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Trading activity in options and stock around price sensitive news announcements

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Abstract

This study investigates the trading activity in options and stock markets around informed events with extreme daily stock price movements. We find that informed agents are more likely to trade options prior to negative news and stocks ahead of positive news. We also show that optioned stocks overreact to the arrival of negative news, but react efficiently to positive news. However, the overreaction patterns are unique to the subsample of stocks with the lowest pre-event abnormal option/stock volume ratio (O/S). This finding suggests that the incremental benefit of option listing is related to the level of option trading activity, over and beyond the presence of an options market on the firm's stock. Finally, we find that the pre-event abnormal O/S is a better predictor of stock price patterns following a negative shock than is the pre-event O/S, implying that the former may contain more information about the future value of stocks than the latter.

JEL classification: G12, G14, G22

Keywords: option trading activity, stock trading activity, informed trading, informational efficiency.

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Abstract

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1. Introduction

We propose an innovative approach that we use to investigate several issues relating to the impact of option listing on the informational efficiency of the underlying stocks. Our analysis is based on examining transactions volumes in options and stock markets around "informed" shocks in excess of 10% (sign ignored)[1] and relating the level of trading activity in options and stock to the stock price reaction to shocks. This approach allows us to address the following important questions empirically: Do informed traders prefer to trade options or stock? Does the relative concentration of informed traders in options or stock markets affect the informational efficiency of the underlying stocks?

Whilst some of these issues have attracted a lot of attention in the literature, existing theoretical arguments remain ambiguous and empirical evidence is largely inconclusive. Figlewski (1989) argues that the effect of options introduction on the informational efficiency of the underlying stocks will mainly depend on the quality of information possessed by the newly attracted traders. Cox and Rubinstein (1985) argue that the opportunity to use options to construct portfolios that effectively circumvent restrictions imposed on selling short may increase the attractiveness of the options markets to informed traders. Thus, options may enhance the speed of price adjustment to information, enabling informed investors to trade more quickly and efficiently on their private information. However, Gorton and Pennacchi (1993) argue that options offer noise traders opportunities to hedge their stock positions at a low cost. Stein (1989) argues that, if options markets are more attractive to noisy traders, information released by option traders may inflict a negative externality on those traders already in the market, impairing their ability to make inferences from prices. In other words, the increased amount of noise trading in the options market may delay the speed at which new information is incorporated into the stock price. More recently, Roll et al. (2010) argue that the informational efficiency benefit from option listing should depend on whether the market for the listed option has sufficient volume, as informed traders would be more active in high-volume markets (Admati & Pfleiderer, 1988).

Consistent with the notion that informed traders prefer to trade options than stock, Easley et al. (1998) and Pan and Poteshman (2006) show that option trading volumes contain useful information about future stock prices. Cao et al. (2005) show that information asymmetry is greater in options than in stock and argue that informed agents find the options

[1] We define "informed" daily price shocks as large one-day price changes caused by the news announcements in the Regulatory News Service (RNS) of the London Stock Exchange (LSE).

markets to be more attractive venues for trading. Peterson (1995) and Choi and Jayaraman (2009) find that optioned stocks react more efficiently to large price declines than their non-optioned counterparts. Roll et al. (2010) examine the trading volume in options (including both call and put contracts) relative to the trading volume in stocks (O/S) around earnings announcements. They argue that the positive association between pre-announcement O/S and post-announcement absolute returns implies that at least part of the pre-announcement option trading is informed[2]. However, many other studies provide evidence in favor of the view that informed traders prefer to transact in stock rather than options markets. Stephan and Whaley (1990) find that the price changes in the stock markets lead the options markets by as much as fifteen minutes. Similarly, Chan et al. (2002) show that the stock net-trading volume, but not the options net-trading volume, has a strong ability to predict stock and options quote revisions.

By examining trading activities in options and stock prior to the arrival of price-sensitive news, and relating these activities to the stock price reaction to informed shocks, this study contributes to the literature in at least two important ways. First, we argue that stock and options volume analysis around informed shocks offers an innovative approach to investigating whether traders prefer to initiate trades in options or stock prior to the arrival of news. Spyrou et al. (2011) provide evidence that informed traders are active in the options markets during the month preceding a mergers and acquisition announcement. However, their analysis does not necessarily imply that informed traders prefer to transact in options than stock markets. Building on Roll et al. (2010), we also use abnormal O/S to evaluate the relative trading activity in the options and stock markets around news announcements. We argue that the changes in trading activity around price-sensitive news announcements may be better captured by abnormal O/S than the standard O/S measure of Roll et al., as a high O/S ratio associated with a given firm may not be unique to the windows around news events. Roll et al. report high O/S around earnings announcements, but do not distinguish between positive and negative announcements. We argue that this distinction is important as short-sale constraints in the equity market may make options markets more attractive venues for trading on negative news than positive news.

Second, we evaluate the extent to which abnormal option or stock trading can increase the speed at which information is incorporated into stock prices. Specifically, we examine the

[2] Roll et al. (2010) uses O/S to measure the relative trading activity in options and stock. They argue that an increase in O/S prior to the arrival of important news would indicate that relatively more informed trading is taking place in options than stock markets, and vice versa.

link between the level of option trading activity and the stock price reaction to new information, in order to test Roll et al.'s (2010) prediction that the incremental benefit of option listing should be related to the level of option trading activity, as a thin, inactive market would repel all traders, both informed and uninformed. Our analysis differs from existing studies on the impact of option listing on stock price adjustments to shocks, such as Peterson (1995) and Choi and Jayaraman (2009), in a number of important aspects. First, we examine the impact of the level of option trading, rather than the availability of option trading on a firm's stock, on the stock price reaction to shocks. Second, our analysis focuses on "informed" events only, as informed trading is conditioned on the presence of information prior to large price changes (see also Larson & Madura, 2003). In other words, if some extreme price movements are caused by liquidity or noise trading, option trading activity prior to these events may not imply the presence of informed trading. Finally, we evaluate option and stock trading activity around both positive and negative shocks to test whether equity short-sale costs lead informed traders to trade options more frequently in the case of negative news than positive news.

Our main findings can be summarized as follows. First, we show that daily abnormal O/S is statistically significant prior to large price declines, but not significantly different from zero in the period immediately prior to positive news announcements. This finding implies that informed traders are more likely to trade options in response to negative signals than positive ones. This evidence is robust to alternative option volume measures, estimation windows and definitions of price shocks. Second, we show that optioned stocks overreact to negative shocks, but react efficiently to positive ones. This result suggests that the existence of options markets does not always cause stock prices to react efficiently to shocks. It also indicates that the informational efficiency benefit of options may depend on other factors, including the relative trading activity in options and stock markets. We show that the positive rebound following a negative shock is negatively associated with pre-event abnormal O/S. In other words, our results suggest that the concentration of informed traders in options helps investors to estimate the true value of the stock. This finding supports Roll et al.'s (2009) view that the informational efficiency benefit of the options markets depends on the trading activity in options, over and above the mere listing of options on the firm's stock. Finally, both the subsample analysis and the regression results suggest that pre-event abnormal O/S is a better predictor of stock price patterns following a negative shock than is the pre-event O/S, implying that the former may contain more information about the future value of stocks than the latter.

The remainder of the paper is organized as follows. Section 2 presents the methodology. Section 3 describes our dataset and provides a brief summary of the descriptive statistics. Section 4 reports the empirical results and Section 5 concludes.

2. Empirical procedures

This section describes the various variables used to evaluate the informational role of options and stock in the period preceding price-sensitive news announcements. Following other studies on the market reaction to price shocks (e.g. Cox & Peterson, 1994; Faff & Hillier, 2005; Mazouz et al. 2009), event study methods are used to estimate abnormal trading activities and abnormal returns around informed shocks.

