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

After 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 attacks. This paper generates systematic information about option market activity that can be used to assess the option trading that precedes any event of interest. Examination of the option trading leading up to September 11 reveals that there was an unusually high level of put buying. This finding is consistent with informed investors having traded options 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 advance 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

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1. All dates in this paper that do not include a year occur in 2001.

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market trading will profit when the underlying stock price falls rather than rises. 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) Web site (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 advance 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 its sources had "never seen that kind of imbalance before" and 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 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 such as 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 Web site, three trading days before, on November 7, the put-call ratio for options on AMR stock was 7.74. On the basis of 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

2. It will be seen below that, in fact, the put-call ratio is usually less than one.

options did not occur 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 led 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 that the orders were based on adverse nonpublic 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. This paper has two goals. 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 1,000 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 values 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 on the basis of 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 to better assess when there is unusual activity in the options that they trade or that 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 on. 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 1,000 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.

One reason to suspect inferences from this comparison, however, is that

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 in which 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.

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 that establishes option market positions that will be profitable if the underlying stock price falls by volume that establishes option market positions that will be profitable if the underlying stock price increases. To address this problem, I define another ratio, ShortLong, which properly aggregates option market volume that is decreasing in the stock price and also properly aggregates 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 that 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 values 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 such as 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 that establishes option positions that 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

5. Likewise, delta-adjusting the option volume used in the option market volume statistics does not change the conclusions.

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 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) conclude that signed option volume does not contain information for subsequent stock price changes. Pan and Poteshman (2006) 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 (2005) 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. Section II describes the data. Section III defines the option market volume statistics used in the paper. Section IV 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. Section VI presents conclusions.

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 also listed at another exchange, the data cover non–market

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.

7. The 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 correspond to the aggregate long and short open interest for the OCC C and F origin codes.

maker open interest for all exchanges at which the option trades. Options that 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 correspond 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 contain 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 Security 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 permanent number (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 London Interbank Offer Rates are obtained from Datastream.

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 that 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 $N_{s,t}^{\text{Calls}}$ and $N_{s,t}^{\text{Puts}}$ be, respectively, the number of calls and puts listed on underlying security s on trade date t.[9] For $j = 1, \ldots, N_{s,t}^{\text{Calls}}$, let $\text{NVol}_{s,j,t}^{\text{LongCall}}$ ($\text{NVol}_{s,j,t}^{\text{ShortCall}}$) be the net long (short) trading volume by non–market makers on the jth call on underlying security s on trade date t. Define $\text{NVol}_{s,j,t}^{\text{LongPut}}$ ($\text{NVol}_{s,j,t}^{\text{ShortPut}}$) 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

8. This method for computing net trading volume implicitly treats option exercises as sales. 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.

9. Underlying security s will typically be an individual stock in 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.

underlying security s by the aggregate non–market maker net trading volume of calls written on underlying security s:

$$\text{PutCall}_t^s \equiv \frac{\sum_{j=1}^{N_{s,t}^{\text{Puts}}}(|\text{NVol}_{s,j,t}^{\text{LongPut}}| + |\text{NVol}_{s,j,t}^{\text{ShortPut}}|)}{\sum_{j=1}^{N_{s,t}^{\text{Calls}}}(|\text{NVol}_{s,j,t}^{\text{LongCall}}| + |\text{NVol}_{s,j,t}^{\text{ShortCall}}|)}. \tag{1}$$

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 it includes only the volume of non–market makers. Daily gross non–market maker put and call volumes on particular stocks are readily available from the OCC Web site. 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 whereas 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, that avoids this problem. ShortLong is a ratio whose numerator adds net trading volume that 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 that 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):

$$\begin{aligned}\text{ShortLong}_t^s \equiv & \left[\sum_{j=1}^{N_{s,t}^{\text{Calls}}}(\text{NVol}_{s,j,t}^{\text{ShortCall}} - \text{NVol}_{s,j,t}^{\text{LongCall}}) \right. \\ & \left. + \sum_{j=1}^{N_{s,t}^{\text{Puts}}}(\text{NVol}_{s,j,t}^{\text{LongPut}} - \text{NVol}_{s,j,t}^{\text{ShortPut}})\right] \\ & \div \left[\sum_{j=1}^{N_{s,t}^{\text{Calls}}}(|\text{NVol}_{s,j,t}^{\text{ShortCall}}| + |\text{NVol}_{s,j,t}^{\text{LongCall}}|) \right. \\ & \left. + \sum_{j=1}^{N_{s,t}^{\text{Puts}}}(|\text{NVol}_{s,j,t}^{\text{LongPut}}| + |\text{NVol}_{s,j,t}^{\text{ShortPut}}|)\right]. \end{aligned} \tag{2}$$

10. For example, for UAL over the period November 6, 2000, through September 4, 2001, the fifth, fiftieth, and ninety-fifth quantiles of the PutCall distribution are, respectively, 0.02, 0.52, and 15.4. The fifth, fiftieth, and ninety-fifth quantiles for the gross non–market maker put divided by gross non–market maker call volume distribution (computed from the OCC Web site data) are, respectively, 0.03, 0.52, and 15.6.

