Does informed trading occur in the options market? Some revealing clues

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Abstract

This paper analyses the relationship between proxy variables for informed trading in the options market and a set of exogenous news variables. The aim is to test directly for the presence or absence of informed trading in the options market and for the possible impact of this trading on underlying asset prices. Our findings reveal that potential informed trading in options markets is channelled basically through out-of-the-money options (OTM), except for volatility trading which mainly involves at-the-money options (ATM) because of their liquidity. In both cases, we have found evidence in favour of investors' strategic fragmentation of transactions into intermediate size trades (stealth trading). Finally, it is shown that lack of consensus among agents also generates increased trading, particularly in OTM options.

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Introduction

Option trading volume may be driven by one of two clearly differentiated factors: hedge-liquidity or information. While the first is easy to explain, the second is less obvious and has therefore been the source of some controversy in the literature. The argument in favour of the information content of option trading volume is grounded on certain characteristics of options, such as higher leverage or the opportunity to bet on volatility, that make them attractive to informed traders. Nevertheless, these arguments might be countered by theories based mainly on the lower liquidity of options in relation to the underlying market.

Most of the existing analyses of this issue have turned to the empirical evidence in an attempt to settle the controversy. The general approach has been to search for variables relating to options trading volume that will serve as good proxies for informed trading. These include the put/call ratio, asymmetry, and positive and negative volume, among others. There is scant evidence, however, of any attempt to test this assumption directly. Our objective, therefore, is to show whether options trading is due to the behaviour of informed investors acting on a direct information source, and determine the type of options in which such investors are more likely to trade.

Our first step in this analysis is to test whether options trading affects underlying asset prices. A necessary, though not sufficient, condition is that if this option trading is motivated by new information, it should be possible to detect a significant impact on the underlying asset price[1]. Otherwise the information embedded in options trading would be redundant. To confirm such a necessary condition, we will begin by analysing the impact of overall options trading volume on underlying asset returns. However, in line with recent literature, we will also focus on the impact of positive and negative options volume and the imbalance of these, since overall volume may conceal other factors apart from trading.

Once these assumptions have been confirmed, the next major step will be to analyse whether these trading volumes are information driven. This undoubtedly key issue in the analysis is not easy to address, however. Our main contribution in this framework is our proposal for direct testing using a database containing all the announcements published in the economic press during the period of analysis. This database, which has been used in two previous studies (Blasco et al. (2002) and Blasco et al. (2005)), concerns the Spanish stock market. In this way we are able to establish a direct relationship between news and trading volume in a financial derivative. In this framework, the most novel feature of our

[1] The significant link between options volume and underlying asset prices might be due to other factors, such as hedging, although in this case the effect would be transitory.

study is that it focuses on trying to see whether factors such as different levels of liquidity and /or degrees of leverage affect the information content in option trades and, thus, if some types of options show more signs of informed trading.

From this database we will contruct a proxy variable for lack of consensus between agents. This variable will allow the direct testing of an additional hypothesis, that is the possibility of a positive relationship between the volume of trading and divergence in investors' expectations. This should also yield useful findings for a better understanding of this phenomenon.

Finally, volume is partitioned into the number of transactions and average trade size, in order to test whether informed trading drives strategic practices based on the fragmentation of transactions into medium-size trades, which helps to camouflage investors' intentions and conceal private information from other market agents (see Barclay and Warner, 1993). These data will also enable us to identify features that are unobservable in the aggregate data.

To sum up, our main contributions to the literature are the following. First, we test directly whether options trading can be explained by information. Such information is identified with a database of news classified into good news or bad news. The classification is ex-ante. It just depends on the assessement suggested in the financial press. Second, this study considers the effect of divergence of investors' expectations on trading volume using the exogenous news database. Third, the partition of the trading volume into the number of transactions and average trade size enables us to determine if these components are related to news releases and to the divergence in investors´expectations. Finally, this paper focuses on the Spanish market which is smaller in size and imposes higher short selling constraints[2] than the US market analysed by other authors. This fact may help us to gain a fuller understanding of the relationship between option trading volume, information, and underlying asset prices.

The remainder of the paper is organised as follows: the next section summarises the main theoretical arguments on which the analysis is grounded and briefly reviews the most significant empirical studies. Section 3 presents the methodology, the hypotheses and the associated tests. Section 4 describes the database; section 5 contains a discussion of the results; and section 6 presents the main conclusions.

2-Theoretical framework and previous literature

The theoretical motivation for our analysis comes from the growing literature on how to incorporate conditioning information in asset-pricing models. This is the central issue of all

[2] In Spain, short selling is typically concentrated in the "*Credibolsa*" system, mainly on stocks in the Ibex-35 (the 35 Spanish blue chips). Positions can be held for no longer than 90 days. However, there is another possibility, securities lending via OTC, which is not restricted to the Ibex-35, nor is it subject to such a strict time limit.

information-based models, which differ in their modelling approach but coincide in incorporating information into stock prices as the result of informed and uninformed trading. Two major references in this vein are Glosten and Milgrom (1985) and Easley and O´Hara (1987).