2.1. Abnormal volume estimates

We begin our analysis by investigating the trading activities in options and stock markets prior to the arrival of price-sensitive news. We estimate the cross-sectional average abnormal volume on day t $(\overline{AVol_{w,t}})$ and over a $\pi = [t_1, t_2]$ window $(\overline{AVol_{w,\pi}})$ around the events as follows:

$$\overline{AVol_{w,t}} = \frac{\sum_{i=1}^{N} AVol_{w,i,t}}{N} \tag{1}$$

$$\overline{AVol_{w,\pi}} = \frac{\sum_{t=t1}^{t2} \overline{AVol_{w,t}}}{\pi} \tag{2}$$

where $AVol_{w,i,t}$ is stock i's abnormal volume on day t, measured as the difference between the daily volume $(Vol_{w,i,t})$ and the average value of $Vol_{w,i,t}$ over T days, from -100 to -11, prior to the arrival of price-sensitive news, subscript w is replaced by s, o and o/s, respectively, when stock volume, option volume and the option to stock volume ratio (O/S) are analyzed, and N is the number of stocks included in the sample. Our use of the average values of trading measures over the window [-100, -11] as benchmarks is consistent with the early work of Bremer and Sweeney (1991) and Cox and Peterson (1994). Furthermore, we require each stock to have at least 30 non-missing observations in the 90-day window prior to the event in order to ensure that the abnormal measures are not affected by less frequently traded stocks.

Stock i's daily stock volume $(Vol_{s,i,t})$, option volume $(Vol_{o,i,t})$ and O/S $(Vol_{o/s,i,t})$ are specified as

$$Vol_{s,i,t} = \left(\frac{EQTV_{i,t}}{NOSH_{i,t}}\right) \quad (3)$$

$$Vol_{o,i,t} = \ln(NCP_{i,t}) \quad (4)$$

$$Vol_{o/s,i,t} = \ln\left(\frac{NCP_{i,t}}{EQTV_{i,t}}\right) \quad (5)$$

where $EQTV_{i,t}$ and $NOSH_{i,t}$ are stock i's daily trading volume and the number of shares outstanding on day t, respectively and $NCP_{i,t}$ is the total number of daily traded option contracts (including both puts and calls) on stock i[3]. The Newey-West adjusted t-statistic (NW t-stat) is used to verify the statistical significance of the relevant abnormal volume measure.

We argue that the use of abnormal O/S to assess the relative informativeness of traders in options and stock markets forms an important methodological innovation in this study. Roll et al.'s (2010) O/S measure may lead to misleading conclusions on the relative ability of options and stock markets to attract informed traders, as some firms may have consistently higher O/S for reasons unrelated to the arrival of information.

2.2. *Stock price reaction to informed shocks*

We examine the link between option trading activity and the informational efficiency of the underlying stocks by analyzing stock price patterns following informed daily price changes in excess of 10% (sign ignored). The purpose of this analysis is to investigate whether the ability of options markets to stimulate informational efficiency depends on the level of option trading activity. We use the following equation to estimate daily abnormal returns ($AR_{i,t}$) around the events (see, e.g., Edmister et al., 1994; Mazouz and Saadouni, 2007):

$$AR_{i,t} = R_{i,t} - \widehat{\alpha}_{pre} - \widehat{\beta}_{pre} R_{m,t} \quad (6)$$

where $R_{i,t}$ is the continuously compounded return of stock i on day t, computed from the mid-point of the bid and ask prices to control for the bid-ask bounce; $R_{m,t}$ is the continuously compounded return on the market portfolio (FTSE All Share Index) at time t; $\widehat{\alpha}_{pre}$ and $\widehat{\beta}_{pre}$

[3] In the case of zero option volume, we add one to $NCP_{i,t}$ before taking the log (see, e.g., Sanders and Zdanowicz , 1992).

are the coefficients of the ordinary least squares (OLS) estimates for the standard market model over the [-201, -11] window prior to the event.

To calculate the cumulative abnormal returns ($CAR_{i,\tau}$) for stock *i* over a window of τ days starting one day after the price shock, we use

$$CAR_{i,\tau} = \sum_{t=1}^{\tau} AR_{i,t} \tag{7}$$

The average cumulative abnormal return over a window of τ days, beginning one day after the shock, and across *N* stocks, is estimated as

$$CAR_{\tau} = \frac{1}{N}\sum_{i=1}^{N} CAR_{i,\tau} \tag{8}$$

We use the NW t-stat[4] to assess the statistical significance of $CAR_{i,\tau}$ and CAR_{τ}. We also employ the non-parametric Mann-Whitney (MW) and Kruskal-Wallis (KW) tests to examine whether the abnormal returns associated with different groups of stocks are statistically different from each other.

3. Data and sample characteristics

Our analysis is based on a sample of the London Stock Exchange (LSE) stocks with options listed on the Euronext[5] over the period from January 1993 to June 2010. To be included in the sample, a stock must have data available from DataStream on the option trading volume, the stock turnover and the stock price. Firm news is extracted from the Factiva news database owned by Dow Jones & Company. Since the regulatory news category in Factiva is compulsory for the exchange house to disclose to the public, we searched for regulatory news on our stocks across the sample period. We matched the date of a price shock, which is defined as a one-day price movement in excess of 10% (sign ignored), with the dates of news announcements from the Factiva database.

[4] We also used the standard t-test to gauge the statistical significance of the abnormal returns. The results are not reported here, because they are quantitatively very similar to the results generated from the NW adjusted t-statistics. Further details are available upon request.

[5] Since our sample period is from 1993 to 2010, we also include stocks whose options were listed in the London International Financial Futures and Options Exchange (LIFFE) before December 2001. In December 2001, the Euronext acquired the shares of the LIFFE.

We define our observation window as the eleven days around a large price change, i.e. day -5 to day +5. The use of a five-day post-event window is justified by the findings in the literature that most of the price reversals for large firms are short-lived, with significant abnormal returns observed only in the first three event days after price shocks (Peterson, 1995; Choi & Jayaraman, 2009). The pre-event five-day window is included in our analysis to account for the behavior of informed traders who may take advantage of information leakage before events. To avoid confounding effects, multiple price shocks in a single observation window are excluded from the analysis[6]. We also require from each firm a complete set of 150 daily return series over the [-200, -11] window in order to estimate abnormal returns. Each event must have at least one data point of option trading volume in the [-5, -1] and [+1, +5] windows. Our final sample consists of 137 stocks with 504 (217 negative and 287 positive) shocks matched with news announcements. More details on the event filtering and news announcement classifications are provided in Appendix A and Appendix B, respectively.

Panel A in Table 1 compares the characteristics of our sample stocks with those of the FTSE All Share Index constituents over the period 1993-2010. The mean values of the price, market capitalization and standard deviation of the sample stocks are higher than those in the 50th, but lower than those in the 90th, percentile of FTSE All Share constituents. The average daily turnover of the sample stocks exceeds that of the 90th percentile portfolio of highest liquid index constituents. Thus, the figures in Table 1 imply that our sample is biased towards large, liquid and volatile stocks. This bias is consistent with Mayhew and Mihov's (2004) finding that option exchanges are often forward looking and tend to list options on stocks with high market capitalization, trading volume and volatility.

Insert Table 1 about here

Panel B in Table 1 reports percentiles of price changes for the sample stocks across 4,420 trading days from 4th January 1993 to 30th June 2010. The first row reports the time-series averages of the cross-sectional means across each trading day. The table shows that the price change of the first percentile is -2.69% and that of the 99th percentile is +2.66%. The second row in Panel B reports pooled time-series and cross-sectional averages of price changes with 516,963 firm-day observations. The first and 99th percentiles of price changes

[6] In unreported results, we found that ignoring the confounding effects did not alter our conclusions. Further details are available upon request.

are -6.09% and +6.69%, respectively. This result suggests that ±10% price shocks are indeed extreme events for individual stocks across the trading days in the sample.

Table 2 presents the descriptive statistics of the different volume measures used in our analysis. For each volume measure, we compute the time-series mean across 4,420 days for each stock and then calculate the cross-sectional mean by averaging for the time-series means across the 137 sample stocks. Panel A-1, Panel B-1 and Panel C-1 in Table 2 show that the averages of raw stock volume, options volume and O/S are 0.01, 226.36, and 28.3, respectively. The means of the raw volumes are much larger than the corresponding medians of 0.01, 85.97, and 1.69, implying that the means are influenced by outliers. The Jarque-Bera test indicates that the daily cross-sectional averages of the three volume series deviate from normality. To mitigate the influence of possible outliers, we use the natural logarithm of each of the volume variables in Panel A-2, Panel B-2 and Panel C-2. The Jarque-Bera test in Table 2 also indicates that the log values of options volume and O/S are normally distributed, but the log values of stock volume deviate from normality.