The denominator normalizes the variable by adding together the absolute values of all the option trading volume. This statistic ranges from minus one to plus one, with a value of minus one indicating that all option volume corresponds to option positions that will increase in value if the underlying security price rises and a value of plus one 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 measures 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]

$$\text{AbnLongPut}_t^s \equiv \frac{\sum_{j=1}^{N_{s,t}^{\text{Puts}}}(\text{NVol}_{s,j,t}^{\text{LongPut}}) - (1/126)\sum_{i=22}^{147}\sum_{j=1}^{N_{s,t-i}^{\text{Puts}}}(\text{NVol}_{s,j,t-i}^{\text{LongPut}})}{\text{std}\{\sum_{j=1}^{N_{s,t-i}^{\text{Puts}}}(\text{NVol}_{s,j,t-i}^{\text{LongPut}}),\ i = 22,\ \ldots,\ 147\}}. \tag{3}$$

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 that measure these quantities are defined as follows:

$$\text{OptVolStat}_{t,t+w}^{s,\text{DailyMax}} \equiv \max\{\text{OptVolStat}_{t+i}^s,\ i = 0,\ \ldots,\ w\}, \tag{4}$$

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

$$\text{PutCall}_{t,t+w}^{s,\text{DailyMax}} \equiv \max\{\text{PutCall}_{t+i}^s,\ i = 0,\ \ldots,\ w\} \tag{5}$$

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

Before I present 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 on 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 there 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

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

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 on 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]

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 that 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 that have underlying stocks in the top 1,000 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), whereas at the 0.95 quantile it is 15.45. The distribution of the ShortLong statistic is roughly similar once it is taken into account that it

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 that 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, whereas 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.

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 500 largest market capitalizations on CRSP on the first trading day of each calendar year are similar to those presented in panel A of table 1.

TABLE 1 **Distribution of Daily Option Market Volume Statistics for 1,000 Largest Market Capitalization Firms, Standard and Poor's Airline Index Firms, and the SPX index, January 2, 1990, through September 4, 2001**

Volume Statistic	*N*	Minimum	Quantiles .001	.01	.05	.10	.25	.50	.75	.90	.95	.99	.999	Maximum
							A. 1,000 Largest Market Capitalization Firms							
PutCall	953,976	.00	.00	.00	.00	.00	.05	.32	1.07	4.02	15.45	Inf	Inf	Inf
ShortLong	953,976	−1.00	−1.00	−1.00	−1.00	−1.00	−.54	.07	.76	1.00	1.00	1.00	1.00	1.00
AbnLongPut	777,631	−348.42	−15.60	−5.28	−.94	−.29	−.07	.01	.13	.54	1.13	4.06	17.01	437.94
							B. Standard and Poor's Airline Index Firms							
PutCall	2,940	.01	.01	.03	.08	.12	.24	.49	.94	1.84	2.89	9.50	38.89	105.17
ShortLong	2,940	−1.00	−1.00	−1.00	−.81	−.61	−.27	.04	.40	.78	.94	1.00	1.00	1.00
AbnLongPut	2,804	−12.85	−8.52	−5.32	−1.02	−.30	−.04	.08	.26	.60	.92	1.93	5.95	14.66
							C. SPX Index							
PutCall	2,940	.01	.03	.12	.28	.44	.79	1.38	2.41	4.41	6.89	15.79	53.17	69.83
ShortLong	2,940	−1.00	−1.00	−1.00	−.51	−.30	−.09	.06	.25	.48	.63	.92	1.00	1.00
AbnLongPut	2,804	−14.84	−10.83	−6.24	−.37	−.05	.05	.15	.27	.41	.54	.88	1.52	9.71

NOTE.—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 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 1,000 largest market capitalization stocks in the CRSP 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.

ranges from minus one to plus one. It will be seen below, however, that the ShortLong statistic 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. On the basis of 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 maxima 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 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 on 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 the contracts that traded were either puts or calls. When only puts trade, the value of the statistic is infinity; when only calls trade, 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 on the basis of past returns and hedge their bets in the option market. The option market volume associated with the hedging would affect the option volume statistics and, hence, would potentially affect 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