The consideration of derivatives introduces a new market on to the scene, thus enriching the existing literature, since it adds to the relationship involving trading, prices and private information a new type of asset that may incorporate further information and thereby affect the pre-existing relationships. Some studies that include derivatives in these relationships are: Grossman (1988), Back (1993), Biais and Hillion (1994), Brennan and Cao (1996), Easley, et al (1998) and John, et al (2008), among others.

The key issue, however, is to analyse the reasons why informed investors might be persuaded to trade in the options market. In this respect, authors such as Black (1975) or Mayhew et al (1995), among others, argue that the attraction of options trading lies in lower transaction costs and higher leverage in relation to the underlying assets, and the lack of short sales constraints in these markets. Back (1993) and Cherian (1993) point out, furthermore, that investors that bet on volatility can only do so in the options market. Nevertheless, what might dissuade investors from engaging in the above practices is a possible preference to trade in the underlying asset market, which offers a higher level of liquidity than the options market.

Among the most outstanding studies on the effect of option trading volume on underlying asset prices we might mention Easley et al (1998), Chan et al (2002), Chen et al (2005), Schlag and Stoll (2005) and Pan and Poteshman (2006). These studies are not conclusive, since they yield mixed results. There are other works, however, that analyse these relationships around specific events. Such is the case of Amin and Lee (1997), who find that a greater proportion of long (or short) positions are initiated in the option market immediately before good (or bad) earnings news on the underlying stock, and Cao et al (2005), who find that the call volume imbalance prior to takeover announcements is strongly related to next day stock returns.

Excepting for the paper by Nofsinger and Prucyk (2003), we have not found direct analyses of the relationship between option trading volume and public announcements in the press. These authors use a regression procedure to examine S&P 100 stock-index option volume and implied volatility around scheduled macroeconomic announcements. As many official announcements of economic indicators are scheduled in advance, interested market participants know the exact day and time of the announcement. Their findings indicate that both trading and volatility increase substantially after bad news is released. Particularly, Consumer Credit, Consumer Spending, Factory Inventories, NAPM and Non-Farm-Payrolls elicit the higher trading response.

The relationship between option trading volume and public announcements or news published in the press can help to clarify many of the assumptions made in the theoretical hypotheses put forward in the literature, since it enables us to establish a direct relationship between volume and news. Unlike Nofsinger and Prucyk (2003), we are dealing with unscheduled announcements and there are no prior expectations for their potential impact on prices, therefore the impact can be interpreted in general terms and not merely as the surprise that would follow an expected announcement. It should be noted, moreover, that our study analyses the impact of news on those volume variables that we have previously found to be potential informed trading measures because they have a significant impact on underlying asset prices. Furthermore, our study examines the differences in the results on informed trading in the options market across different degrees of moneyness as well as the impact of news on the components of trading volume. Not all these aspects have been addressed by the authors mentioned.

3-Hypotheses and associated tests

3.1-Underlying asset prices and options trading volume.

The first step is to test whether options trading affects underlying asset prices. Following the literature, we first explore the contemporaneous relationship between underlying asset returns and volume traded in the corresponding options market. The empirical model for analysing this relationship has the following form:

$$\Delta P_t = \beta_{0,s} + \beta_{1,s}\Delta P_{t-1} + \beta_{2,s} X_{s,t} + u_{t,s} \quad ; \; \left(u_{t,s} / \phi_{t-1}\right) \sim N(0, h_{t,s})$$

$$h_{t,s} = \alpha_{0,s} + \alpha_{1,s} u^2_{t-1,s} + \varpi_{1,s} h_{t-1,s} \qquad (1)$$

where P_t is the natural log of the price of the underlying asset, X_t is the variable that proxies for the level of informed trading in the options market and ϕ_t is the information set available on day t.

X_t is not an obvious choice. In fact, the literature has proposed several different measures for this purpose, including overall volume, positive and negative volume, and imbalance among others. In the above expression, the subscript s refers to the different measures of volume considered, as will be discussed later[3]. Given the presence of significant first order autocorrelation, we include the lagged dependent variable in the regression. We use conditional volatility models, specifically the GARCH(1,1) specification[4], because Engle's ARCH test revealed the presence of significant ARCH effects.

[3] Lagged $X_{s,t}$, has also been used in previous estimations, but it was not significant in all cases (overall volume, positive or negative volume or imbalance); the final estimation therefore includes only the contemporaneous variable. As will be explained later, these results indirectly support the information hypothesis.

[4] The analyses were also performed including an asymmetrical variance specification (the GJR model). The results obtained do not alter those reported here.

In this regression the main issue is to analyse the sign of $\beta_{2,s}$, and the factors that may lie behind the estimated value. In a perfect market all news would immediately be made public and available to all market agents; quotes would immediately adjust to the information, and trading would convey no additional information. This would lead to an expected value of $\beta_{2,s}=0$. In contrast, on the basis of arguments presented in Schlag and Stoll (2005), if options trading volume has an impact on underlying asset prices, the coefficient should be $\beta_{2,s}>0$ and significant. As a consequence, the first null hypothesis to test is H1: $\beta_{2,s}=0$. If we reject this null hypothesis we will have empirical evidence in favour of the impact of options trading on the underlying asset prices.