Insert Table 2 about here

Table 3 provides cross-sectional summary statistics of the partial autocorrelation up to five lags of Vol_s, Vol_o and $Vol_{o/s}$, respectively. It shows that the partial correlations of all the volume measures are positive and decline monotonically over time. The positive autocorrelations may reflect the behavior of informed traders, who may begin trading a few days ahead of the arrival of news and trade slowly to maximize their profits (Kyle, 1985; Roll et al., 2010). To mitigate the influence of autocorrelation on our results, we use the NW *t*-stat to assess the statistical significance of the abnormal volume measures.

Insert Table 3 about here

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4. Empirical results

4.1. Informed trading in options and stock markets

The levels of trading activity in options and stock prior to the arrival of price-sensitive news are used to investigate whether informed traders are more likely to transact in options or stock. Table 4 reports the results on the various abnormal volume estimates for the period immediately before the arrival of price-sensitive news. Panel A of Table 4 shows that the average abnormal stock volume over the [-5,-1] and [-3, -1] windows around negative news announcements is positive, but not statistically significant. The highest level of stock trading activity of 0.0188 (with a NW *t*-stat of 6.49) is observed on the day of the negative news announcement, and a significantly positive abnormal stock volume of 0.0019 is reported one day prior to the arrival of negative news. However, the abnormal stock volumes associated with days -2 through -5 prior to negative news are positive, but not statistically significant. This finding indicates that stock market traders anticipate the arrival of negative news one day before the announcement date. Our evidence is consistent with the view that at least some informed trading is taking place in the stock market prior to the arrival of news (see, e.g., Easley et al., 2002; Pan & Poteshman, 2006; Spyrou et al., 2011).

Panel A of Table 4 also reports the pre-negative-shock abnormal option volume. The average cumulative abnormal option volumes over the [-5,-1] and [-3,-1] windows preceding negative shocks are 30.79% and 44.57%, respectively. Both figures are significant at the 5% level. The highest daily abnormal option volume of 155.74% is reported on the negative news announcement dates. The abnormal option volumes on days -3 through -1 prior to a negative news announcement are positive and statistically significant. This finding suggests that option traders anticipate the arrival of negative news two days earlier than stock traders. Panel A of Table 4 also reports significantly positive abnormal O/S of 20.00% and 31.01% over the [-5, -1] and [-3, -1] windows, respectively. The abnormal O/S on days -4 through -2 are also positive and significant at least at the 10% level. These findings are consistent with the view that option traders are more active than stock traders in the period preceding a negative news announcement (see, e.g., Cox & Rubinstein, 1985; Chakravarty et al., 2004).

Insert Table 4 about here

Panel B in Table 4 reports the abnormal trading activity in options and stock in the periods preceding events with positive news announcements. It shows that the average abnormal stock volumes over the [-5, -1] and [-3,-1] windows preceding positive shocks are 0.0010 and 0.0014, respectively. These figures are significant at the 5% level. By comparing the results in Panels A and B, we can see that the magnitude of the abnormal stock volume associated with positive shocks is nearly two times larger than that observed in the case of negative shocks. This result shows that abnormal stock trading is more pronounced prior to positive news than negative news. Similar to the case of negative shocks, we also report the highest daily abnormal stock volume of 0.0188 (with a NW *t*-stat of 6.23) on the positive news announcement dates. The significantly positive abnormal volumes associated with days -4, -2 and -1 imply that stock market traders anticipate the arrival of positive news and begin their trading before the announcement dates. Our results are in line with Korczak et al.'s (2010) evidence that insider trading in the stock market is more prevalent before good than bad news announcements.

Panel B in Table 4 reports the highest daily abnormal option volume (of 208.87%) on the dates of positive news announcements. However, unlike the case of abnormal stock volume, the abnormal option volume in the period immediately before the arrival of positive news is not statistically significant, indicating that informed agents may prefer to trade stock rather than options when they anticipate the arrival of good news. The results in Panel B also indicate that the abnormal O/S over the windows of [-5, -1] and [-3,-1] prior to good news are negative, but not statistically significant. The abnormal O/S on day -5 through -1 are also not statistically different from zero, implying that the option volume does not lead the stock volume in the period preceding a positive news announcement. Roll et al. (2010) show that O/S is high around earnings announcements. However, the authors do not distinguish between announcements with positive and negative price impacts. Thus, our results imply that the decision to transact options or stock depends on the type of information possessed by informed agents. Collectively, our findings suggest that informed agents are more likely to trade options ahead of bad news and stock when they anticipate the arrival of good news[7].

4.2. Option trading and stock price reactions to shocks

We examine the link between trading activity in options and stock and the stock price patterns following informed daily price changes in excess of 10% (sign ignored) so as to assess the ability of the options markets to stimulate the informational efficiency of the underlying stocks. The results of this analysis are reported in Table 5. The figures in Table 5 indicate that the average values of positive and negative shocks are 11.25% and -12.84%, respectively. The cumulative abnormal returns (CARs) following positive informed shocks are not significantly different from zero, implying that optioned stocks react efficiently to the arrival of positive price-sensitive news. However, the CARs subsequent to negative informed shocks are all positive and statistically significant, ranging from 0.97% (with a NW *t*-stat of 2.39) on day 1 to 2.42% (with a NW *t*-stat of 3.46) on day 5. This finding is consistent with

[7] To shed further light on the issue of whether abnormal O/S reflects the trading activity of informed traders, we compare the abnormal O/S prior to informed shocks with the abnormal O/S observed in periods immediately before uninformed shocks. We find that the abnormal O/S before an uniformed shock is not significantly different from zero and its magnitude is significantly smaller than the abnormal O/S preceding an informed shock. This finding indicates that the pre-event abnormal O/S is likely to reflect the behavior of informed traders. Further details on these results are available upon request.

the overreaction hypothesis, which suggests that investors respond too strongly to unfavorable information and temporarily price securities below their intrinsic value (see, e.g., Howe, 1986; Bremer & Sweeney, 1991; Cox & Peterson, 1994), but contradicts Choi and Jayaraman's (2009) evidence that only non-optioned stocks overreact to the arrival of negative news in the US market. We argue that the different reactions of the UK and US optioned stocks to negative news may be related, at least partly, to the differences in the levels of option and stock trading activity in these markets[8].

Insert Table 5 about here

We use subsample analysis to investigate the relationship between option and stock trading activity and stock price efficiency. Specifically, we examine the price reaction to negative shocks associated with three subsamples (the top 30%, middle 40% and bottom 30%) of stocks ranked on the basis of abnormal options volume, abnormal stock volume, abnormal O/S and O/S over the [-3, -1] window around the events, respectively[9]. A summary of these results is presented in Table 6. Panel A of Table 6 shows that the stocks with high levels of pre-event option trading activity react efficiently to negative price shocks while the overreaction effect is only observed in the case of stocks with low pre-event abnormal options volume. However, the paired *t*-test suggests that the CAR_1 and CAR_2 associated with the subsamples of stocks with high and low pre-event options volume are not significantly different from each other. The non-parametric MW test also suggests that, with the exception of CAR_4 and CAR_5, the post-shock abnormal returns associated with stocks with high and low pre-event option volumes belong to the same distribution. Similarly, for CAR_1 to CAR_3, the KW test fails to reject the hypothesis that the post-event CARs of the three subsamples ranked by pre-event option volume are drawn from the same distribution.

Insert Table 6 about here

Panel B of Table 6 reports the post-event abnormal returns associated with the subsamples of low, medium and high pre-event abnormal stock volume. The CARs associated with the three subsamples are positive, but not statistically significant in most

[8] The difference in the reactions of the US and UK markets to shocks may be related to other factors, including insider trading regulations (Fidrmuc et al., 2006), executive option trades, option market regulation, and taxation differences on profits from option trading (Kyriacou et al., 2008).

