options on firms in the Standard and Poor's airline index, and for options on the Standard and Poor's 500 stock market index (SPX). The quantiles of the maximum daily value of the option volume statistics over four trade date windows are also reported, because it appears from the case of the September 11 attacks that inferences are sometimes made based upon the largest daily value of an option market volume statistic that occurs over a window of several trade dates leading up to an event. The unconditional distributions can be used to assess option market trading leading up to the public release of important information while controlling for baseline levels of option market activity (i.e., speculating, hedging, etc.) that is unrelated to varying conditions in the option or underlying stock markets.

In order to capture the impact of potentially significant conditioning information, quantile regression is used to regress option volume statistics on independent variables that might have an important impact on their distributions. The independent variables used are: the volume of options traded on the underlying stock, the current and past returns on the underlying stock, the current and past volume on the underlying stock, and the current and past return on the stock market as a whole. The resulting conditional distributions can be employed to evaluate option market trading leading up to the public release of important information while controlling for baseline levels of option market activity (i.e., speculating, hedging, etc.) that vary with changing conditions in the option or underlying stock markets.

The characterization of the unconditional and conditional distribution of option market activity should be of interest to several audiences. Option market participants and corporate executives clearly will have use for tools that help them better to assess when there is unusual

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activity in the options that they trade or which are written on the firms they manage. Exchange officials, regulators, and policy makers can also use this information in the design and enforcement of insider trading rules. DeMarzo, Fishman, and Hagerty (1998) argue that an optimal insider trading enforcement policy should balance the benefits of having market makers face a reduced adverse selection problem against the costs of enforcement. It may be possible to use the distributions provided in this paper to lower the costs of enforcement with the implication that relatively more monitoring effort should be devoted to the option market. Finally, investors, stock analysts, journalists, and the public at large can use the distributions to assess whether there was unusual option market trading leading up to any event of interest.

The paper's second set of results uses the historical distribution of option market activity to assess the option market trading in the days leading up to September 11. I will refer to the four trade dates beginning September 5 and ending September 10 as the *target period*. I investigate this period for two reasons. First, these are the days that most commentators seemed to be focused upon. Second, Osama bin Laden claimed that he learned on September 5 that the attacks would occur on September 11.[3] One of my option volume statistics, *PutCall*, is similar to the standard put-call ratio. The maximum daily value that it attained for AMR or UAL during the target period was 105.42.[4] This value is at the 0.97 quantile of the historical daily distribution of the *PutCall* statistic computed from the option activity on the 1000 largest market capitalization firms that trade at the CBOE. Consequently, against this benchmark it appears that during the target period there is evidence of abnormally large option market bets that the airline stock prices were going to fall.

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[3] Bin Laden said that he learned the timing of the attacks in Afghanistan on September 6. (Bumiller and Miller, 2001) Part of September 6 in Afghanistan includes a period when the U.S. option markets were open on September 5.

[4] Below I will detail the differences between my *PutCall* statistic and the put-call ratio reported by the OCC.

One reason to suspect inferences from this comparison, however, is that the *PutCall* ratio adds together long and short put volume in the numerator and long and short call volume in the denominator. As a result, it does not divide volume which establishes option market positions that will be profitable if the underlying stock price falls by volume that establishes option market positions which will be profitable if the underlying stock price increases. To address this problem, I define another ratio, *ShortLong*, which properly aggregates together option market volume that is decreasing in the stock price and also properly aggregates together option market volume that is increasing in the stock price. The *ShortLong* statistic has a maximum daily value for AMR or UAL during the target period which is at only the 0.80 quantile of its daily distribution. Hence, on this measure the option market trading during the target period does not look very unusual. Another important issue is that market observers seemed to be choosing for scrutiny the most extreme daily option volume during the target period. Insofar as this is the case, the most extreme daily value of the *ShortLong* statistic during the target period should be judged against the historical distribution of the daily maximum value of *ShortLong* over four trade date windows. Under this comparison the *ShortLong* statistic during the target period is at the 0.49 quantile of its distribution. When viewed in this way, the option market activity during the target period could hardly have been more ordinary.

Since the most straightforward way for terrorists or their associates to have profited from foreknowledge of the attacks would have been for them simply to take long positions in puts on stocks like AMR or UAL, I also investigate a daily measure of abnormal long put volume, *AbnLongPut*. The maximum value of this measure for AMR or UAL during the target period is at the 0.99 quantile of its daily distribution and the 0.96 quantile of the distribution of its greatest daily values over four trade date windows. Consequently, it appears that long put volume was

elevated during the target period. Since long put volume is a cleaner indicator of option market

volume which establishes option positions which will be profitable if the underlying stock price

declines than the volume ratios, I conclude that option market activity does provide evidence that

is consistent with the terrorists or their associates having traded ahead of the September 11

attacks. Conditioning on the variables discussed above (i.e., total option volume, return on the

underlying stock, volume on the underlying stock, and return on the market) does not change the

conclusions drawn from either the option volume ratio indicators or the put volume indicator.[5]

The terrorists or their associates might have tried to profit in the option market from the

decline in the prices of stocks on airlines other than AMR or UAL or from an overall market

decline in the wake of the September 11 attacks. In order to assess this possibility, I compare

trading during the target period in options on stocks in the Standard and Poor's airline index and

on the SPX index with their historical distributions. This comparison does not yield evidence of

trading ahead of the attacks in the option market. It should be borne in mind, however, that even

if there had been informed trading ahead of the attacks in options on other airline stocks or the

SPX index, it would be considerably more difficult to detect because of the substantially larger

baseline of option market activity in the aggregate airline stocks and the SPX index.

The analysis presented in this paper is most closely related to a strand of literature that

investigates the linkage between option market volume and subsequent price movements of the

underlying stock. In a recent contribution, Easley, O'Hara, and Srinivas (1998) argue that there

is a small amount of information in positive and negative option volume for future stock price

changes.[6] On the other hand, using a different methodology, Chan, Chung, and Fong (2002)

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[5] Likewise, delta-adjusting the option volume used in the option market volume statistics does not change the
conclusions.
[6] Positive option volume is purchases of calls or sales of puts by non-market makers. Negative option volume is
sales of calls or purchases of puts by non-market makers.

conclude that signed option volume does not contain information for subsequent stock price changes. Pan and Poteshman (2003) employ cleaner measures of positive and negative volume and provide evidence that there is substantial information in option volume for future stock prices. Cao, Chen, and Griffin (2003) show that in the period leading up to takeover announcements option volume contains information about next day stock price movements. They hypothesize that prior to "extreme information events" the option market is the primary venue for informed trading. This hypothesis is consistent with the terrorists or their associates having traded in the option market ahead of the September 11 attacks.

The remainder of the paper is organized as follows. The second section describes the data. Section III defines the option market volume statistics used in the paper. The fourth section computes the distributions of these statistics both unconditionally and when conditioning on the overall level of option activity, the return and trading volume on the underlying stocks, and the return on the overall market. Section V uses these distributions to assess the extent to which the option market trading leading up to September 11 was out of the ordinary. The sixth section concludes.