Deviations from 0 could be explained either by information or hedging (liquidity) effects. When it has to do with information, it is acknowledged that transactions in the options market may carry information that is not reflected in prices in other market, thus lending support to the argument that informed investors trade in the options market. In our case, however, we are dealing with a stock index; it is therefore hard to believe that investors will have private information about all the component stocks. It cannot be ruled out, however, that investors may use indexes to adjust the leverage in their portfolios when in possession of private market-wide information arising, for example, from general news circulating in the financial markets. This would lead to permanent price effects[5]. The other situation that could give rise to $\beta_{2,s}$ being different from 0 is when these assets are used for hedging purposes, which would mean that all options trading would be based on liquidity and therefore trading volume itself would not be informative. In this case the relationship is transitory[6] because of the temporary price impact.

Despite the appeal of these arguments, the estimation of parameter $\beta_{2,s}$ cannot be considered a *"direct test"* of the relationship between options volume and information. Furthermore, the possible presence of informed trading does not rule out the possibility of options being traded for hedging or liquidity purposes. Therefore, overall volume may include investors with diverse objectives, thus complicating the task of distinguishing between permanent and temporary effects. The test proposed here, however, allows for a direct examination of the relationship between information and volume, with no need to enter into any further considerations.

Returning to our line of reasoning, first we will study the relationship between the proxies for informed trading volume in the options market and variations in underlying asset prices. As noted earlier, the literature reports the use of several proxies for informed trading. In this paper we use three alternative measures. The first is aggregate options trading volume on day t. The first regression to be estimated will therefore be given by:

$$\Delta P_t = \beta_{0,1} + \beta_{1,1}\Delta P_{t-1} + \beta_{2,1} Vol_t + u_{t,1} \qquad ; \quad (u_{t,1} / \phi_{t-1}) \sim N(0, h_{t,1})$$

[5] This would mean that the coefficients of the lagged volumes would be equal to zero (see Schlag and Stoll, 2005)

[6] According to Schlag and Stoll (2005), we would find lagged volumes with negative coefficients due to the reversal effect.

$$h_{t,1} = \alpha_{0,1} + \alpha_{1,1} u_{t-1,1}^2 + \varpi_{1,1} h_{t-1,1} \qquad (2)$$

The second alternative measure uses positive and negative volume. Positive volume (vol^+) is the volume of calls purchased plus volume of puts sold on day t and negative volume (vol^-) is the volume of calls sold plus volume of puts purchased on day t. For this analysis, we estimate the following regression[7] :

$$\Delta P_t = \beta_{0,2} + \beta_{1,2} \Delta P_{t-1} + \beta_{2,2} vol_t^+ + \beta_{3,2} vol_t^- + u_{t,2} \quad ; \quad (u_{t,2} / \phi_{t-1}) \sim N(0, h_{t,2})$$

$$h_{t,2} = \alpha_{0,2} + \alpha_{1,2} u_{t-1,2}^2 + \varpi_{1,2} h_{t-1,2} \qquad (3)$$

In the third alternative, volume is captured by imbalance (IB), the difference between positive and negative volume on day t. Formally, the estimation is defined as follows:

$$\Delta P_t = \beta_{0,3} + \beta_{1,3} \Delta P_{t-1} + \beta_{2,3} \mathrm{IB}_t + u_{t,3} \quad ; \quad (u_{t,3} / \phi_{t-1}) \sim N(0, h_{t,3})$$

$$h_{t,3} = \alpha_{0,3} + \alpha_{1,3} u_{t-1,3}^2 + \varpi_{1,3} h_{t-1,3} \qquad (4)$$

3.2-Options volume and information

In the case of having rejected the H1 null hypothesis, the result supports the existence of a contemporaneous relationship between the spot price and volume in options, signed volume in options, or the imbalance between positive and negative volume. The next step now is to test the information that this conveys. In other words, we seek to determine whether volume occurs as a result of the release of news, a claim that has been taken as a premise in the literature but has never been directly proven. The only existing evidence is that presented by Nofsinger and Prucyk (2003), who found that options volume is positively related to news but did not demonstrate in advance whether this aggregate volume had a price impact on the underlying asset (the rejection of the H1 null hypothesis), and therefore whether the relationship was unequivocably due to informed trading in the options market.

In overall terms, volume should be related to news, either through the release of exogenous information, be it public or private, (ε), or through endogenous information (conveyed through trading), (η). To this we need to add the volume resulting from liquidity/hedging trades (θ). Mathematically, trading volume can therefore be written as:

$$Vol_t = f(\varepsilon_t, \eta_t, \theta_t). \qquad (5)$$

In this section we analyse the relationship between volume in options and exogenous news, in order to test for the existence of informed trading in options, as well as the potential effect of private information on the components of options trading volume (number of transactions and average trade size).

[7] As argued by Schlag and Stoll (2005), the shortcoming of running separate regressions for positive and negative volume is that it rules out the possibility of controlling for potentially offsetting volume effects.