[9] We also ranked our stocks on the basis of volume measures over the [-5, -1] window. The results were quantitatively similar and are available upon request.

cases. The paired *t*-test and the MW test suggest that the post-shock CARs for stocks with high and low abnormal stock volume are not significantly different from each other. The KW test also fails to reject the hypothesis that the post-shock CARs associated with the subsamples ranked by abnormal stock volume are drawn from the same distribution.

Panel C of Table 6 reports the post-event CARs associated with the subsamples of high, medium and low pre-event abnormal O/S stocks. The results imply that stocks with high abnormal O/S react efficiently, while stocks with low and medium abnormal O/S overreact, to the arrival of negative news. The paired *t*-test suggests that the post-shock CARs of stocks with low abnormal O/S are significantly larger than the post-shock CARs of those with high abnormal O/S. The MW test also rejects the hypothesis that the post-event CARs of stocks with high and low abnormal O/S belong to the same distribution. Similarly, the results of the KW test suggest that the post-event abnormal returns are significantly different across the low, medium and high subsamples. This finding is consistent with Roll et al.'s (2010) view that the contribution of options to stock price efficiency depends on the level of option trading activity above and beyond the presence of options markets.

Earlier, we argued that abnormal O/S may capture informed trading activity in options and stock better than the standard O/S. As a first attempt to verify the validity of this claim, we examine the post-shock price patterns associated with subsamples of stocks ranked on the basis of their O/S over the [-3,-1] window around the events. The results of this analysis are reported in Panel D of Table 6. Similar to the case of abnormal O/S, the *t*-stat suggests that the post-event CARs are only significant in the case of stocks with low pre-event O/S. However, the difference in CARs between stocks with high and low trading activity is more pronounced when abnormal O/S rather than O/S is used as the trading activity measure. Unlike in the case of abnormal O/S, the paired *t*-test in Panel D indicates that the CAR_1 and CAR_2 associated with the subsamples of stocks with high and low pre-event O/S are not significantly different from each other. Similarly, with the exception of CAR_5, the MW test fails to reject the hypothesis that the post-event CARs associated with stocks with high and low pre-event O/S belong to the same distribution. Similar results are reported when the KW test is used to test whether the post-event CARs associated with stocks with high, medium and low pre-event O/S belong to the same distribution. Collectively, our results indicate that pre-event abnormal O/S is a better predictor of stock price patterns following negative shocks than pre-event O/S, implying that the former may contain more information about the future value of stocks than the latter.

4.3. Regression analysis

The previous section examines the impact of trading activity on the speed of stock price adjustments to information. Consistent with the view that active options markets improve stock price efficiency, we show that high pre-event abnormal O/S stocks experience significant price drops on the bad news announcement date and no significant abnormal returns on subsequent days. In this section, we investigate the relationship between trading activity measures and the sensitivity of stock prices to negative news announcements. Roll et al. (2010) argue that high levels of informed trading prior to an earnings announcement would be expected to result in bigger price movements after the announcement. Thus, the extent to which a trading activity measure can reflect informed trading is likely to depend on the ability of such a measure to predict the price movement caused by a news announcement. This issue is formally investigated using the following regression model[10]:

$$CAR_{i,\tau} = \alpha_0 + \alpha_1 \overline{AVol_{i,w,[-3.-1]}} + \alpha_2 \ln MV_i + \alpha_3 \ln BTMV_i + \alpha_4 MOM_i + \\ +\alpha_5 Ris_{i,s} + \omega_i \qquad (10)$$

where $CAR_{i,\tau}$ is the cumulative abnormal return of stock i over a window of τ days starting from the event (i.e. negative shock). $\ln BTMV_i$ and $\ln MV_i$ are the natural logarithms of stock i's book-to-market ratio and market capitalization measure on day -11 prior to the event, respectively. Fama and French (1993, 1996) show that the size and value characteristics are the key determinants of cross-sectional stock returns. Similarly, Bremer and Sweeney (1991) argue that the price reaction to a shock depends on the market capitalization of the firm. The variable MOM_i is the momentum factor measured over the six-month period prior to the event date. Carhart (1997) shows that the momentum factor explains a significant proportion of the cross-sectional return variation. $Ris_{i,s}$ is the volatility of the stock return measured over the [-100, -11] window prior to the event date. Campbell et al. (2001) and Fu (2009) report a positive association between stock volatility, a measure of idiosyncratic risk, and cross-sectional stock returns. $\overline{AVol_{i,w,[-3.-1]}}$ is stock i's average abnormal volume over the [-3,-1] window around the event, where subscript *w* is replaced by *s*, *o* and *o/s*, respectively, when

[10] We use this regression for negative shocks only, as the CARs following positive shocks are not significantly different from zero. We also used the volume estimated over the [-5, -1] window instead of the [-3, -1] window, as one of the explanatory variables in Eq.(10). The results were similar to those reported here and are available upon request.

abnormal stock volume, abnormal option volume and abnormal O/S are analyzed. ω_i is the error term.

Insert Table 7 about here

Table 7 reports the results of the OLS estimation of Eq.(10). The coefficients on $\overline{AVol_{o,[-3,-1]}}$ in Panel A of Table 7 are negative, but only significant in the case of $CAR_{[0, +5]}$. The coefficients on $\overline{AVol_{s,[-3,-1]}}$ in Panel B are not significantly different from zero, implying that the level of trading activity in stocks does not predict the post-event CARs. Panel C shows that $\overline{AVol_{o/s,[-3,-1]}}$ is negatively and significantly associated with all the post-shock CARs. This finding suggests that pre-event abnormal O/S may capture the extent of informed trading, as more informed trading prior to the negative events may result in greater price declines in the post-event periods. For comparison purposes, we also estimate Eq.(10) using average pre-event O/S over the window [-3,-1] around the events ($\overline{Vol_{o/s,[-3,-1]}}$) as an alternative trading activity measure. The results in Panel D of Table 7 show that $\overline{Vol_{o/s,[-3,-1]}}$ is also negatively associated with the post-event CARs, but its coefficient is only significant when $CAR_{[0,+1]}$ is used as the dependent variable. To gain further insight into whether informed trading is better captured by pre-event abnormal O/S or pre-event O/S, we also include both $\overline{AVol_{o/s,[-3,-1]}}$ and $\overline{Vol_{o/s,[-3,-1]}}$ as explanatory variables in Eq.(10)[11]. While the details are not reported, so as to save space, the results indicate that $\overline{AVol_{o/s,[-3,-1]}}$ is negatively and significantly associated with the post-event CARs but the coefficients on $\overline{Vol_{o/s,[-3,-1]}}$ are not significantly different from zero. This finding, therefore, suggests that informed trading may be better captured by pre-event abnormal O/S than pre-event O/S.

The coefficients on $lnBVMV_i$ in Table 7 are consistently positive and statistically significant, implying that growth stocks react less strongly to negative market signals than to value stocks. This finding is consistent with Rozeff and Zaman (1998), who show that growth stocks tend to lie above their fundamental values and value stocks tend to lie below their fundamental values. The remaining variables in Table 7, namely $\ln MV_i$, MOM_i and $Ris_{i,s}$, are statistically insignificant in most cases.

[11] While the correlation between $\overline{AVol_{o/s,[-3,-1]}}$ and $\overline{Vol_{o/s,[-3,-1]}}$ is quite high (0.532), the variance inflation factor (VIF) indicates that including both variables in the regression does not result in multicollinearity problems.

4.4. *Robustness checks*

We carry out a number of robustness checks to investigate the sensitivity of our findings to alternative volume measures, the length of the pre-event benchmark period, and an alternative definition of shocks. The results of the robustness checks are presented in Table 8. To save space, we only report the results associated with using $AVol_{o/s,i,t}$ as a trading activity measure[12].