TABLE 2 **Distribution of Daily Maxima of Option Market Volume Statistics over Four Trade Date Intervals for 1,000 Largest Market Capitalization Firms, Standard and Poor's Airline Index Firms, and the SPX index, January 2, 1990, through September 4, 2001**

Volume Statistic	*N*	Minimum	Quantiles .001	.01	.05	.10	.25	.50	.75	.90	.95	.99	.999	Maximum
						A. 1,000 Largest Market Capitalization Firms								
$\text{PutCall}^{\text{DailyMax}}$	238,018	.00	.00	.00	.09	.24	.64	1.61	5.44	Inf	Inf	Inf	Inf	Inf
$\text{ShortLong}^{\text{DailyMax}}$	238,018	−1.00	−1.00	−.67	−.16	.06	.47	.91	1.00	1.00	1.00	1.00	1.00	1.00
$\text{AbnLongPut}^{\text{DailyMax}}$	194,730	−11.10	−.37	−.14	−.06	−.02	.04	.20	.69	1.80	3.15	9.41	33.55	437.94
						B. Standard and Poor's Airline Index Firms								
$\text{PutCall}^{\text{DailyMax}}$	736	.14	.15	.26	.41	.53	.76	1.29	2.31	4.58	7.48	17.43	91.29	105.17
$\text{ShortLong}^{\text{DailyMax}}$	736	−.50	−.49	−.30	−.07	.05	.25	.52	.87	1.00	1.00	1.00	1.00	1.00
$\text{AbnLongPut}^{\text{DailyMax}}$	675	−1.72	−1.65	−1.21	−.89	−.76	−.55	−.29	.26	1.05	1.74	5.92	22.87	23.87
						C. SPX Index								
$\text{PutCall}^{\text{DailyMax}}$	736	.57	.58	.84	1.14	1.37	1.96	3.25	5.57	9.00	13.35	30.78	66.75	69.83
$\text{ShortLong}^{\text{DailyMax}}$	736	−.19	−.18	−.06	.02	.08	.18	.32	.54	.76	.89	1.00	1.00	1.00
$\text{AbnLongPut}^{\text{DailyMax}}$	701	−.04	−.04	.02	.10	.13	.21	.31	.47	.67	.85	1.34	9.15	9.71

NOTE.—This table presents the minimum, maximum, and quantiles of the daily maxima over four trade date intervals of three option market volume statistics over the period January 2, 1990 through September 4, 2001. See also the note to table 1.

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 that 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

$$\begin{aligned}\text{OptVolStat}_t^s = {} & \beta_0 + \beta_1 \text{OptVol}_t^s + \beta_2 \text{RDay}_t^s + \beta_3 \text{RWeek}_t^s \\ & + \beta_4 \text{RMonth}_t^s + \beta_5 \text{AbnVolDay}_t^s \\ & + \beta_6 \text{AbnVolWeek}_t^s + \beta_7 \text{AbnVolMonth}_t^s \\ & + \beta_8 \text{RVWDay}_t + \beta_9 \text{RVWWeek}_t \\ & + \beta_{10} \text{RVWMonth}_t + \varepsilon_t^s, \qquad (6)\end{aligned}$$

where OptVolStat_t^s is a standardized version of either 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 be performed only for cases in which 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 (i.e., 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 $t-22$. The variables 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 reports the results of performing quantile regression over the period January 2, 1990, through September 4, 2001, when the universe of underlying stocks is the 1,000 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–independently and identically distributed (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, these data are readily available at the OCC Web site.[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 above, I consider this target period because it contains the trade dates most market observers seemed to be focusing on 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

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 Web site pertain to gross rather than net trading. However, as was discussed in n. 10, this difference should not have a significant impact on the comparison.

16. Conditional quantiles were also computed for ShortLong, for a delta-adjusted version of the statistics, and for the cases in which 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.