3.2.1 Options volume and response to news

Since our main concern in this study is the relationship between volume and private information, we need to focus on those volume measures that affect spot prices and may therefore serve to measure informed trading. It should be noted, moreover, that, in order to gain a proper understanding of this issue, it seems more correct to relate, not trading volume, but unexpected volume to news, in order to detect whether surprises in volume are due to news release or to events of another nature. Thus, the problem to be analysed can be formulated as follows:

$$UVol_t^* = \lambda_0 + \lambda_1 GN_{t'} + \lambda_2 BN_{t'} + \lambda_3 . \hat{R}_t + u_{t,UV}$$

$$UVol_t^* = Vol_t^* - \mathrm{E}(Vol_t^* / \phi_{t-1}) \quad ; \qquad \mathrm{E}(Vol_t^* / \phi_{t-1}) = \mathrm{ARMA}(p,q) \tag{6}$$

This empirical model relates unexpected trading volume $UVol_t^*$ to general good and bad news releases in the Spanish financial press[8], using an error term that captures the impact of endogenous information revealed through market trading and hedge or liquidity trades. The variable Vol_t^* denotes total (Vol_t), positive (vol_t^+) or negative (vol_t^-) options trading volume or imbalance. GN stands for the dummy variable for good news and BN is the dummy variable for bad news. The subscript t´ in the dummy variables for news indicates that such information is published by the financial newspaper on day t+1 even though it is available for informed agents on day t. In order to avoid misleading conclusions if option investors simply respond to movements in the underlying market in a "trend-following" way, it would be interesting to include the underlying asset return along the trading session as an additional explanatory variable[9]. Nevertheless, given that this return may also be affected by good and bad news, we find it preferable to include the news-adjusted return on daily session t ($\hat{R}_t$) after filtering the influence of GN_t and BN_t[10]. Expected volume is estimated by means of an ARMA model (p,q) to find the best fit for the data[11]

The null hypothesis H2: $\lambda_1=\lambda_2=0$ indicates that the abnormal trading volume does not relate to exogenous information (proxied by exogenous news).

In performing this analysis we aim to link up with the literature addressing the issue of how informed trading in the options market is distributed across different degrees of

[8] The analysis was also repeated using the top and bottom quintiles of the residual of the index as the reference when creating the dummy variables to proxy for good and bad news respectively. The results lead to the same conclusions that can be drawn when using the press announcement. This validates its use since these news releases are spread throughout the trading day, while the residuals used as an alternative are only accessible expost.

[9] We would like to thank an anonymous referee for this suggestion.

[10] In the case of the Spanish stock market, good news is positively significant at the 5% significance level and bad news is negatively significant at the 0% significance level when explaining the underlying asset return. As an additional robustness test, we alternatively include overnight return (that is assumed to reflect other information than news) and raw return, respectively, as explanatory variables. The conclusions remain unchanged. All these results are available upon request.

[11] In most of the series analysed, the final specification was an AR(2). However, the results do not differ significantly from those obtained using other specifications, such as AR(5). Our proposal differs from that presented by Nofsinger and Prucyk (2003) in that these authors analyse differences in trading volume during 30-minute event windows.

moneyness. Chakravarty et al (2004) and Chen et al (2005) argue that this is a key issue because options with different degrees of moneyness have different levels of liquidity and different degrees of leverage. The theory also suggests various factors that might influence informed investors when making the choice between one strike price and another. Thus, on the one hand, though OTM options provide investors with more leverage, they also tend to involve higher delta-to-premium ratios, due to higher bid-ask spread and commissions. In ATM options, bid-ask spread tends to be lower, so investors trading on volatility tend to concentrate their trades in these. On the other hand, ATM options also expose informed investors to higher volatility risk (vega). Finally, ITM options generally involve lower commissions. The relative importance of these competing factors is an empirical question that has yet to be resolved. Chakravarty et al (2004), for example, find that price discovery is higher in OTM. Investors aiming to make the most of their private information should prefer to trade in options with the highest possible delta-to-premium ratio (Chen et al (2005)). Therefore, any study that fails to incorporate this issue runs the unavoidable risk of confounding the empirical results.

In light of this literature, it appears reasonable to suspect that daily volume in all positions may be masking different intentions among investors trading in options with different degrees of moneyness. Following the suggestion of Easley et al (1998), we will attempt to explore the informed trading hypothesis by considering particular options series. An informed investor may make more by trading in the options contracts with the highest leverage (OTM), while investors trading on volatility will tend to concentrate on ATM options. Those aiming to hedge, meanwhile, will likely opt for options contracts offering high liquidity, which will also be easier to find in ATM contracts. To overcome this problem, we will break down options trading volume into ATM, OTM and ITM options and estimate the regression equation described above for each of the three groups.

The database additionally allows us to explore the issue of investor disagreement. In particular, as is shown in the data description, four news scenarios are possible each day. News can be good, bad, mixed or absent. Assuming the coexistence of good and bad news on a single day to be a potential source of investor disagreement, it is possible to maintain the hypothesis that, *ceteris paribus,* such days will cause a greater divergence of opinion than might occur on a good news day, a bad news day or a no news day. The dummy variable DO, divergence of opinion, was created in order to examine the relationship between unexpected volume and investor disagreement. This variable will take a value of 1 for days when there is both good and bad news and a value of 0 otherwise.

Within this framework, in order to test the explanatory power of divergence of opinion (DO) for potentially informed trading, we propose a regression for unexpected volume similar to that used for news releases. The regression estimated in this case is given by:

$$UVol_t^* = \gamma_0 + \gamma_1 DO_{t'} + \gamma_2 \hat{R}_t + u_{t,UVD}$$

$$UVol_t^* = Vol_t^* \text{ -E}(Vol_t^* / \phi_{t-1}) \text{ ; } \quad \text{E}(Vol_t^* / \phi_{t-1}) = \text{ARMA(p,q)} \qquad (7)$$

The H3: $\gamma_1=0$ null hypothesis indicates the divergence of opinion is not an explanatory variable for the unexpected options volume measures.