II. Data

The main data for this paper were obtained from the CBOE. The data consist of a daily record from January 2, 1990 through September 20, 2001 of long and short open interest for non-market makers on all options listed at the CBOE.[7] The long (short) open interest for a particular option contract on a particular trade date is the number of long (short) contracts that non-market maker investors have outstanding at the end of that trade date. When a CBOE listed option is

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[7] The Options Clearing Corporation (OCC) recognizes three origin codes for option trades, "C" (Public Customers), "F" (Firm Proprietary Accounts of OCC members), and "M" (Market Makers). The data used in this paper corresponds to the aggregate long and short open interest for the OCC "C" and "F" origin codes.

also listed at another exchange, the data covers non-market maker open interest for all exchanges at which the option trades. Options which are not listed at the CBOE on a given trade date, however, do not appear in the data on that trade date. Long (short) net trading volume is then computed for each option on each trade date by subtracting the long (short) open interest on that trade date from the long (short) open interest on the previous trade date. Consequently, the data analyzed in this paper corresponds to the daily net trading volume of all non-market makers in all markets at which CBOE listed options trade.[8]

This paper investigates data on all options on individual stocks and on the SPX index. The CBOE data contains the ticker symbol for the stock or index that underlies each option. This ticker symbol is used to extract information on the underlying stock or index for each option from the Center for Research in Securities Prices (CRSP) files. For the options on individual stocks, when a given option observation on a particular trade date cannot be matched with a CRSP permno, it is dropped from the analysis. For each option on each trade date, the information extracted from CRSP on the underlying stock or index is the closing price, the daily return for the current and past 62 trade dates, the daily trading volume for the current and past 147 trade dates, and the dividends paid over the remaining life of the option. Daily returns for the CRSP value-weighted index are also obtained from CRSP. Daily one month LIBOR rates are obtained from Datastream.

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[8] This method for computing net trading volume implicitly treats option exercises as sales and assignments of exercises as purchases. Unreported results indicate that the findings below are practically the same if exercises are factored out when calculating net trading volume. Since exercising and selling an option both involve getting out of the option position, this paper chooses to treat them both in the same way.

III. Option volume statistics

This section of the paper defines the three non-market maker option volume statistics that will be analyzed. Two of the statistics are option volume ratios which provide measures of the extent to which option trading results in net non-market maker option positions that will have greater (lesser) value if the underlying stock price subsequently decreases (increases). The other statistic measures the degree of abnormal net put buying by non-market makers.

The first volume ratio, *PutCall*, corresponds closely to the put-call ratio that is widely reported in the popular press. In order to define *PutCall*, let $N_{s,t}^{Calls}$ and $N_{s,t}^{Puts}$ be, respectively, the number of calls and puts listed on underlying security s on trade date t.[9] For $j = 1,..., N_{s,t}^{Calls}$, let $NVol_{s,j,t}^{Long\ Call}$ $\left(NVol_{s,j,t}^{Short\ Call} \right)$ be the net long (short) trading volume by non-market makers on the jth call on underlying security s on trade date t. Define $NVol_{s,j,t}^{Long\ Put}$ $\left(NVol_{s,j,t}^{Short\ Put} \right)$ for puts analogously. The $PutCall_t^s$ statistic just divides the trade date t aggregate non-market maker net trading volume of puts written on underlying security s by the aggregate non-market maker net trading volume of calls written on underlying security s

$$PutCall_t^s \equiv \frac{\sum_{j=1}^{N_{s,t}^{Puts}} \left(\left| NVol_{s,j,t}^{Long\ Put} \right| + \left| NVol_{s,j,t}^{Short\ Put} \right| \right)}{\sum_{j=1}^{N_{s,t}^{Calls}} \left(\left| NVol_{s,j,t}^{Long\ Call} \right| + \left| NVol_{s,j,t}^{Short\ Call} \right| \right)} \qquad (1)$$

This measure has the virtue of being similar to the standard put-call ratio that is frequently reported in the popular press. It differs in that it uses net trading volume rather than gross trading volume and that it only includes the volume of non-market makers. Daily gross non-market maker put and call volumes on particular stocks are readily available from the OCC

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[9] Underlying security s will typically be an individual stock or the SPX index. For one set of results, however, the underlying security s will be considered to be any stock in the Standard and Poor's airline index.

website. Dividing the daily gross non-market maker put volume by the daily gross non-market maker call volume produces a number very close to the *PutCall* statistic, and it is reasonable to judge this number against the *PutCall* distributions that are reported below.[10]

A drawback of the *PutCall* measure (and of the widely reported put-call volume ratio) is that it does not distinguish between long and short volume. This is a problem, because long put positions increase in value when the underlying security price falls while short put positions decrease in value when the underlying security price falls. It can be seen, however, from the numerator of equation (1) that the *PutCall* measure treats the purchase and the sale of put positions in the same way. The treatment of the call volume in the denominators suffers from the same difficulty.

I define a second volume ratio, *ShortLong*, which avoids this problem. *ShortLong* is a ratio whose numerator adds net trading volume which corresponds to option positions that increase in value when the underlying security price falls (i.e., the selling of calls and the buying of puts) and subtracts net trading volume which corresponds to option positions that decrease in value when the underlying security price falls (i.e., the buying of calls and the selling of puts):

$$ShortLong_t^s \equiv \frac{\sum_{j=1}^{N_{s,t}^{Calls}} \left(NVol_{s,j,t}^{Short\ Call} - NVol_{s,j,t}^{Long\ Call} \right) + \sum_{j=1}^{N_{s,t}^{Puts}} \left(NVol_{s,j,t}^{Long\ Put} - NVol_{s,j,t}^{Short\ Put} \right)}{\sum_{j=1}^{N_{s,t}^{Calls}} \left(\left| NVol_{s,j,t}^{Short\ Call} \right| + \left| NVol_{s,j,t}^{Long\ Call} \right| \right) + \sum_{j=1}^{N_{s,t}^{Puts}} \left(\left| NVol_{s,j,t}^{Long\ Put} \right| + \left| NVol_{s,j,t}^{Short\ Put} \right| \right)} \qquad (2)$$

The denominator normalizes the variable by adding together the absolute values of all of the option trading volume. This statistic ranges from -1 to $+1$, with a value of -1 indicating that all option volume corresponds to option positions that will increase in value if the underlying

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[10] For example, for UAL over the period November 6, 2000 through September 4, 2001, the 5th, 50th, and 95th quantiles of the *PutCall* distribution are, respectively, 0.02, 0.52, and 15.4. The 5th, 50th, and 95th quantiles for the gross non-market maker put divided by gross non-market maker call volume distribution (computed from the OCC website data) are, respectively, 0.03, 0.52, and 15.6.

security price rises and a value of +1 indicating that all option volume corresponds to option positions that will increase in value if the underlying security price declines.