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

Quantile	Intercept	OptVol	RDay	RWeek	RMonth	AbnVol Day	AbnVol Week	AbnVol Month	RVW Day	RVW Week	RVW Month
	A. Dependent Variable Is PutCallStand										
.01	−.0001	.0000002	−.0003	−.0006	−.0005	.0000	.0000	.0000	−.0002	.0002	−.0002
	(−11.83)	(8.18)	(−19.97)	(−18.31)	(−4.25)	(.74)	(5.84)	(5.35)	(−6.53)	(1.26)	(−.88)
.05	−.0000	.0000006	−.0004	−.0007	−.0005	.0000	.0000	.0000	−.0001	−.0004	−.0009
	(−19.56)	(61.27)	(−23.84)	(−20.20)	(−8.63)	(6.40)	(5.52)	(3.14)	(−4.08)	(−5.09)	(−6.74)
.10	.0003	.0000013	−.0066	−.0133	−.0083	.0005	.0002	.0000	−.0035	−.0071	−.0210
	(6.67)	(63.77)	(−6.95)	(−7.00)	(−4.57)	(6.62)	(4.66)	(.29)	(−3.31)	(−3.28)	(−4.53)
.50	.2547	.0000012	−.7298	−.7405	.1483	.0006	.0055	.0061	−.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)
.90	.7890	−.000001	−.9423	−1.3404	−.8649	−.0078	−.0058	−.0047	−.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)
.95	.9122	−.000001	−.7772	−1.2696	−1.2247	−.0083	−.0082	−.0061	−.2685	−1.6263	−2.8549
	(1,287.51)	(−67.27)	(−46.94)	(−39.19)	(−16.26)	(−36.68)	(−13.74)	(−6.97)	(−4.64)	(−12.38)	(−10.24)
.99	1.0000	−.000001	−.0009	−.0022	−.0022	−.0000	−.0000	−.0000	.0001	−.0001	.0002
	(739,614.15)	(−399.09)	(−11.90)	(−12.63)	(−12.73)	(−7.38)	(−7.59)	(−1.35)	(2.90)	(−.80)	(.96)

	B. Dependent Variable Is AbnLongPut										
.01	−1.7843	−.001008	4.5976	11.6153	−11.617	−.1886	−.3001	−.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)
.05	−.3459	−.000385	2.3440	5.5054	1.4653	−.0677	−.0822	−.0239	1.1623	−.0367	7.8825
	(−56.58)	(−32.70)	(23.49)	(32.37)	(4.12)	(−12.27)	(−21.60)	(−4.64)	(4.34)	(−.06)	(7.22)
.10	−.1547	−.000199	1.3072	3.0826	1.1486	−.0233	−.0308	−.0074	.1092	.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)
.50	.0175	−.000007	.3237	1.0128	.7868	.0128	−.0010	−.0056	−.2085	−.3563	−.4818
	(53.55)	(−15.46)	(51.22)	(82.52)	(38.93)	(37.47)	(−4.00)	(−26.89)	(−11.39)	(−9.10)	(−6.62)
.90	.4204	.0000776	−.0829	3.7349	6.0357	.2248	.0014	−.0079	−2.6051	−6.6174	−13.1340
	(136.85)	(23.27)	(−1.39)	(31.92)	(29.59)	(68.06)	(.66)	(−3.30)	(−15.19)	(−19.49)	(−20.93)
.95	.8185	.0001518	−1.1273	4.3717	9.6728	.4111	.0013	.0019	−4.2902	−11.3030	−23.0505
	(108.43)	(17.21)	(−6.91)	(15.12)	(18.95)	(51.38)	(.19)	(.28)	(−10.19)	(−12.73)	(−14.66)
.99	2.6400	.0005165	−6.2834	3.2687	19.9191	1.1519	.0141	.0416	−10.8549	−25.2803	−69.9030
	(68.18)	(11.48)	(−7.58)	(2.18)	(8.53)	(27.50)	(.64)	(1.36)	(−6.53)	(−6.81)	(−10.97)

NOTE.—This table reports the results of performing quantile regression of two option market volume statistics on a number of explanatory variables. The data consist of options on the 1,000 largest market capitalization firms over the period from January 2, 1990 through September 4, 2001. The option volume data were obtained directly from the CBOE, and all other data come from CRSP. The regression specification is eq. (6). The *t*-statistics reported in parentheses are computed assuming non-iid error terms using the sparsity estimation method described in Koenker (2002).

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

Volume Statistic	Prior to September 11				After September 11			
	Sept. 5	Sept. 6	Sept. 7	Sept. 10	Sept. 17	Sept. 18	Sept. 19	Sept. 20
	A. AMR							
PutCall	.75	.68	.73	7.07	.45	1.28	.99	1.67
ShortLong	.16	−.32	.86	.89	−.91	−.27	−.37	.34
AbnLongPut	−.02	.08	.65	3.83	−1.11	−1.49	1.83	−.96
	B. UAL							
PutCall	7.40	105.42	15.21	1.66	.44	.55	.66	5.59
ShortLong	−.87	.87	.24	−.14	−.18	.02	−.07	.16
AbnLongPut	−.12	1.45	1.23	.15	.78	.63	−.21	3.79
	C. Standard and Poor's Airline Index Firms							
PutCall	7.31	1.90	1.67	1.77	.21	.17	.86	3.17
ShortLong	−.02	.37	.59	.47	−.65	−.33	−.08	−.14
AbnLongPut	−.13	.63	.66	.85	.54	−.66	1.03	2.76
	D. SPX Index							
PutCall	3.96	.69	1.25	.21	.44	.25	.83	.23
ShortLong	.26	.02	−.13	−.16	−.05	−.05	−.18	−.02
AbnLongPut	−.07	.25	.54	−.09	−.26	.04	.38	.10

NOTE.—This table reports the values of three option market volume statistics on AMR, UAL, the Standard and Poor's airline index firms, 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.