3.2.2 Components of options trading volume and response to news.

Finally, if our results indicate the rejection of hypotheses 1 and 2 (or even hypothesis 3 although it is not necessary for our next empirical purpose) and, therefore, we find favourable evidence about the existence of informed trading in the options market, it becomes relevant to investigate whether private information increases the incentive for investors to trade strategically, camouflaging their intentions by ordering smaller trades that give away less information to other traders. In this section, we will examine this issue by considering the components of trading volume: the number of transactions and average trade size.

According to Barclay and Warner (1993), in the presence of informed trading, there is a higher incentive for traders to make medium-size trades in order to camouflage their strategy and thus avoid revealing information. This strategy, known as stealth-trading, leads investors to increase their trading frequency and exhibit a preference for medium-size trades. What follows is an increase in the number of trades and some reduction in average trade size. A breakdown of the data would enable us to determine whether any significant changes that might have taken place in either of these variables have been offset by the impact of the other variable. More specifically, it is possible that the number of trades might increase while the average size decreases, thus giving the impression that volume remains unaffected.

Our proposed estimation to analyse the impact of informed trading on the number (T) and average size of trades (TS), relies, like previous estimations, on the unexpected values of the relevant variables. More specifically, UT_t denotes the number of unexpected trades in period t and UTS_t denotes the average size of unexpected trades in period t, thus, the equations to be estimated are formally given by:

$$UT_t = \delta_{0,T} + \delta_{1,T} GN_{t'} + \delta_{2,T} BN_{t'} + \delta_{3,T} .\hat{R}_t + u_{t,UT}$$

$$UT_t = T_t \text{ -E}(T_t / \phi_{t-1}) \text{ ; } \text{E}(T_t / \phi_{t-1}) = \text{ARMA(p,q)} \qquad (8)$$

$$UTS_t = \delta_{0,S} + \delta_{1,S} GN_{t'} + \delta_{2,S} BN_{t'} + \delta_{3,S} .\hat{R}_t + u_{t,UTS}$$

$$UTS_t = TS_t \text{ -E}(TS_t / \phi_{t-1}) \text{ ; } \text{E}(TS_t / \phi_{t-1}) = \text{ARMA(p,q)} \qquad (9)$$

The null hypothesis H4a: $\delta_{1T}=\delta_{2T}=0$ indicates that the number of unexpected trades is not related to news. Similarly, the null hypothesis H4b: $\delta_{1S}=\delta_{2S}=0$ indicates that the average size of unexpected trades is not related to information.

In parallel with the approach used to explore news effects, we also analysed the impact of divergence of opinion on the number and average size of trades. Thus the models to be analysed for each of these variables take the following form:

$$UT_t = \omega_{0,T} + \omega_{1,T} DO_{t'} + \omega_{2,T} \hat{R}_t + u_{t,UTD}$$

$$UT_t = T_t - E(T_t / \phi_{t-1}) \; ; \quad E(T_t / \phi_{t-1}) = ARMA(p,q) \qquad (10)$$

$$UTS_t = \omega_{0,S} + \omega_{1,S} DO_{t'} + \omega_{2,S} \hat{R}_t + u_{t,UTSD}$$

$$UTS_t = TS_t - E(TS_t / \phi_{t-1}) \; ; \quad E(TS_t / \phi_{t-1}) = ARMA(p,q) \qquad (11)$$

Finally, the null hypothesis H5a: $\varpi_{1T}=0$ indicates that the number of unexpected trades is not related to the divergence of opinion and the null hypothesis H5b: $\varpi_{1s}=0$ indicates that neither is the average size of unexpected trades related to the divergence of opinion.

4-The database and variables for informed trading

We employed two databases, one for each of the instruments considered in the analysis, the Ibex-35 and Ibex-35 options. The first contained daily prices for the Ibex-35 index, which comprises the 35 most liquid common stocks traded on the Spanish "Stock Exchange Interconnection System" (*SIBE*). Daily data were used because of the need to match prices to the database of daily news announcements, which will be described later. We also used intraday transaction prices for options on the Spanish IBEX-35 index, in order to obtain data on options trading volume. These data were supplied by *MEFF,* the Spanish Official Exchange for financial futures and options. It belongs to the holding "*Bolsas y Mercados Financieros".* MEFF is fully regulated, controlled and supervised by the Spanish authorities ("*Comisión Nacional del Mercado de Valores*" and "*Ministerio de Economía*"). The option on the Ibex-35 index is European and trading began in January 1992.

To reduce the effect of option expiration, the options used in the analysis have at least five days to expiration and in order to avoid systematic biases arising from the lack of liquidity, options with more than 45 days to expiration are also removed. This primarily involves options at the first expiry (which clearly account for the bulk of the trading volume in the Spanish options market), but excluding transactions made close to the expiry date, which may have a significant impact on trading (for further details on this issue in the market under analysis see Corredor et al 2001) though none directly relating to the aims of this paper.