Since the most straightforward way for an investor to benefit in the option market from private information about impending bad news would be for him simply to buy puts, I will also analyze a statistic that directly measure abnormal net long put volume. In particular, the *AbnLongPut* statistic will measure non-market maker abnormal net long put volume on trade date t for a particular underlying security s. It is defined as the absolute net long put volume on trade date t for security s minus the daily average of this quantity over a six month historical period from 147 to 22 trade dates before t normalized by the standard deviation of the absolute net long put volume during the historical period[11]

$$AbnLongPut_t^s \equiv \frac{\sum_{j=1}^{N_{s,t}^{Puts}} \left(NVol_{s,j,t}^{Long\ Put} \right) - \frac{1}{126} \sum_{i=22}^{147} \sum_{j=1}^{N_{s,t-i}^{Puts}} \left(NVol_{s,j,t-i}^{Long\ Put} \right)}{std\left\{ \sum_{j=1}^{N_{s,t-i}^{Puts}} \left(NVol_{s,j,t-i}^{Long\ Put} \right), \quad i = 22,...,147 \right\}}. \tag{3}$$

Finally, the maximum daily value attained by the option volume measures over some window of trade dates from t to $t+w$ will also be analyzed. Statistics which measure these quantities are defined as follows

$$OptVolStat_{t,t+w}^{s,Daily\ Max} \equiv Max\left\{ OptVolStat_{t+i}^s, \ i = 0,...,w \right\} \tag{4}$$

where *OptVolStat* is any of the options volume statistics. For example,

$$PutCall_{t,t+w}^{s,Daily\ Max} \equiv Max\left\{ PutCall_{t+i}^s, \ i = 0,...,w \right\} \tag{5}$$

is the maximum daily value obtained by the *PutCall* statistic for underlying security s over trade dates t through $t+w$.

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[11] The notation $std\left\{ x_i, \quad i = a,...,b \right\}$ refers to the sample standard deviation of the set with elements $x_a,...,x_b$.

Before presenting the distributions of the option market volume statistics in the next section of the paper, it is worth commenting on their use in detecting option market trading based upon private information. Since the statistics are built from all option market activity, they contain trading that is motivated by a number of factors such as uninformed speculation (i.e., noise trading), hedging, trading on public information, and trading on private information. Consequently, when a statistic obtains a value that is extreme relative to its historical distribution, one can infer that their was an unusual amount of activity related to one or more of the option trading motivations. Although the statistics do not distinguish between trading motivations, if an extreme value is observed just before an important piece of news becomes public, then it is reasonable to infer that there was option market trading based upon private information rather than a shock to the trading from one of the other motivations. Indeed, the fact that the statistic has obtained an extreme value indicates that a shock to trading from another motivation would have to be unusually large to account for the observed option market trading. Of course, it is possible that the typical option trading from the other motivations varies systematically with changes in the state of the option or underlying security market. This is the reason that conditional as well as unconditional distributions for the statistics will be computed in the next section.[12]

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[12] It should be noted that if investors trade on private information in the market for the underlying security and hedge their trading in the option market, there may be a bias against detecting private information trading in the option market. For example, suppose there are two investors with private positive information about a stock. The first investor exploits it by buying the stock and hedges his position by selling a call while the second investor exploits it simply by buying a call. The option market activities of these two investors will tend to cancel one another out in the computation of the volume ratios even though both are trading on positive private information.

IV. The distribution of option market volume statistics

This section of the paper computes the distributions of the option market volume statistics defined above both unconditionally and when conditioning on a number of variables which may be associated with systematic changes in the distributions. These distributions can be used to assess option market activity around any event of interest. In the next section of the paper, they are used to evaluate the option market trading in the days leading up to the September 11 attacks.

Table 1 reports the minimum, maximum, and quantiles of the option market volume statistics computed on a daily basis over the January 2, 1990 through September 4, 2001 period. For the *AbnLongPut* statistic, values are included in the distributions for all trade dates t that have option data on the underlying stock for at least 100 of the trade dates between $t-147$ and $t-22$.

Panel A of Table 1 reports the distributions obtained from all options that trade at the CBOE which have underlying stocks in the top 1000 CRSP market capitalizations on the first trading day of each calendar year.[13] The median value of the *PutCall* distribution is only 0.32 which suggests that *ceteris paribus* a belief that one is the typical value for this statistic might actually cause observers to underestimate the extent to which large values of this statistic are unusual. It is also interesting to note that the statistic is highly variable. At the 0.25 quantile the statistic is 0.05 (which is close to its minimum value of zero) while the 0.95 quantile is 15.45. The distribution of the *ShortLong* statistic is roughly similar once it is taken into account that it ranges from minus one to plus one. It will be seen below, however, that the *ShortLong* statistic

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[13] Market capitalization is defined as the price per share times the number of shares outstanding. Distributions obtained from all CBOE options or all CBOE options with underlying stocks that are among the largest 500 market capitalizations on CRSP on the first trading day of each calendar year are similar to those presented in Panel A of Table 1.

can lead to different inferences about option market trading. The *AbnLongPut* statistic measures the number of standard deviations that net long put volume for a given underlying stock on a given trade date varies from the average for the underlying stock. The median value is close to zero, and the distribution around the median is roughly symmetric. Panels B and C of Table 1 report the distributions of the statistics when the underlying security on each trade date is the 18 stocks in the Standard and Poor's airline index as of September 2001 or the SPX index.

The distributions in Table 1 can be used to compare the option market activity on a trade date against its daily distribution. Based on the news reports in the weeks after September 11, it appears that sometimes the most extreme daily value of an option market volume statistic over some period of trade dates is used to judge option market activity. For this reason, I report in Table 2 the distribution of the daily maximum of the option market volume statistics over disjoint four trade date intervals. I choose four trade date intervals, because they will be useful in evaluating the option market activity in the days leading up to September 11. As expected, all of the distributions are shifted upward in Table 2 relative to the distributions in Table 1. For example, the median value of the *PutCall* statistic increases from 0.32 to 1.61. It will not be surprising if different inferences are made about whether unusual option market activity has occurred around some event depending upon which of the distributions is used as a benchmark.

It seems plausible *a priori* that the distribution of the option market volume ratios will be influenced by a number of factors. One factor that probably is important is the total number of option contracts traded on an underlying asset on a given trade date. To see why, consider the case of the *PutCall* statistic. When the total number of option contracts transacted on a trade date is very small there is a relatively high probability that all of the contracts that traded were either puts or calls. When only puts trade the value of the statistic is infinity and when only call

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trades the value of the statistic is zero. Consequently, one would expect that the lower (upper) quantiles of the *PutCall* statistic will have lesser (greater) values when the total number of option contracts traded is smaller.

The distributions of the option volume statistics may well also change as a function of the return on the underlying stock. For example, momentum or contrarian investors may place option market bets on future movements in the underlying stock price in response to past returns. Another possibility is that investors place bets directly in the underlying stock market based upon past returns and hedge their bets in the option market. The option market volume associated with the hedging would impact the option volume statistics and, hence, would potentially impact their distributions. The trading volume of the underlying stock might be important as well insofar as it indicates the extent to which there is information being released or attention being paid to a firm. Finally, the return on the overall market might matter, because it contains information about macroeconomic factors or overall investor sentiment.