Insert Table 8 about here

4.4.1. *Pound volume measure*

In this subsection, we examine the robustness of our earlier findings to the use of the pound options volume, rather than the number of options contracts traded on each stock, as an options volume measure. Following Roll et al. (2010), we define stock i's daily pound options volume as the aggregated value of the total contracts traded on each option multiplied by the end-of-day quote midpoint. As stated earlier, we define the stock pound volume as the total number of stocks traded multiplied by the closing price on each trading day. Thus, pound O/S is the option pound volume over the stock pound volume. Since data on the options volume in pounds are only available from January 2006, fewer informed shocks (111 positive and 101 negative) are identified during this period. Panel A of Table 8 reports the pre-shock abnormal pound O/S. The results indicate that the pre-negative shock $AVol_{o/s,t}$ is positive, but only significant on days -3 and -2. The $\overline{AVol_{o/s,\pi}}$ over windows [-5, -1] and [-3, -1] is also positive. The NW t-stats indicate that the pre-negative-shock $\overline{AVol_{o/s,\pi}}$ is significant at the 10% level. Panel A of Table 8 further suggests that the pre-event $AVol_{o/s,t}$ and $AVol_{o/s,\pi}$ associated with the positive shocks are also positive but not statistically significant. The asymmetric abnormal O/S patterns are consistent with our earlier evidence that informed agents are more likely to transact options ahead of negative news.

4.4.2. *The magnitude of the price shock*

Definitions of price shocks tend to vary considerably across studies. For example, Dennis and Strickland (2002) define shocks as daily market price declines in excess of 2%,

[12] The results associated with $AVol_{s,t}$ and $AVol_{o,t}$ are available upon request.

Bremer and Sweeney (1991) use daily price drops of 10% or more, and Howe (1986) employs weekly price changes of more than 50%. To verify the sensitivity of our results to the identification of extreme events, we repeat our analysis using one-day price movements in excess of 5% (sign ignored) as price shocks. Applying the filtering process described in Section 3 to the 5% price changes, we identified a total of 730 informed shocks (287 negative and 443 positive). The results are presented in Panel B of Table 8. The results show that the abnormal O/S preceding both positive and negative shocks are positive. They also show that abnormal O/S is more pronounced prior to negative shocks than positive ones. Specifically, our statistical test implies that the abnormal O/S are significantly positive on days -2 and -1 prior to negative shocks and only on day -1 prior to positive shocks. Furthermore, the results in Panel B suggest that the abnormal O/S over the windows [-5, -1] and [-3, -1] are only statistically significant in the case of negative shocks. This finding is again consistent with our earlier evidence that option traders are more likely to trade ahead of negative news than positive news.

4.4.3. Pre-event benchmark period

There is no consensus in the empirical literature on the choice of the pre-event benchmark period. To investigate the sensitivity of our findings to the choice of estimation windows, we repeat our analysis using the averaged volume in the pre-event period [-120, -20] as an alternative benchmark. Panel C of Table 8 shows that, with the exception of day -5, the values of $AVol_{o/s,i,t}$ on the days immediately before announcements of bad news with large price impacts are positive and significant. Furthermore, the abnormal O/S over the [-5, -1] and [-3, -1] windows are 21.68% and 32.69%, respectively. The NW *t*-stat implies that these figures are significant at less than the 5% and 10% levels, respectively. Panel C of Table 8 also reports abnormal O/S prior to positive shocks. It also shows that the abnormal O/S preceding positive shocks are not significantly different from zero and that their magnitudes are generally smaller than those observed prior to negative shocks. This finding is consistent with our earlier evidence suggesting that informed traders are less active in options markets before positive news.

5. Conclusion

This study provides an innovative approach to investigating informed trading activity in the stock and options markets. Our analysis yields the following important conclusions.

First, the pre-event abnormal volume analysis indicates that informed agents are more likely to trade in the options market ahead of bad news than good news. Specifically, we report significant abnormal option volumes prior to negative shocks and significant abnormal stock volumes in the periods immediately before positive shocks. We show that pre-event abnormal O/S is only significant in the case of negative news, indicating that, due to short-sale constraints, informed traders are more likely to transact in options in response to negative signals than positive ones. These findings are robust to alternative definitions of event windows, options volume measures and price shocks.

Second, by examining stock price reactions to shocks, we show that the impact of option listing on the informational efficiency of stocks depends on the option trading activity over and above the presence of an options market. Specifically, we show that optioned stock prices react efficiently to informed positive shocks, but overreact to negative ones. The overreaction of optioned stocks to negative news contradicts the US evidence of Peterson (1995) and Choi and Jayaraman (2009), and implies that listing options on stocks does not necessarily result in efficient stock markets. Further analysis suggests that the price reaction to shocks depends largely on the pre-event abnormal O/S, with low pre-shock abnormal O/S stocks overreacting to negative news and high pre-shock abnormal O/S stocks reacting efficiently to the arrival of negative information.

Finally, we show that abnormal O/S outperforms Roll et al.'s (2010) O/S as a measure of informed trading activity. Specifically, both the subsample analysis and the regression results indicate that pre-event abnormal O/S is a better predictor of stock price patterns following negative shocks than pre-event O/S, suggesting that the former may contain more relevant information about the future value of stocks than the latter.

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TABLE1. Sample stock characteristics

Panel A: Stock Characteristics						
	Price (£)	Daily turnover (%)	Daily bid-ask spread (%)	MV £1 million	Return volatility (%)	β
Our sample137 stocks	6.41	0.96	0.76	9,564.00	2.13	0.85
All constituent stocks	4.19	0.52	1.94	2,156.00	1.89	1.00
10th percentile portfolio	2.31	0.24	4.84	42.31	2.14	0.33
50th percentile portfolio	3.64	0.35	1.86	249.27	1.69	0.46
90th percentile portfolio	7.80	0.59	0.41	17,055.47	2.03	1.08
Panel B: Daily Price Change						
Percentile	1%	5%	10%	90%	95%	99%
Daily price change	-0.0269	-0.0150	-0.0100	0.0100	0.0144	0.0266
Pooled daily price change	-0.0609	-0.0316	-0.0207	0.0218	0.0333	0.0669

Note: Panel A in the table compares the characteristics of our sample stocks with those of the constituents of the FTSE All Share Index over the period 04/01/1993 to 30/06/2010. The reported figures represent the mean values of the stock price, daily turnover (daily trading volume over the number of shares outstanding), daily bid-ask spread (computed as $\frac{a_{i,t}-b_{it}}{((a_{i,t}+b_{it})/2)}$, with $b_{i,t}$ and a_{it} denoting stock i's bid price and ask price, respectively), MV (market capitalization), return volatility (or standard deviation of returns) and the market model beta. The mean values of the stock price, daily turnover, daily bid-ask spread, and MV are computed from time-series averages of cross-sectional means; return volatility is the yearly averaged standard deviation of daily returns; the mean beta value is the average of the betas from the time-series regressions for each stock over the entire sample period. The 10th, 50th, and 90th portfolios are based on total market capitalization at the beginning of each year from 1993 to 2010. Panel B reports percentiles of daily price changes for our sample stocks across 4,420 trading days. The first row in Panel B reports the time-series average of cross-sectional means across all trading days. The second row is for pooled time-series and cross-sectional averages with 516,963 firm-day observations.