The literature has proposed several different measures for informed trading, including overall volume, positive and negative volume, and imbalance among others. To obtain the last two measures of informed trading on the options market it was necessary to identify each transaction as a purchase, when the transaction was made at the ask price, or as a sale, when it was made at the bid price. The trading system established by the MEFF allows for ready classification of each transaction because all are made at the ask price or the bid price. This avoids the need to establish the classification algorithms presented in other research such as Lee and Ready (1991), Easley et al (1998) or Chan et al (2002) among others. The advantage of using this type of classification as opposed to algorithms is that we can be certain which type of transaction has taken place and there is no need for assumptions.

Bearing these points in mind, we considered all call and put transactions with expiration periods of 5 to 45 days indicating in each case whether the transaction was a purchase or a sale. This gives us two variables: positive volume, vol^{+} (volume of calls purchased plus volume of puts sold on day t), and negative volume, vol^{-} (volume of calls sold plus volume of puts purchased on day t). The daily sum of the positive and negative volume gives us an additional variable that captures overall options trading volume on a given day. In addition to these measures of trading volume, we calculate imbalance, which is a variable that represents the difference between positive and negative volume each day.

Table 1 gives the descriptive statistics for the volume data analysed in our sample. Each table includes both aggregate statistics and a separation by ATM, OTM and ITM options. ATM options refer to S/K values (where S is the underlying asset price and K the strike price) in the range of 0.98-1.02. Call options with S/K values below 0.98 or put options above 1.02 are classed as OTM. Finally, put options with S/K values below 0.98 or call options above 1.02 are classed as ITM. It is interesting to note the differences in trading volume between the various types of option. Thus, ATM options account for 62% of trading, OTM options for 34%, and ITM options for 4%. These percentages also hold for the number of transactions. It is also worth noting that transactions are split almost symmetrically down the middle between positive volume and negative volume. There is barely any difference in average trade size between ATM and OTM options, however, while ITM trades are roughly half the size on average.

In addition to these two databases for stocks traded on *SIBE* and securities traded on the derivatives market, we also have a database of news items of economic significance taken from the economic press. These include news of potential general interest to investors (for example, public announcements of economic statistics, such as the unemployment rate, the consumer price index, events of economic significance or the prediction of major events by practitioners and academics). This database contains a total of 413 news items published in the Spanish financial press. It has also been used in other studies on the impact of news on stock market prices (see Blasco et al, 2002 and Blasco et al, 2005). Each news item is classed as good or bad depending on the qualitative assessment suggested in the financial press. We think that ex post classification depending on the market price change after the announcement may induce misleading conclusions[12]. Our approach gives us four potential daily news scenarios: good news, bad news, mixed news or no news of interest.

We construct two dummy variables for the subsequent analysis. GN is a variable that captures good news, it takes a value of 1 on days when good news is announced and 0 otherwise; BN is the variable that captures bad news, it takes a value of 1 on bad announcement days and 0 otherwise.

Since the information we are analysing is in the form of financial press releases, timing is an important issue. It is worth mentioning that news included as explanatory variables corresponds to the news published in the next day's press. The argument underlying this choice is that most of the news published in the economic press on day t + 1 would have taken place during the interval from the open of day t to the close of day t. The subscript t´ in the dummy variables for news indicates that such information is published by the financial newspaper on day t+1 even though it is available for informed agents on day t because it is likely to reach the market on day t through many other information servers. Since the informational advantage is short-lived, informed traders have no incentive to restrict their trading in order to have a larger informational advantage on the next day.

As a consequence, it is reasonable to assume that both the actual breaking of the news and the informed trading should take place prior to the public announcement in the press. If this assumption is correct, there should be significant correlation, on the day prior to announcement, between the information series and other proxies for public information variables[13]. On announcement day, meanwhile, since we are dealing with daily data, there should be no significant correlation at all. This assumption is tested by means of an ex-post analysis, where the time series of the index return is regressed on the proxies used to capture the presence of good or bad news on the market. The results support the above argument, since, when the return on day t is regressed on to the news published on day t (supposedly known on t-1), the coefficients are non-significant, and when it is regressed on to the next day's published news (supposedly known on t) they are significant and exhibit the expected sign. These results support the use of the press release database as well as the suitability of the definition proposed for the time subscript of news variables.

Finally, let us point out that our analysis spans January 1997 to December 1998, a period chosen mainly because of the stability of the trading systems in the Spanish market and the amount of open derivative contracts involving stocks listed in the Ibex-35.

[12] See Blasco et al (2002) or Blasco et al (2005) for further details on the database.

[13] As a robustness check, the residual series of the index return (usually identified with unexpected news) is regressed on the proxies used to capture the presence of good or bad news on the market. The results support the above argument, since, when the residuals of day t are regressed on the news released on day t, the coefficients are non-significant, and when they are regressed on the next day's news (t+1) they are significant and of the expected sign. These results also validate the use of the press release database. This database is thought to be more useful to investors than other information proxies (such as residuals) which are not known until close of trading.

5-Empirical results

5.1-Underlying asset prices and options trading volume.