I will use quantile regression to estimate the quantiles of the option market volume statistics conditional on total option volume, the return on the underlying asset, the abnormal trading volume of the underlying asset, and the return on the overall stock market. Classical linear regression is used to estimate conditional *mean* functions. Median regression is a similar statistical technique that is used to estimate conditional *median* functions. Quantile regression is a generalization of median regression which can be used to estimate conditional *quantile* functions. Details on quantile regression can be found in Koenker and Basset (1978), Koenker and Hallock (2001), and Koenker (2002).

The regression model that will be estimated is

$$OptVolStat_t^s = \beta_0 + \beta_1 OptVol_t^s + \beta_2 RDay_t^s + \beta_3 RWeek_t^s + \beta_4 RMonth_t^s + \beta_5 AbnVolDay_t^s$$
$$+ \beta_6 AbnVolWeek_t^s + \beta_7 AbnVolMonth_t^s + \beta_8 RVWDay_t + \beta_9 RVWWeek_t \qquad (6)$$
$$+ \beta_{10} RVWMonth_t + \varepsilon_t^s$$

where $OptVolStat_t^s$ is either a standardized version of the *PutCall* statistic or the *AbnLongPut* statistic. The *PutCall* variable cannot be used because it ranges up to infinity. The standardized version of *PutCall,* which will be called *PutCallStand,* is defined as the net put volume divided by the net put plus net call volume. *PutCallStand,* ranges from zero to one. The regressions will only be performed for cases where the underlying securities are individual stocks. The first independent variable, $OptVol_t^s$, is the total net option volume on underlying stock s on trade date t (that is, it is the sum of the absolute values of the net long and short, put and call trading.) The next three independent variables, $RDay_t^s$, $RWeek_t^s$, and $RMonth_t^s$, are, respectively, the return on underlying stock s on trade date t, the average daily return on stock s over trade dates $t-5$ through $t-1$, and the average daily return on stock s over trade dates $t-21$ through $t-6$. The next three variables, $AbnVolDay_t^s$, $AbnVolWeek_t^s$, and $AbnVolMonth_t^s$, are, respectively, the abnormal trading volume on stock s on trade date t and the average daily abnormal trading volumes on trade dates $t-5$ through $t-1$ and trade dates $t-21$ through $t-6$. Here abnormal trading volume is obtained by subtracting from the trading volume on trade date t or the daily average trading volume on trade dates $t-5$ through $t-1$ or trade dates $t-21$ through $t-6$ the daily average trading volume for stock s over trade dates $t-147$ through $t-22$ and then dividing by the standard deviation of the daily trading volume for stock s over trade dates $t-147$ through $t-22$. $RVWDay_t$, $RVWWeek_t$, and $RVWMonth_t$ are, respectively, the CRSP value weighted market return on trade date t and the daily average CRSP value weighted market return on trade dates $t-5$ through $t-1$ and trade dates $t-21$ through $t-6$.

Table 3 report the results of performing quantile regression over the period January 2, 1990 through September 4, 2001 when the universe of underlying stocks is the 1000 largest CRSP market capitalization firms at the beginning of each calendar year. The *t*-Statistics for the coefficient estimates reported in parentheses are computed from standard errors that assume non-iid regression residuals.[14] The coefficient estimates in Panel A of Table 3 can be used to assess the option trading around any event of interest as follows. First, collect the values of the independent variables for the underlying stock and trade date of interest. Next, sum the products of these values and the coefficient estimates from model (6) to compute the conditional quantiles of the option volume statistics. Finally, calculate the value of the statistics for the underlying stock and trade date of interest, and compare it to the computed quantiles. In the final step, use data for the put and call activity by non-market makers. For *PutCallStand*, this data is readily available at the OCC website.[15] Exchange officials, regulators, and prosecutors should have no problem acquiring the necessary data for the *AbnLongPut* statistic as well.[16]

V. Option market trading in the days leading up to September 11

This section of the paper investigates whether there was unusual option market activity in the days leading up to September 11 that is consistent with the terrorists or their associates trading ahead of the attacks. The target period that I examine for unusual option market activity is the four trade dates leading up to September 11 (i.e., September 5, 6, 7, and 10.) As explained

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[14] With non-iid regression residuals the limiting covariance matrix for the coefficient estimates takes the form of a "Huber sandwich." This sandwich is estimated using the sparsity estimation method described in Koenker (2002).
[15] The data at the OCC website is for gross rather than net trading. However, as was discussed in Footnote 10, this difference should not have a significant impact on the comparison.
[16] Conditional quantiles were also computed for *ShortLong*, for delta-adjusted version of the statistics, and for the cases where the option volume statistics correspond to the daily maximum over four trade date intervals. It turns out that in the analysis performed in the next section of the paper there was no difference in the inferences obtained from the unconditional and conditional distributions. Consequently, the results from these other conditional quantile estimations are not reported here.

above, I consider this target period, because it contains the trade dates most market observers seemed to be focusing upon, and because Osama bin Laden appears to have learned on September 5 that the attacks would occur on September 11.

Table 4 contains the values of the option market volume statistics for AMR, UAL, the airline index stocks, and the SPX index on the trade dates surrounding September 11. Consistent with the reports in the popular press, during the target period the option market volume ratios had their greatest values for AMR on September 10 and for UAL on September 6. The *PutCall* statistic was 7.07 September 10 for AMR and 105.42 on September 6 for UAL. Upon casual consideration, it is easy to believe that these numbers – especially the one on UAL – indicate that there were an unusual level of option market positions established during the target period which would profit from a drop in the price of AMR or UAL. Since the option volume statistics on the airline index stocks and the SPX index are less variable than those on the individual stocks, it also appears from Panels C and D of Table 4 that the option market volume ratios may have been elevated for the airline index stocks and the SPX index on September 5 when they had *PutCall* values of 7.31 and 3.96, respectively.[17]

Table 5 evaluates the maximum daily value obtained by each of the option market volume statistics for the various groups of underlying securities during the target period. In particular, it reports the quantiles of these maximum daily values computed from the unconditional distributions for the statistics constructed either from the daily values of the statistics or from the maximum daily values over disjoint four trade date intervals. These unconditional distributions are just the ones reported in Tables 1 and 2.[18] Panel A of Table 5

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[17] When AMR and UAL are removed from the airline index, the September 5 *PutCall* value drops from 7.31 to 5.04.
[18] Recall that the distributions are constructed over the January 2, 1990 through September 4, 2001 period, and the universe of underlying stocks considered in the distributions are the 1000 largest market capitalization firms in the

reports the quantiles for AMR and UAL. When the benchmark distributions are built from the daily values of the statistics, the maximum value of *PutCall* during the target period is seen to be at the 0.97 quantile. Consequently, if this comparison is the appropriate way to decide whether option market trading was unusual in the days leading up to September 11, then there is evidence that is significant at conventional levels that an unusual quantity of option market positions that would profit from a decrease in the price of AMR or UAL were established during the target period.