TABLE 2. Summary statistics for volume measures

	Mean	Median	Sigma	Skewness	Kurtosis	Max.	Min.	Mean	Median	Sigma	Skewness	Kurtosis	Max.	Min.
				Panel A-1: O/S							Panel A-2: $Vol_{o/s}$			
Mean	28.30	1.21	141.61	10.42	216.15	1166	0.07	-2.11	-1.72	3.09	-0.80	4.23	4.42	-10.34
Median	1.69	0.38	4.76	8.68	114.17	91.99	0.01	-2.13	-1.19	3.36	-0.89	2.88	4.52	-10.40
Sigma	228	5.62	1276	6.88	403.62	9554	0.70	1.88	2.44	0.75	0.85	3.51	1.95	1.26
Skewness	10.04	10.23	10.85	4.08	7.57	10.96	11.26	-0.39	-1.35	-0.88	0.66	2.33	-2.10	0.68
Kurtosis	106.72	107.74	121.28	29.62	72.94	123.90	127.86	3.24	4.60	3.81	3.37	10.97	17.75	5.17
Maximum	2496.66	60	14390	63.83	4178	10900	0.10	2.68	4.09	5.02	1.96	24.47	11.51	-4.97
Minimum	0.04	0.01	0.29	3.34	18.34	4.97	0.00	-8.37	-9.72	0.29	-2.71	1.00	-7.23	-13.09
p value of Nor. Test	0.00							0.12						
				Panel B-1: O							Panel B-2: Vol_o			
Mean	226.36	61.77	605.59	10.21	189.61	16490	2.74	6.32	6.58	3.20	-0.75	3.84	12.95	1.20
Median	85.97	15	275.49	8.34	114.64	5072	1.00	6.22	7.31	3.44	-0.84	2.64	13.13	0.98
Sigma	548.67	146.33	1530	5.23	209.83	71981	0.58	2.24	3.11	0.74	0.88	3.07	2.09	0.14
Skewness	8.04	5.09	9.06	1.31	2.72	10.94	2.38	-0.07	-1.17	-1.62	0.82	2.67	-3.30	11.48
Kurtosis	79.63	35.15	96.05	4.47	12.41	125.09	22.06	2.48	3.45	6.87	3.82	15.54	22.24	133
Maximum	578.14	1233	16931	28.85	1324	83705	5.00	11.22	11.72	4.42	2.09	24.07	18.24	4.60
Minimum	3.51	1.00	11.31	3.19	14.61	1.00	0.00	1.13	0.00	0.07	-2.79	1.21	0.00	0.00
p value of Nor. Test	0.00							0.33						
				Panel C-1: Vol_S							Panel C-2:ln(Vol_S)			
Mean	0.01	0.00	0.08	8.53	184.09	0.58	0.00	-5.54	-5.50	0.92	-0.33	5.06	-1.98	-10.27
Median	0.01	0.00	0.01	6.32	82.21	0.13	0.00	-5.51	-5.48	0.84	-0.24	4.18	-2.07	-9.79
Sigma	0.06	0.00	0.65	6.48	261.40	10.56	0.00	0.98	0.95	0.32	0.72	3.96	1.38	1.96
Skewness	8.62	4.59	9.34	1.68	2.57	8.39	1.70	1.81	1.24	2.27	-0.82	5.20	0.72	-0.47
Kurtosis	79.64	37.13	93.13	5.70	9.78	73.00	5.92	23.81	20.10	10.42	12.81	36.57	11.25	6.25
Maximum	0.56	0.04	6.86	31.07	1372	0.86	0.00	1.55	0.91	2.69	3.19	37.21	4.61	-1.60
Minimum	0.00	0.00	0.00	1.16	4.21	0.00	0.00	-9.29	-9.29	0.52	-4.09	1.00	-8.16	-17.08
p value of Nor. Test	0.00							0.00						

Note: This table reports summary statistics for the various volume measures used in the analysis. For each volume measure, we compute the time-series average across 4,420 days for each stock and then calculate the cross-sectional average for 137 sample stocks. O/S is defined as the total number of option contracts over the total number of stock traded. O is defined as the number of option contracts. Vol_s is defined as total stock volume over the number of shares outstanding. $Vol_{O/S}$ and Vol_O are O/S and options expressed as natural logarithms, respectively. ln(Vol_S) is Vol_s as a natural logarithm. The last row in each panel reports *p*-values for the Jarque-Bera normality test based on the cross-sectional mean values.

TABLE 3. Partial autocorrelations for volume measures

	Lag(trading days)				
	1	2	3	4	5
Panel A: Vol $_{O/S}$					
Mean	0.2615	0.2140	0.1824	0.1601	0.1435
Median	0.2393	0.1920	0.1652	0.1463	0.1319
Sigma	0.1055	0.1200	0.0912	0.0800	0.0762
Panel B: Vol_S					
Mean	0.4626	0.3194	0.2531	0.2140	0.1900
Median	0.4774	0.3282	0.2604	0.2216	0.1961
Sigma	0.1400	0.1077	0.0912	0.0836	0.0748
Panel C: Vol_O					
Mean	0.3151	0.2469	0.2079	0.1804	0.1599
Median	0.2773	0.2203	0.1879	0.1639	0.1459
Sigma	0.1514	0.1140	0.0963	0.0845	0.0761

Note: Partial autocorrelations using five lags are computed from each firm's time-series observations of $Vol_{O/S}$, Vol_O, and Vol_S. Then, the partial autocorrelations are averaged across the 137 sample firms. Vol_s is the total stock volume over the number of shares outstanding. $\mathrm{Vol}_{O/S}$ and Vol_O are the logarithmic values of O/S and options volume, respectively. There are 4,420 trading days in the sample from January 1993 to June 2010.

TABLE4. The pre-shock abnormal volume measures

	Panel A: Negative Shocks (≤-10%)			Panel B: Positive Shocks (≥+10%)		
Date	AVol $_S$	AVol $_O$	AVol $_{O/S}$	AVol $_S$	AVol $_O$	AVol $_{O/S}$
-5	0.0007	0.0162	0.0889	0.0000	0.1337	0.0874
	(1.05)	(0.08)	(0.43)	(0.11)	(0.70)	(0.48)
-4	0.0003	0.2187	0.1588	0.0006	0.1008	0.0428
	(0.43)	(1.05)	(1.75)*	(0.76)	(0.51)	(0.24)
-3	0.0002	0.4917	0.4317	0.0003	0.0370	-0.0946
	(0.19)	(2.20)**	(2.03)**	(0.58)	(0.20)	(-0.57)
-2	0.0003	0.3981	0.3081	0.0008	-0.1708	-0.2815
	(0.29)	(1.95)**	(1.65)*	(1.57)	(-0.89)	(-1.58)
-1	0.0019	0.4474	0.1905	0.0031	0.2272	0.0573
	(1.92)*	(1.84)*	(0.84)	(2.61)***	(1.13)	(0.31)
0	0.0188	1.5574	0.4527	0.0188	2.0887	0.9912
	(6.49)***	(6.49)***	(2.21)**	(6.23)***	(11.78)***	(6.41)***
[-5, -1]	0.0005	0.3079	0.2000	0.0010	0.0507	-0.0606
	(0.24)	(2.27)**	(1.66)*	(1.80)*	(0.43)	(-0.61)
[-3,-1]	0.0007	0.4457	0.3101	0.0014	0.0064	-0.1444
	(0.79)	(2.83)***	(2.19)**	(2.26)**	(0.05)	(-1.19)
Obs	217			287		

Note: This table reports the three abnormal trading volume measures used to investigate the behavior of informed traders around informed shocks. $AVol_S$, $AVol_O$ and $AVol_{O/S}$ are the abnormal stock volume (the number of shares traded over shares outstanding), abnormal option trading volume (the natural logarithm of the number of option contracts traded) and abnormal option trading relative to stock trading (options volume over stock volume), respectively. Each abnormal volume measure is calculated as its own value on event day *t* over its historical average value during a benchmark period between *t-100* and *t-11*. The fixed windows of [-5,-1] and [-3, -1] means averaged abnormal values between event day -5 and -1 and between event day -3 and -1, respectively. A negative price shock is defined as a daily price drop of more than 10%, while a positive price shock is for a daily price increase of more than 10%. We report the Newey-West adjusted *t*-statistics in parentheses. ***, ** and * represent statistical significance at 1%, 5% and 10% respectively.