The first step consists of analysing the relationship between option trading volume and asset price changes. The results for equation 2 are given in the first column of Table 2. As can be seen, the results of this first analysis show that aggregate volume is not statistically significant and, therefore, we can not reject the null hypothesis H1: $\beta_{2,s}=0$. This result suggests that aggregate options trading volume is not a reliable measure of informed trading and, consequently, has no effect on underlying asset prices. The key to this lack of significance probably lies in the fact that this variable covers different positions, which may cancel each other out at the aggregate level. Easley et al (1998) argue that they do not expect to find overall option volume to have predictive power. This is because options are used for a wide variety of liquidity-based purposes, and these would generally involve using options to follow movements in the underlying stock. Moreover, because every option trade has both a writer and a buyer, simply looking at overall volume essentially "averages" the buyer and seller together. This makes it impossible to determine the active side of the trade, and so vitiates the results about the information content.

These results lead to the analysis using positive and negative volume separately. The results for equation 3 are given in the second column of Table 2. As can be seen, the findings have changed considerably, now clearly pointing to the presence of a contemporaneous relationship between the type of volume and the impact on underlying asset prices (the null hypothesis H1: $\beta_{2,s}=0$ is clearly rejected). Thus, $\beta_{2,2}$, which captures the effect of vol^+ on underlying asset prices, appears positive and significant; and $\beta_{3,2}$, which captures the effect of vol^- on the underlying asset, is negative and significant. This supports a contemporaneous relationship between the type of volume and the sign of the impact on the underlying asset. In fact, positive volume would appear to be associated with a price increase in the underlying asset while negative volume would appear to be linked to a price decrease. As in Easley et al (1998), our results have shown asymmetric positive and negative effects. In absolute terms, the effect of negative options trading volume is greater than that of positive volume, which suggests that options markets may appeal to investors seeking to act on bad news. It is often argued that the role of options markets is to provide a means to overcome short-sales constraints in spot markets, which is more prevalent in small markets such as the one that concerns us, and can be circumvented through precisely the type of transactions that make up negative trading volume. We will attempt to highlight this possibility with the following volume measure.

In the case in which volume is captured by imbalance (IB) (see the third column of Table 2) the results support those obtained via the second alternative, while also adding some further information. Note that this variable proves significant and positive, which means that, when one volume is higher than the other, returns move in the expected direction. Thus, when the imbalance is positive (in other words, positive volume is higher than negative volume) prices rise and when the imbalance is negative (negative volume is higher than positive volume) prices fall. These results support those obtained in the previous regressions.

The set of results presented here allows us to reject the null H1 hypothesis of absence of impact of options trading volume on their underlying assets in favour of a clear contemporaneous relationship between them, which is observed when using disaggregated positive and negative volume and also when considering imbalance. This relationship only fails to emerge when informed trading is proxied by aggregate volume. Thus, in the case of the Spanish market, analysis of the relationship between potentially informed trading volume and news should focus on these measures.

5.2-Options volume and information

5.2.1 Options volume and response to news

It should be stressed, however, that the results obtained in the previous section are consistent not only with the fact that options trading volume may reflect an information effect but also with the fact that it may be due to transactions made for liquidity/hedging purposes involving the derivative and its underlying asset. To investigate this issue, in this section we perform a direct test of the influence of news releases as direct measures of information on positive and negative options trading volume. This will enable us to draw some conclusions regarding this key issue.

Table 3 gives the results of the regression 6, which is estimated using the Newey and West variance and covariance matrix. The results are very enlightening since the news impact is reflected only in the OTM options trading volume. The H2: $\lambda_1=\lambda_2=0$ null hypothesis is not rejected in ATM and ITM options. It therefore appears that trading volume in ATM and ITM options may be linked to factors other than news, such as liquidity or lower transactions costs, while investors trading on news tend to go for OTM options. Furthermore, this impact is not evenly spread over positive and negative volume, since bad news is reflected in negative volume only.

The fact that bad news has a stronger impact than good news is also highlighted in the article by Nofsinger and Prucyk (2003) who show moreover that bad news, unlike good news, leads to high volatility. These authors find a 2-hour delay between the announcement and post-announcement volume increases. However, they also observe that abnormal trading volume is positive and significant 30 minutes before the bad-news announcement, but they assert that it is not related to informed trading because the behaviour of negative-trade volume is significantly lower than expected before the announcement. A similar result is shown in good-news announcements. Nonetheless, these authors do not take into account the different levels of option moneyness in their analysis and this characteristic is very important for informed traders who, in deciding where to place their trades, are not entirely indifferent to option moneyness, degree of information asymmetry, and option liquidity, and generate feedback relations between trades in out-of-the-money (OTM) options and the underlying equities (see Chen, et al. 2005).

Our findings for the relationship between negative volume in this class of option and bad news are consistent with the argument put forward in Branger and Schlag (2005). Investors showing a high level of loss aversion and a strong incentive to hedge against natural disasters or sudden market shocks are the main traders in this type of product based on OTM put options. An informed investor of these characteristics displays high sensitivity to bad news, which explains the statistical significance of bad news in negative trading volume in OTM options. This argument is also directly linked to the presence of short sales constraints, which are much higher in the market that concerns us than in larger markets such as that of the US.

As well as the relationship between volume and news, the literature has also reported lack of consensus among investors to be positively related to volume. Studies such as Hong and Stein (2003) or Vega (2006), among others, provide examples of this.

In the specific case of the options market, Driessen and Maenhout (2007) report that aversion to loss or to uncertainty, which are reflected in investors' disagreement or discrepancy, leads risk averse investors, who would avoid trading in the shares market only, to hold significant positions in derivatives and, more specifically, short positions in OTM put options and ATM straddles when these are available[14].