This comparison, however, is not appropriate for two reasons. First, as was discussed above, the *PutCall* statistic does not correctly aggregate option market positions that will increase (or decrease) in value when the underlying stock price declines. *ShortLong*, on the other hand, does aggregate these volumes correctly, and Table 5 shows that its maximum daily value for AMR or UAL during the target period was at the 0.80 quantile of its daily distribution. Hence, when an option market ratio that correctly aggregates volume is considered, the trading during the target period does not look very unusual. The second problem with the comparison in the previous paragraph is that it judges the maximum value of a statistic over a four trade date period against its daily distribution. Clearly, the maximum daily value of a statistic over the four trade date target period should be assessed against the historical distribution of the maximum value of the statistic over four trade date intervals. This comparison is also reported in Table 5, and the quantile of the maximum observed *ShortLong* statistic over the four trade date windows drops from 0.80 to 0.49. Hence, the option market volume ratios (at least for AMR and UAL options) do not provide any evidence that the trading leading up to September 11 was unusual.

CRSP database on the first trade date of each calendar year. At the beginning of 2001, AMR and UAL were, respectively, the 426th and 863rd largest market capitalization firms on CRSP.

In fact, the 0.49 quantile of the *ShortLong* statistic suggests that the trading was not in any way out of the ordinary.[19]

Simply buying puts on AMR or UAL would have been the most straightforward way for terrorists or their associates to have profited in the option market. The values of the volume ratio statistics, on the other hand, are impacted not only by long put volume but also by short put volume and long and short call volume. The *AbnLongPut* statistic measures only (abnormal) non-market maker net long put trading. Table 5 reports that the maximum daily value that it attains for either AMR or UAL during the target period was 3.83 which indicates that during one of the four trade dates of the target period the net long put trading was 3.83 standard deviations greater than average. The 3.83 value of the statistic is at the 0.99 quantile of its daily distribution and the 0.96 quantile of the distribution of daily maximum over four trade date windows. Hence, on this measure it does appear that significant abnormal option market positions were established that would profit from the decline of one of the airlines stocks most directly impacted by the attacks. Recall that the historical distributions of *AbnLongPut,* from which the quantiles were computed, control for option trading that is not motivated by private information.

Since *AbnLongPut* is a more direct measure than the option volume ratios of the option market positions that would most likely be established to profit from a decline in the price of the airlines stocks, I conclude that the unconditional evidence supports the proposition that there was unusual trading in the option markets leading up to September 11 which is consistent with the terrorists or their associates having traded on advance knowledge of the impending attacks.

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[19] Given that airplanes from two airlines were crashed, in the case of the September 11 attacks it would also be of interest to compare the maximum daily value of the statistics for either AMR or UAL over the four trade date target period to the historical distribution of the daily maximum of the statistics for pairs of underlying stocks over four trade date windows. Since there is no reason to believe that events will tend to naturally involve two underlying stocks (and even in the case of September 11 one could reasonably include firms headquartered at the World Trade Center, insurance companies with exposure from the attacks, etc.), I did not in the previous section develop the tools to make this comparison.

Given the opposite conclusion that is drawn from the *ShortLong* statistic, a more general lesson appears to be that option market volume ratios may not be reliable indicators of the presence of unusual trading in the option markets.

In unreported results, the quantiles of the AMR and UAL statistics during the target period were also computed relative to historical distributions built only from AMR option trading, UAL option trading, and option trading on 38 stocks that the Securities and Exchange Commission identified for special scrutiny after September 11. The main conclusions are not altered by using these alternative distributions as the benchmarks. Delta-adjusting the option volume used in the statistics also has very little influence on the conclusions.

Terrorist or their associates may have believed either that all airline stocks or the stock market as a whole would suffer declines after the attacks and might have tried to profit by trading options either on the stocks of airlines other than AMR and UAL or on the market as a whole. Panels B and C of Table 5 report the quantiles of option trading on, respectively, the Standard and Poor's airline index and the SPX index during the target period. The *ShortLong* statistic is at the 0.55 and 0.38 quantiles and the *AbnLongPut* statistic is at the 0.88 and 0.82 quantiles of their historical distributions of daily maximum over four trade date windows. Consequently, there is no clear evidence of unusual option trading on airline stocks as a whole or on the SPX index. In unreported results, a similar conclusion is reached if the analysis is repeated after removing AMR and UAL from the airline index or if it is repeated on the S&P 100 (OEX) or NASDAQ 100 (NDX) index.

It should be kept in mind, however, that there is much more option activity on the stocks in the airline index or on the market indices than on AMR or UAL. In particular, AMR and UAL are only two of eighteen companies in the airline index, and during the month leading up to

September 11 the option volume on SPX options was more than 100 times greater than that on either AMR or UAL options. Consequently, it would be much more difficult to detect an option market bet of a fixed size among all of the stocks in the airline index or in the SPX market. It seems that the appropriate conclusion to draw is that while it is unlikely that the terrorists or their associates placed very large option market bets among airline stocks or the SPX index leading up to September 11, not much should be inferred about whether they used these options to place small or moderate sized bets.

Table 4 also includes the values of the option market volume statistics for each of the four trade dates after the exchange re-opened following September 11. For AMR, the option market volume statistics do not appear to be out of the ordinary. For UAL, on the other hand, *AbnLongPut* had a value of 3.79 on September 20 (four trade dates after re-opening.) Although this number would be large when judged against the historical distributions, the September 11 attacks were such a unique event – especially for AMR and UAL – that it seems inappropriate to draw any conclusions about the few days after the market re-opened, even if the conditional distributions are used as benchmarks.

I now turn to an analysis of the option trading on AMR and UAL during the target period which conditions on the state of the option and stock market at this time. I do this by summing the products of quantile regression coefficient estimates from equation (6) by the values of the independent variables for AMR and UAL during the target period to produce conditional estimates for *ShortLong* and *AbnLongPut*. These conditional quantile estimates are reported in Table 6.[20]

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[20] Table 3 does not contain the coefficient estimates for *ShortLong*. The quantile regression, however, was performed for *ShortLong* and the resulting coefficient estimates are used to construct the conditional *ShortLong* quantiles reported in Table 6.

The largest value of the *ShortLong* statistic during the target period was 0.89 which occurred for AMR on September 10. This value of *ShortLong* is at the 0.80 quantile of the unconditional daily distribution. Panel A of Table 6 indicates that on September 10 the 0.50 quantile of the conditional daily distribution on *ShortLong* for AMR was –0.034 and the 0.90 quantile of this distribution was 0.954. Consequently, it appears that in this case there is little difference between the conditional and the unconditional quantile. The largest daily value of the *AbnLongPut* variable during the target period, 3.83, also occurred for AMR on September 10. This value of *AbnLongPut* was seen to be at the 0.99 quantile of the unconditional distribution. Panel B of Table 6 indicates that on September 10 the 0.95 quantile of the conditional daily distribution on *AbnLongPut* for AMR was 1.285 and the 0.99 quantile of this distribution was 4.265. Once again, it seems that there is not much difference between the unconditional and the conditional quantile. Unreported analysis show that the conditional and unconditional results are also very similar for the statistics that measure maximum daily values over four trade date windows. Hence, it does appear that the *AbnLongPut* ratio for AMR and UAL was unusually high during the target period even after accounting for variation in its distribution associated with the independent variables in the quantile regression model.[21] This finding is consistent with the widespread speculation shortly after September 11 that the terrorists or their associates traded ahead in the option market based upon foreknowledge of the impending attacks.