TABLE 5. CARs following positive and negative shocks

	CARs (Cumulative Abnormal Returns)	
Date	Positive shocks (≥+10%)	Negative shocks (≤-10%)
0	0.1125	-0.1284
	(28.92)***	(-16.30)***
+1	-0.0016	0.0097
	(-0.65)	(2.39)**
+2	-0.0019	0.0148
	(-0.53)	(3.26)***
+3	-0.0040	0.0166
	(-1.26)	(3.39)***
+4	-0.0054	0.0255
	(-1.47)	(3.65)***
+5	-0.0070	0.0242
	(-1.61)	(3.46)***
Obs	287	217

Note: This table provides the cumulative abnormal returns following 287 positive shock (≥+10%) events and 217 negative shock events over the period from 02/01/1993 to 30/06/2010. We use the FTSE All-Share Index as a market portfolio to estimate abnormal returns for each event. The market model is estimated from *t-200* to *t-11* and the prediction period is from event day 0 to event day +5. CAR is cumulative abnormal returns, which are accumulated from event day 1 to event day 5. We report the Newey-West adjusted *t*-statistics in parentheses. *, **, and *** represent significance at 10%, 5% and 1%, respectively.

TABLE 6. High, middle and low abnormal measures and post-shock CARs

			Panel A: AVol $_O$			
	Low	Middle	High	Low-High	MW Test	KW Test
CAR0	-0.1329	-0.1192	-0.1360	0.0031		
	(-10.30)***	(-11.96)***	(-8.14)***	(0.15)	(0.16)	(1.23)
CAR1	0.0205	0.0065	0.0031	0.0174		
	(1.89)*	(1.23)	(0.48)	(1.36)	(1.06)	(1.12)
CAR2	0.0263	0.0135	0.0049	0.0214		
	(2.04)**	(1.86)*	(0.68)	(1.44)	(0.76)	(0.58)
CAR3	0.0359	0.0128	0.0022	0.0336		
	(2.39)**	(1.53)	(0.29)	(1.97)*	(1.48)	(2.23)**
CAR4	0.0562	0.0179	0.0049	0.0513		
	(3.17)***	(1.73)*	(0.61)	(2.62)***	(1.92)*	(3.80)***
CAR5	0.0579	0.0138	0.0043	0.0537		
	(3.46)***	(1.31)	(0.46)	(2.81)***	(2.30)**	(5.78)***
obs	66	86	65			
			Panel B: AVol $_S$			
CAR0	-0.1362	-0.1436	-0.1000	-0.0358		
	(-10.69)***	(-10.48)***	(-9.60)***	(-2.17)**	(-1.37)	(3.28)***
CAR1	0.0102	0.0085	0.0108	-0.0006		
	(0.99)	(1.66)*	(1.40)	(-0.05)	(-0.34)	(0.78)
CAR2	0.0205	0.0108	0.0142	0.0062		
	(1.64)*	(1.62)	(1.62)	(0.40)	(0.39)	(0.15)
CAR3	0.0231	0.0108	0.0177	0.0054		
	(1.61)	(1.56)	(1.59)	(0.29)	(0.14)	(0.04)
CAR4	0.0399	0.0161	0.0236	0.0163		
	(2.24)**	(2.02)**	(1.88)*	(0.74)	(0.04)	(0.04)
CAR5	0.0412	0.0094	0.0264	0.0148		
	(2.46)**	(1.14)	(2.01)**	(0.69)	(0.42)	(1.11)
obs	66	86	65			
			Panel C: AVol $_{O/S}$			
CAR0	-0.1434	-0.1107	-0.1362	-0.0071		
	(-11.23)***	(-11.10)***	(-8.30)***	(-0.34)	(-1.06)	(7.42)***
CAR1	0.0293	0.0005	0.0021	0.0274		
	(2.78)***	(0.10)	(0.30)	(2.14)**	(2.23)**	(6.10)***
CAR2	0.0349	0.0055	0.0068	0.0282		
	(2.73)***	(0.86)	(0.81)	(1.83)*	(1.71)*	(3.31)***
CAR3	0.0412	0.0079	0.0034	0.0378		
	(2.73)***	(1.05)	(0.38)	(2.16)**	(1.88)*	(4.95)***
CAR4	0.0540	0.0235	0.0015	0.0505		
	(3.41)***	(2.23)**	(0.13)	(2.60)***	(2.33)**	(5.84)***
CAR5	0.0540	0.0200	-0.0006	0.0546		
	(3.41)***	(1.91)*	(-0.05)	(2.84)***	(2.52)**	(6.55)***
obs	66	86	65			

TABLE 6 continued

	Panel D: Vol $_{O/S}$					
	Low	Middle	High	Low-High	MW Test	KW Test
CAR0	-0.1351	-0.1165	-0.1315	-0.0035		
	(-10.84)***	(-12.19)***	(-7.92)***	(-0.16)	(-0.71)	(1.41)
CAR1	0.0209	0.0076	0.0003	0.0206		
	(1.92)*	(1.34)	(0.04)	(1.61)	(1.47)	(2.15)
CAR2	0.0288	0.0110	0.0056	0.0232		
	(2.18)**	(1.48)	(0.84)	(1.55)	(0.90)	(0.82)
CAR3	0.0363	0.0119	0.0034	0.0328		
	(2.42)***	(1.36)	(0.44)	(1.94)*	(1.33)	(1.98)**
CAR4	0.0560	0.0167	0.0082	0.0478		
	(3.23)***	(1.53)	(0.98)	(2.47)**	(1.60)	(3.30)***
CAR5	0.0580	0.0127	0.0078	0.0502		
	(3.45)***	(1.17)	(0.86)	(2.61)***	(2.04)**	(5.23)*
obs	66	86	65			

Note: This table provides cumulative abnormal returns (CARs) conditional on the abnormal options volume (AVol $_O$), abnormal stock volume (AVol $_S$), abnormal options volume/stock volume (AVol $_{O/S}$) and options volume/stock volume over the [-3, -1] window prior to the arrival of negative news with a significant price impact (⩽-10%). The low, middle and high groups are defined as the bottom 30%, middle 40% and top 30% of the abnormal measure in question. CARs are cumulative abnormal returns calculated by estimating the market model from t-200 to t-11, and the prediction period is from event day 0 to event day 5. We report the Newey-West adjusted *t*-statistics in parentheses. We also use two non-parametric tests, Mann-Whitney (MW) and Kruskal-Wallis (KW), to examine whether the abnormal returns associated with different groups of stocks are statistically different from each other. *, ** and *** represent significance at 10%, 5% and 1%, respectively.