AMR on September 10 and for UAL on September 6. The PutCall statistic was 7.07 on 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 for UAL—indicate that there was an unusual level of option market positions established during the target period that 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 dis-

17. When AMR and UAL are removed from the airline index, the September 5 PutCall value drops from 7.31 to 5.04.

TABLE 5 Quantiles of Maximum Observed Values of Option Market Volume Statistics, September 5 through September 10

Volume Statistic	Maximum Observed	Quantile of Daily Distribution	Quantile of Maximum over Four Trade Date Distribution
		A. AMR/UAL	
PutCall	105.42	.97	.89
ShortLong	.89	.80	.49
AbnLongPut	3.83	.99	.96
		B. Standard and Poor's Airline Index Firms	
PutCall	7.31	.99	.95
ShortLong	.59	.84	.55
AbnLongPut	.85	.94	.88
		C. SPX Index	
PutCall	3.96	.88	.62
ShortLong	.26	.76	.38
AbnLongPut	.54	.95	.82

NOTE.—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 values of the statistics over disjoint four trade date intervals. The distributions were computed over the January 2, 1990, through September 4, 2001, time period.

tributions are just the ones reported in tables 1 and 2.[18] Panel A of table 5 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 was 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

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 is the 1,000 largest market capitalization firms in the 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.

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 values 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. In fact, the 0.49 quantile for 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 affected 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 maxima 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 airline stocks most directly affected 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 airline 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. 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

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.), in the previous section I did not develop the tools to make this comparison.

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.

Terrorists or their associates may have believed that either 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 maxima 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 or NASDAQ 100 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 18 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 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 on 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 reopened 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 reopening). 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 reopened, even if conditional distributions are used as benchmarks.

I now turn to an analysis of the option trading on AMR and UAL during the target period that 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) and the values of the independent variables for AMR and UAL during the target period to produce conditional estimates for

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

	Sept. 5		Sept. 6		Sept. 7		Sept. 10	
Quantile	AMR	UAL	AMR	UAL	AMR	UAL	AMR	UAL
				A. ShortLong				
.01	−1.000	−1.000	−1.000	−1.000	−1.000	−1.000	−1.000	−1.000
.05	−1.000	−.999	−1.000	−.998	−.999	−.996	−.997	−1.000
.10	−.958	−.908	−.989	−.955	−.988	−.885	−.978	−.948
.50	.051	.102	−.048	−.053	−.079	.078	−.034	−.017
.90	.982	.978	.972	.954	.954	.960	.954	.953
.95	1.000	.999	.999	.997	.998	.997	.996	.999
.99	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
				B. AbnLongPut				
.01	−1.463	−2.166	−1.914	−3.553	−2.784	−3.898	−3.739	−2.445
.05	−.353	−.554	−.469	−1.027	−.829	−1.172	−1.245	−.677
.10	−.179	−.261	−.230	−.491	−.404	−.557	−.632	−.312
.50	.006	.018	.004	.012	.012	.021	−.007	.016
.90	.331	.604	.407	.818	.743	.949	.646	.734
.95	.666	1.168	.815	1.587	1.446	1.808	1.285	1.431
.99	2.256	3.678	2.732	5.012	4.592	5.603	4.265	4.507

NOTE.—This table reports conditional estimates of the quantiles for AMR and UAL over the four trade dates preceding September 11, 2001 from the model eq. (6). The reported conditional quantile estimates are obtained by summing the products of the coefficient estimates for the model and the values of the independent variables for either AMR or UAL on each of the designated trade dates.

ShortLong and AbnLongPut. These conditional quantile estimates are reported in table 6.[20]

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 quantiles. 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 quantiles. 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 one accounts for variation

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.

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 on the basis of foreknowledge of the impending attacks.

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 advance 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 that measure in different ways the extent to which non–market maker volume establishes option market positions that 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; 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 that is consistent with investors trading on advance knowledge of the attacks.

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 have 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.

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