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[21] It is, of course, possible that some important explanatory variables have been omitted from the quantile regression model. However, since the intuitively important variables contained in the model had little impact on the distributions of the statistics, it seems reasonable to believe that inclusion of other explanatory variables would probably not alter the main conclusion.

VI. Conclusion

Options traders, corporate managers, security analysts, exchange officials, regulators, prosecutors, policy makers, and – at times – the public at large have an interest in knowing whether unusual option trading has occurred around certain events. A prime example of such an event is the September 11 terrorist attacks, and there was indeed a great deal of speculation about whether option market activity indicated that the terrorists or their associates had traded in the days leading up to September 11 on advanced knowledge of the impending attacks. This speculation, however, took place in the absence of an understanding of the relevant characteristics of option market trading.

This paper begins by developing systematic information about the distribution of option market activity. It constructs benchmark distributions for option market volume statistics which measure in different ways the extent to which non-market maker volume establishes option market positions which will be profitable if the underlying stock price rises or falls in value. The distributions of these statistics are calculated both unconditionally and when conditioning on the overall level of option activity on the underlying stock, the return and trading volume on the underlying stock, and the return on the overall market. These distributions are then used to judge whether the option market trading in AMR, UAL, the Standard and Poor's airline index, and the S&P 500 market index in the days leading up to September 11 was, in fact, unusual.

The option market volume ratios considered do not provide evidence of unusual option market trading in the days leading up to September 11. The volume ratios, however, are constructed out of long and short put volume and long and short call volume, while simply buying puts would have been the most straightforward way for someone to have traded in the option market on foreknowledge of the attacks. A measure of abnormal long put volume was

also examined and seen to be at abnormally high levels in the days leading up to the attacks. Consequently, the paper concludes that there is evidence of unusual option market activity in the days leading up to September 11 which is consistent with investors trading on advanced knowledge of the attacks.

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Table 1: Distribution of Daily Option Market Volume Statistics for 1000 Largest Market Capitalization Firms, Standard and Poor's Airline Index Firms, and the SPX index, January 2, 1990 through September 4, 2001

This table presents the minimum, maximum and quantiles of the daily values of three option market volume statistics over the period January 2, 1990 through September 4, 2001. The underlying data from which the statistics are computed are the daily closing non-market maker long and short open interest for each option listed at the Chicago Board Options Exchange (CBOE). Daily net long (short) volumes are defined as the first difference in the daily long (short) open interest on an option. Panel A reports the distributions computed from options written on the 1000 largest market capitalization stocks in the Center for Research in Security Prices database on the first trading day of the calendar year. Panel B reports the distributions when the volume statistics are computed on each trade date from all net option volume on Standard and Poor's airline index firms. Panel C reports the distributions from options on the SPX index.

| Volume Statistic | N | Min | Quantiles | | | | | | | | | | | Max |
			0.001	0.01	0.05	0.10	0.25	0.50	0.75	0.90	0.95	0.99	0.999	
			Panel A: 1000 Largest Market Capitalization Firms											
PutCall	953,976	0.00	0.00	0.00	0.00	0.00	0.05	0.32	1.07	4.02	15.45	Inf	Inf	Inf
ShortLong	953,976	-1.00	-1.00	-1.00	-1.00	-1.00	-0.54	0.07	0.76	1.00	1.00	1.00	1.00	1.00
AbnLongPut	777,631	-348.42	-15.60	-5.28	-0.94	-0.29	-0.07	0.01	0.13	0.54	1.13	4.06	17.01	437.94
			Panel B: Standard and Poor's Airline Index Firms											
PutCall	2,940	0.01	0.01	0.03	0.08	0.12	0.24	0.49	0.94	1.84	2.89	9.50	38.89	105.17
ShortLong	2,940	-1.00	-1.00	-1.00	-0.81	-0.61	-0.27	0.04	0.40	0.78	0.94	1.00	1.00	1.00
AbnLongPut	2,804	-12.85	-8.52	-5.32	-1.02	-0.30	-0.04	0.08	0.26	0.60	0.92	1.93	5.95	14.66
			Panel C: SPX Index											
PutCall	2,940	0.01	0.03	0.12	0.28	0.44	0.79	1.38	2.41	4.41	6.89	15.79	53.17	69.83
ShortLong	2,940	-1.00	-1.00	-1.00	-0.51	-0.30	-0.09	0.06	0.25	0.48	0.63	0.92	1.00	1.00
AbnLongPut	2,804	-14.84	-10.83	-6.24	-0.37	-0.05	0.05	0.15	0.27	0.41	0.54	0.88	1.52	9.71

Table 2: Distribution of Daily Maximum of Option Market Volume Statistics over Four Trade Date Intervals for 1000 Largest Market Capitalization Firms, Standard and Poor's Airline Index Firms, and the SPX index, January 2, 1990 through September 4, 2001

This table presents the minimum, maximum and quantiles of the daily maximum over four trade date intervals of three option market volume statistics over the period January 2, 1990 through September 4, 2001. The underlying data from which the statistics are computed are the daily closing non-market maker long and short open interest for each option listed at the Chicago Board Options Exchange (CBOE). Daily net long (short) volumes are defined as the first difference in the daily long (short) open interest on an option. Panel A reports the distributions computed from options written on the 1000 largest market capitalization stocks in the Center for Research in Security Prices database on the first trading day of the calendar year. Panel B reports the distributions when the volume statistics are computed on each trade date from all net option volume on Standard and Poor's airline index firms. Panel C reports the distributions from options on the SPX index.

Volume Statistic	N	Min	Quantiles											Max
			0.001	0.01	0.05	0.10	0.25	0.50	0.75	0.90	0.95	0.99	0.999	
Panel A: 1000 Largest Market Capitalization Firms														
$PutCall^{Daily\ Max}$	238,018	0.00	0.00	0.00	0.09	0.24	0.64	1.61	5.44	Inf	Inf	Inf	Inf	Inf
$ShortLong^{Daily\ Max}$	238,018	-1.00	-1.00	-0.67	-0.16	0.06	0.47	0.91	1.00	1.00	1.00	1.00	1.00	1.00
$AbnLongPut^{Daily\ Max}$	194,730	-11.10	-0.37	-0.14	-0.06	-0.02	0.04	0.20	0.69	1.80	3.15	9.41	33.55	437.94
Panel B: Standard and Poor's Airline Index Firms														
$PutCall^{Daily\ Max}$	736	0.14	0.15	0.26	0.41	0.53	0.76	1.29	2.31	4.58	7.48	17.43	91.29	105.17
$ShortLong^{Daily\ Max}$	736	-0.50	-0.49	-0.30	-0.07	0.05	0.25	0.52	0.87	1.00	1.00	1.00	1.00	1.00
$AbnLongPut^{Daily\ Max}$	675	-1.72	-1.65	-1.21	-0.89	-0.76	-0.55	-0.29	0.26	1.05	1.74	5.92	22.87	23.87
Panel C: SPX Index														
$PutCall^{Daily\ Max}$	736	0.57	0.58	0.84	1.14	1.37	1.96	3.25	5.57	9.00	13.35	30.78	66.75	69.83
$ShortLong^{Daily\ Max}$	736	-0.19	-0.18	-0.06	0.02	0.08	0.18	0.32	0.54	0.76	0.89	1.00	1.00	1.00
$AbnLongPut^{Daily\ Max}$	701	-0.04	-0.04	0.02	0.10	0.13	0.21	0.31	0.47	0.67	0.85	1.34	9.15	9.71