TABLE 7. Abnormal measures and post-event CARs

			Panel A: $AVol_O$				
	lnMV	Mom	lnBVMV	Ris	$\overline{AVol_{O,[-3,-1]}}$	Cons	Adj_R^2
CAR $_{[0,+1]}$	0.0056	0.0417	0.0272	-0.2139	-0.0063	-0.1212	0.09
	(0.83)	(1.90)*	(4.52)***	(-0.60)	(-1.47)	(-1.92)**	
CAR $_{[0,+2]}$	0.0045	0.0265	0.0274	-0.1634	-0.0056	-0.1134	0.07
	(0.62)	(1.10)	(4.16)***	(-0.42)	(-1.18)	(-1.64)*	
CAR $_{[0,+3]}$	0.0051	0.0227	0.0297	-0.0972	-0.0066	-0.1172	0.08
	(0.65)	(0.89)	(4.21)***	(-0.23)	(-1.31)	(-1.59)	
CAR $_{[0,+4]}$	0.0089	0.0192	0.0359	0.1598	-0.0086	-0.0795	0.12
	(0.11)	(0.70)	(4.72)***	(0.36)	(-1.60)	(-1.01)	
CAR $_{[0,+5]}$	0.0024	0.0221	0.0365	0.3272	-0.0101	-0.0978	0.14
	(0.29)	(0.81)	(4.84)***	(0.74)	(-1.90)*	(-1.25)	
			Panel B: $AVol_S$				
	lnMV	Mom	lnBVMV	Ris	$\overline{AVol_{S,[-3,-1]}}$	Cons	Adj_R^2
CAR $_{[0,+1]}$	0.0038	0.0348	0.0286	-0.1052	0.3092	-0.1213	0.08
	(0.56)	(1.55)	(4.59)***	(-0.29)	(0.42)	(-1.89)	
CAR $_{[0,+2]}$	0.0042	0.0245	0.0275	-0.1705	0.1856	-0.1142	0.07
	(0.57)	(1.01)	(4.15)***	(-0.43)	(0.23)	(-1.63)*	
CAR $_{[0,+3]}$	0.0046	0.0199	0.0295	-0.0827	0.7076	-0.1190	0.08
	(0.58)	(0.77)	(4.16)***	(-0.20)	(0.81)	(-1.59)	
CAR $_{[0,+4]}$	0.0005	0.0159	0.0356	0.1433	-0.6774	-0.0806	0.11
	(0.06)	(0.58)	(4.69)***	(0.32)	(-0.73)	(-1.01)	
CAR $_{[0,+5]}$	0.0017	0.0185	0.0356	0.3471	-0.4118	-0.0992	0.12
	(0.20)	(0.66)	(4.74)***	(0.77)	(-0.45)	(-1.25)	
			Panel C: $AVol_{O/S}$				
	lnMV	Mom	lnBVMV	Ris	$\overline{AVol_{O/S,[-3,-1]}}$	Cons	Adj_R^2
CAR $_{[0,+1]}$	0.0054	0.0421	0.0273	-0.2213	-0.0082	-0.1202	0.09
	(0.82)	(1.92)*	(4.55)***	(-0.62)	(-1.82)*	(-1.90)*	
CAR $_{[0,+2]}$	0.0044	0.0271	0.0275	-0.1753	-0.0079	-0.1121	0.08
	(0.62)	(1.13)	(4.20)***	(-0.45)	(-1.70)*	(-1.63)*	
CAR $_{[0,+3]}$	0.0051	0.0237	0.0299	-0.1158	-0.0099	-0.1154	0.08
	(0.65)	(0.93)	(4.28)***	(-0.28)	(-1.95)**	(-1.57)	
CAR $_{[0,+4]}$	0.0008	0.0197	0.0357	0.1503	-0.0111	-0.0778	0.13
	(0.09)	(0.72)	(4.75)***	(0.34)	(-2.01)**	(-0.99)	
CAR $_{[0,+5]}$	0.0021	0.0225	0.0362	0.3206	-0.0125	-0.0961	0.14
	(0.26)	(0.83)	(4.87)***	(0.72)	(-2.24)**	(-1.23)	
			Panel D: $Vol_{O/S}$				
	lnMV	Mom	lnBVMV	Ris	$\overline{Vol_{O/S,[-3,-1]}}$	Cons	Adj_R^2
CAR $_{[0,+1]}$	0.0126	0.0351	0.0257	-0.1843	-0.0063	-0.1973	0.09
	(1.62)*	(1.59)	(4.25)***	(-0.51)	(-1.92)**	(-2.63)***	
CAR $_{[0,+2]}$	0.0112	0.0198	0.0263	-0.1563	-0.0058	-0.1842	0.08
	(1.32)	(0.82)	(3.97)***	(-0.40)	(-1.60)	(-2.24)**	
CAR $_{[0,+3]}$	0.0125	0.0149	0.0284	-0.0867	-0.0054	-0.1960	0.08
	(1.37)	(0.58)	(4.01)***	(-0.21)	(-1.59)	(-2.23)**	
CAR $_{[0,+4]}$	0.0076	0.0104	0.0337	0.1922	-0.0060	-0.1541	0.12
	(0.76)	(0.38)	(4.47)***	(0.43)	(-1.40)	(-1.66)*	
CAR $_{[0,+5]}$	0.0109	0.0114	0.0337	0.3918	-0.0057	-0.1936	0.14
	(1.14)	(0.42)	(4.50)***	(0.88)	(-1.38)	(-2.09)**	

Note: This table reports the regression results for post-shock CARs. CARs are cumulative abnormal returns from day 0 to day +5. Panels A, B, C and D provide results for $\overline{AVol_{o[-3,-1]}}$, $\overline{AVol_{s[-3,-1]}}$, $\overline{AVol_{o/s[-3,-1]}}$ and

$\overline{Vol_{o/s[-3,-1]}}$, respectively. lnMV and lnBVMV are total market capitalization and the book-to-market ratio on event day -11, respectively. MOM is the past six-month returns, ending on event day -11. *Ris* is a stock's return standard deviations in [-100,-11]. The total number of observations is 217. The Newey-West adjusted *t*-statistics are reported in parentheses. *, ** and *** represent significance at 10%, 5% and 1%, respectively.

TABLE 8. Robustness checks

	Panel A: £ volume		Panel B: ±5% shocks		Panel C: [-120,-20]	
Date	≤-10%	≥+10%	≤-5%	≥+5%	≤-10%	≥+10%
-5	0.2833	0.2814	0.0094	-0.0935	0.0721	0.1292
	(0.85)	(0.94)	(0.20)	(-0.69)	(0.31)	(0.69)
-4	0.2643	0.1684	0.0115	0.1080	0.1756	0.0849
	(0.98)	(0.64)	(0.28)	(0.73)	(1.80)*	(0.46)
-3	0.5684	0.1678	0.0470	0.0251	0.4485	-0.0525
	(1.75)*	(0.61)	(0.99)	(0.17)	(2.43)**	(-0.30)
-2	0.3673	0.1306	0.1025	0.0979	0.3249	-0.2397
	(1.68)*	(0.55)	(2.13)**	(0.73)	(1.96)**	(-1.34)
-1	0.2803	0.1804	0.1069	0.3228	0.2073	0.0152
	(0.87)	(0.76)	(2.10)**	(2.34)**	(1.65)*	(0.08)
0	0.7910	1.0698	1.7231	1.1064	0.4694	1.0333
	(3.03)***	(4.58)***	(4.69)***	(9.30)***	(2.32)**	(6.34)***
[-5, -1]	0.3397	0.2071	0.0553	0.0922	0.2168	-0.0185
	(1.85)*	(1.49)	(2.26)**	(1.05)	(1.86)*	(-0.18)
[-3,-1]	0.4017	0.1841	0.0851	0.1488	0.3269	-0.1023
	(1.83)*	(1.13)	(2.64)***	(1.50)	(2.23)**	(-0.84)
obs	101	111	287	443	217	287

Note: This table reports the results obtained by using alternative abnormal measures for $AVol_{O/S}$ prior to events. Panel A provides results based on the pound volume, $AVol_{O/S}$. Panel B shows results based on alternative definitions for price shocks (±5%). Panel C provides results based on the averaged $Vol_{O/S}$ in the period from day -120 to -20. We report the Newey-West adjusted *t*-statistics in parentheses. *,** and *** represent significance at 10%, 5% and 1%, respectively.

Appendix A. Event filtering

Filter	Criterion	No. of Events
	Panel A: Positive 10% shocks	
1.	Total number of events sorted on one-day price change for 137 stocks from January 1993 to June 2010	1267
2.	Number of events with two price changes within [-5, +5]	-452
3.	Number of events without news in the Factiva news service*	-326
4.	Number of events with no option trading within [-5, +5]	-202
	Total number of events	287
	Panel B: Negative 10% shocks	
1.	Total number of events sorted on one-day price change for 137 stocks from January 1993 to June 2010	908
2.	Number of events with two price changes within [-5, +5]	-396
3.	Number of events without news in the Factiva news service	-160
4.	Number of events with no option trading within [-5, +5]	-135
	Total number of events	217

* 99,167 pieces of daily news are extracted from the Factiva news service for 137 stocks from January 1993 to June 2010.

Appendix B. News classifications

News Classifications	≥+10%	≤-10%	Total
Company appointments, directors and meetings	31	36	67
Deals, transactions and operational updates	61	50	111
Documents and circulars	5	3	8
Equity, debt and investment trusts	39	29	68
Financial statements and dividends	44	42	86
Market, Regulatory News Service and related announcements	7	5	12
Offers Update	9	6	15
Other statements and announcements	9	1	10
Publication of prospectus	13	2	15
Shareholder and Panel on Takeovers and Mergers(POTAM) disclosures	52	34	86
Undefined	17	9	26
Total	287	217	504

Note: We classify the news accompanied by the various price shocks in excess of 10% (sign ignored) into eleven categories. These classifications are the official categories used by the London Stock Exchange. Further details are available online via the following link: http://www.londonstockexchange.com/products-and-services/rns/regulatory/headline/explained.htm.