Table 3: Quantile Regression of Option market Volume Statistics on Options Volume, Underlying Returns, Underlying Abnormal Trading Volumes, and Market Returns

This table reports the results of performing quantile regression of two option market volume statistics on a number of explanatory variables. The data consists of options on the 1000 largest market capitalization firms over the period from January 2, 1990 through September 4, 2001. The option volume data were obtained directly from the Chicago Board Options Exchange and all other data come from the Center for Research in Security Prices. The regression specification is

$$OptVolStat_t^s = \beta_0 + \beta_1 OptVol_t^s + \beta_2 RDay_t^s + \beta_3 RWeek_t^s + \beta_4 RMonth_t^s + \beta_5 AbnVolDay_t^s + \beta_6 AbnVolWeek_t^s + \beta_7 AbnVolMonth_t^s$$
$$+ \beta_8 RVWDay_t + \beta_9 RVWWeek_t + \beta_{10} RVWMonth_t + \varepsilon_t^s$$

where $OptVolStat_t^s$ is the option volume statistic indicated in Panels A and B, either $PutCallStand_t^s$ or $AbnLongPut_t^s$. $OptVol_t^s$ is the total net options volume on underlying stock s on trade date t. The next three variables, $RDay_t^s$, $RWeek_t^s$, and $RMonth_t^s$, are, respectively, the return on underlying stock s on trade date t, the average daily return on stock s over trade dates $t-5$ through $t-1$, and the average daily return on stock s over trade dates $t-21$ through $t-6$. The next three variables, $AbnVolDay_t^s$, $AbnVolWeek_t^s$, and $AbnVolMonth_t^s$, are, respectively, the abnormal trading volume on stock s on trade date t and the average daily abnormal trading volumes on trade dates $t-5$ through $t-1$ and trade dates $t-21$ through $t-6$. $RVWDay_t$, $RVWWeek_t$, and $RVWMonth_t$ are, respectively, the CRSP value weighted market return on trade date t and the daily average CRSP value weighted market return on trade dates $t-5$ through $t-1$ and trade dates $t-21$ through $t-6$. The t-Statistics reported in parentheses are computed assuming non-iid error terms using the sparsity estimation methods described in Koenker (2002).

Table 3 – Continued

Quantile	Intercept	OptVol	Rday	Rweek	Rmonth	AbnVolDay	AbnVolWeek	AbnVolMonth	RVWDay	RVWWeek	RVWMonth
					Panel A: Dependent Variable = *PutCallStand*						
0.01	-0.0001	0.0000002	-0.0003	-0.0006	-0.0005	0.0000	0.0000	0.0000	0.0000	-0.0002	0.0002	-0.0002
	(-11.83)	(8.18)	(-19.97)	(-18.31)	(-4.25)	(0.74)	(5.84)	(5.35)	(-6.53)	(1.26)	(-0.88)
0.05	-0.0000	0.0000006	-0.0004	-0.0007	-0.0005	0.0000	0.0000	0.0000	-0.0001	-0.0004	-0.0009
	(-19.56)	(61.27)	(-23.84)	(-20.20)	(-8.63)	(6.40)	(5.52)	(3.14)	(-4.08)	(-5.09)	(-6.74)
0.10	0.0003	0.0000013	-0.0066	-0.0133	-0.0083	0.0005	0.0002	0.0000	-0.0035	-0.0071	-0.0210
	(6.67)	(63.77)	(-6.95)	(-7.00)	(-4.57)	(6.62)	(4.66)	(0.29)	(-3.31)	(-3.28)	(-4.53)
0.50	0.2547	0.0000012	-0.7298	-0.7405	0.1483	0.0006	0.0055	0.0061	-0.7920	-1.7728	-4.1055
	(501.38)	(39.45)	(-57.85)	(-22.78)	(2.38)	(2.91)	(11.79)	(8.93)	(-16.98)	(-16.59)	(-20.00)
0.90	0.7890	-0.000001	-0.9423	-1.3404	-0.8649	-0.0078	-0.0058	-0.0047	-0.6069	-2.3830	-5.3688
	(984.12)	(-36.72)	(-56.03)	(-27.59)	(-9.40)	(-76.63)	(-9.73)	(-6.55)	(-8.67)	(-14.26)	(-16.59)
0.95	0.9122	-0.000001	-0.7772	-1.2696	-1.2247	-0.0083	-0.0082	-0.0061	-0.2685	-1.6263	-2.8549
	(1287.51)	(-67.27)	(-46.94)	(-39.19)	(-16.26)	(-36.68)	(-13.74)	(-6.97)	(-4.64)	(-12.38)	(-10.24)
0.99	1.0000	-0.000001	-0.0009	-0.0022	-0.0022	-0.0000	-0.0000	-0.0000	0.0001	-0.0001	0.0002
	(739614.15)	(-399.09)	(-11.90)	(-12.63)	(-12.73)	(-7.38)	(-7.59)	(-1.35)	(2.90)	(-0.80)	(0.96)
					Panel B: Dependent Variable = *AbnLongPut*						
0.01	-1.7843	-0.001008	4.5976	11.6153	-11.617	-0.1886	-0.3001	-0.1883	10.2061	-18.8214	25.6630
	(-57.41)	(-23.95)	(9.88)	(9.09)	(-4.27)	(-16.37)	(-9.40)	(-4.66)	(7.01)	(-6.12)	(3.24)
0.05	-0.3459	-0.000385	2.3440	5.5054	1.4653	-0.0677	-0.0822	-0.0239	1.1623	-0.0367	7.8825
	(-56.58)	(-32.70)	(23.49)	(32.37)	(4.12)	(-12.27)	(-21.60)	(-4.64)	(4.34)	(-0.06)	(7.22)
0.10	-0.1547	-0.000199	1.3072	3.0826	1.1486	-0.0233	-0.0308	-0.0074	0.1092	0.2348	2.6802
	(-68.93)	(-37.51)	(42.67)	(64.77)	(10.73)	(-17.60)	(-16.74)	(-4.46)	(1.21)	(1.21)	(7.73)
0.50	0.0175	-0.000007	0.3237	1.0128	0.7868	0.0128	-0.0010	-0.0056	-0.2085	-0.3563	-0.4818
	(53.55)	(-15.46)	(51.22)	(82.52)	(38.93)	(37.47)	(-4.00)	(-26.89)	(-11.39)	(-9.10)	(-6.62)
0.90	0.4204	0.0000776	-0.0829	3.7349	6.0357	0.2248	0.0014	-0.0079	-2.6051	-6.6174	-13.1340
	(136.85)	(23.27)	(-1.39)	(31.92)	(29.59)	(68.06)	(0.66)	(-3.30)	(-15.19)	(-19.49)	(-20.93)
0.95	0.8185	0.0001518	-1.1273	4.3717	9.6728	0.4111	0.0013	0.0019	-4.2902	-11.3030	-23.0505
	(108.43)	(17.21)	(-6.91)	(15.12)	(18.95)	(51.38)	(0.19)	(0.28)	(-10.19)	(-12.73)	(-14.66)
0.99	2.6400	0.0005165	-6.2834	3.2687	19.9191	1.1519	0.0141	0.0416	-10.8549	-25.2803	-69.9030
	(68.18)	(11.48)	(-7.58)	(2.18)	(8.53)	(27.50)	(0.64)	(1.36)	(-6.53)	(-6.81)	(-10.97)

Table 4: AMR, UAL, Standard and Poor's Airline Index, and SPX Option Market Volume Statistics on the Trading Days Surrounding September 11

This table reports the values of three option market volume statistics on AMR, UAL, the Standard and Poor's airline index firm, and the SPX index over the four trade dates leading up to and following September 11, 2001. The underlying data from which the statistics are computed are the daily closing non-market maker long and short open interest for each option. Daily net long (short) volumes are defined as the first difference in the daily long (short) open interest on an option.

Volume Statistic	Prior to September 11				Post September 11			
	9/5/2001	9/6/2001	9/7/2001	9/10/2001	9/17/2001	9/18/2001	9/19/2001	9/20/2001
Panel A: AMR								
PutCall	0.75	0.68	0.73	7.07	0.45	1.28	0.99	1.67
ShortLong	0.16	-0.32	0.86	0.89	-0.91	-0.27	-0.37	0.34
AbnLongPut	-0.02	0.08	0.65	3.83	-1.11	-1.49	1.83	-0.96
Panel B: UAL								
PutCall	7.40	105.42	15.21	1.66	0.44	0.55	0.66	5.59
ShortLong	-0.87	0.87	0.24	-0.14	-0.18	0.02	-0.07	0.16
AbnLongPut	-0.12	1.45	1.23	0.15	0.78	0.63	-0.21	3.79
Panel C: Standard and Poor's Airline Index Firms								
PutCall	7.31	1.90	1.67	1.77	0.21	0.17	0.86	3.17
ShortLong	-0.02	0.37	0.59	0.47	-0.65	-0.33	-0.08	-0.14
AbnLongPut	-0.13	0.63	0.66	0.85	0.54	-0.66	1.03	2.76
Panel D: SPX Index								
PutCall	3.96	0.69	1.25	0.21	0.44	0.25	0.83	0.23
ShortLong	0.26	0.02	-0.13	-0.16	-0.05	-0.05	-0.18	-0.02
AbnLongPut	-0.07	0.25	0.54	-0.09	-0.26	0.04	0.38	0.10

**Table 5: Quantiles of Maximum Observed Values of Option Market Volume Statistics,
September 5 through September 10**

This table reports the quantiles of the maximum daily value of three option market volume statistics obtained over the four trade dates leading up to September 11, 2001. The underlying data from which the statistics are computed are the daily closing non-market maker long and short open interest for each option. Daily net long (short) volumes are defined as the first difference in the daily long (short) open interest on an option. Quantiles of the maximum observed value are reported for both the daily distributions of the statistics and the distribution of the maximum value of the statistics over disjoint four trade date intervals. The distributions were computed over the January 2, 1990 through September 4, 2001 time period.

Volume Statistic	Max Observed	Quantile of Daily Distribution	Quantile of Max. over Four Trade Date Distribution
Panel A: AMR/UAL			
PutCall	105.42	0.97	0.89
ShortLong	0.89	0.80	0.49
AbnLongPut	3.83	0.99	0.96
Panel B: Standard and Poor's Airline Index Firms			
PutCall	7.31	0.99	0.95
ShortLong	0.59	0.84	0.55
AbnLongPut	0.85	0.94	0.88
Panel C: SPX Index			
PutCall	3.96	0.88	0.62
ShortLong	0.26	0.76	0.38
AbnLongPut	0.54	0.95	0.82

Table 6: Conditional Quantile Estimates of Option Market Volume Statistics for AMR and UAL for the Four Trade Dates Preceding September 11

This table reports conditional estimates of the quantiles for AMR and UAL over the four trade dates preceding September 11, 2001 from the model

$$OptVolStat_t^s = \beta_0 + \beta_1 OptVol_t^s + \beta_2 RDay_t^s + \beta_3 RWeek_t^s + \beta_4 RMonth_t^s + \beta_5 AbnVolDay_t^s + \beta_6 AbnVolWeek_t^s$$
$$+ \beta_7 AbnVolMonth_t^s + \beta_8 RVWDay_t + \beta_9 RVWWeek_t + \beta_{10} RVWMonth_t + \varepsilon_t^s$$

where the dependent variable, $OptVolStat_t^s$, is indicated in Panels A and B. The reported conditional quantile estimates are obtained by multiplying the coefficient estimates for the model by the value of the independent variables for either AMR or UAL on each of the designated trade dates.

	9/5/2001		9/6/2001		9/7/2001		9/10/2001	
Quantile	AMR	UAL	AMR	UAL	AMR	UAL	AMR	UAL
				Panel A: *ShortLong*				
0.01	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
0.05	-1.000	-0.999	-1.000	-0.998	-0.999	-0.996	-0.997	-1.000
0.10	-0.958	-0.908	-0.989	-0.955	-0.988	-0.885	-0.978	-0.948
0.50	0.051	0.102	-0.048	-0.053	-0.079	0.078	-0.034	-0.017
0.90	0.982	0.978	0.972	0.954	0.954	0.960	0.954	0.953
0.95	1.000	0.999	0.999	0.997	0.998	0.997	0.996	0.999
0.99	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
				Panel B: *AbnLongPut*				
0.01	-1.463	-2.166	-1.914	-3.553	-2.784	-3.898	-3.739	-2.445
0.05	-0.353	-0.554	-0.469	-1.027	-0.829	-1.172	-1.245	-0.677
0.10	-0.179	-0.261	-0.230	-0.491	-0.404	-0.557	-0.632	-0.312
0.50	0.006	0.018	0.004	0.012	0.012	0.021	-0.007	0.016
0.90	0.331	0.604	0.407	0.818	0.743	0.949	0.646	0.734
0.95	0.666	1.168	0.815	1.587	1.446	1.808	1.285	1.431
0.99	2.256	3.678	2.732	5.012	4.592	5.603	4.265	4.507