The results of testing the explanatory power of divergence of opinion (DO), hypothesis 3, (see Table 4) reveal that negative options trading volume is not explained by the disgreement variable in any of the three types of option considered, whereas positive volume in OTM options is. The results for the remaining ATM and ITM options show that trading volume in these assets is unaffected by discrepancy among investors faced simultaneously with good and bad news and the potential impact of this on market performance. Therefore, hypothesis 3 (γ_1=0) is only rejected in the case of OTM options. These results are revealing because in times of disagreement, risk averse agents tend to take significant short positions in OTM puts, that is, in one of the components of positive volume. Apparently, therefore, positive trading volume in OTM options is indeed related to news, although indirectly by means of the lack of consensus among investors about the market reaction to simultaneous good and bad news, rather than by good news in itself.

Our results suggest that it is a highly complex mechanism that moves informed investors to trade in the options market. Thus, the simple relationship reported in the literature linking positive volume to good news and negative volume to bad news is in fact not that straightforward. In fact, we have found greater information content in OTM options, where negative volume is indeed directly related to bad news. Positive volume, meanwhile, more closely reflects lack of consensus among investors as to the final outcome of the news[15]. Thus, it appears that bad news on the market is accepted as being accurate while good news is treated with more caution. This asymmetric reaction to news is also described in other papers (see Nofsinger and Prucyk, 2003 for the US options market or Blasco et al., 2002 and 2005 for the Spanish stock market).

5.2.2 Components of options trading volume and response to news.

In this section we analyse whether private information increases the incentives for investors to trade strategically, by examining the components of trading volume.

Table 5 shows the impact of news on the number and average size of trades, broken down by type of option: ITM, ATM and OTM (equations 8 and 9). In line with the results presented earlier, in ITM options, both the number and average size of trades remain unexplained by news. This corroborates the notion that informed trading, when it occurs, has a negligible impact on this type of option. Furthermore, in line with the theory advanced earlier, the impact of good news on OTM or ATM options also lacks statistical significance. In the presence of bad news, however, there is a significant increase in the number of trades in both these types of option. Specifically, bad news is followed by a 32% rise in the number of ATM options traded and by a 59% rise in the number of OTM options traded. Therefore, hypothesis 4a ($\delta_{1T}=\delta_{2T}=0$) is only rejected for ATM and OTM options.

This provides clear evidence of the relationship between informed trading and the number of trades in these options. Leverage reasons, as indicated earlier, explain the higher increase in OTM options. Nevertheless, due to their higher liquidity in this market, ATM options also appear to attract informed traders, especially those trading on volatility. This would explain the lack of any significant relationship between signed volumes (positive and negative volume) and news in this type of option. The fact that these bets can occur in either of the two alternatives disperses the effect.

The impact on average trade size in all types of option is negative but it is only significant for OTM options. In the case of ITM options, this can be explained by the absence of any news effect on the volume or number of trades. For ATM the results are consistent with the reasoning used in Barclay and Warner (1993) or Chakravarty, (2001) where it is reported that, in the presence of informed trading, the main effect will be an

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[14] Since straddles are difficult to detect in the Spanish market, we focus our attention on the effects of short positions in OTM options.

[15] Chen and Goodhart (1998) argue that volume alone is unable to tell the full story about market expectations, because, if trading lacks information content, an increase in demand (supply) may simply be offset by an increase in supply (demand) and leave options prices unchanged. If, however, the increase in demand (supply) reflects new information, options dealers will adjust prices upwards (downwards). Repetition of the exercise using monetary volume yields similar results.

increase in the number of medium-size trades that may go unnoticed in the rest of the trading pattern[16]. Therefore, hypothesis 4b ($\delta_{1S}=\delta_{2S}=0$) is only rejected for OTM options.

Informed trading in OTM options is largely explained by the fact that they offer higher leverage, which logically maximises returns. The motivation for the possible presence of informed trading in ATM options is explained in the case of the Spanish options market by reasons of liquidity. As already mentioned, given that there is no significant impact on signed options volume, this finding appears to be consistent with the idea of volatility trading, which, as noted by Easley et al (1998) is more likely to occur in this type of option, thanks to their higher liquidity.

The results for equations 10 and 11 are given in Table 6. As can be seen, the effects of investor disagreement, while less intense, are very similar to those of news. In this case, there is a 24% rise in the number of trades in ATM options and a 42% rise in the number of OTM options traded, while no significant effect is found on ITM options. Therefore, hypotheses 5a ($\varpi_{1T}=0$) and 5b ($\varpi_{1s}=0$) are only rejected for ITM options. The effects on average trade size are considerably more moderate than in the presence of news, suggesting the absence in this case of any impact from stealth trading.

In short, the results obtained reveal that options trading volume, especially in the case of OTM options, carries significant information to the underlying asset market, especially when driven by bad news, which investors may be more ready to believe. This finding is backed up by the results obtained for the number and average size of trades, which show some signs of stealth trading in these cases. The presence of investor disagreement also generates an increase in trading volume in these options, though not to the degree caused by the presence of news.

In ATM options, however, there is no observable statistically significant impact on signed volume in options (positive or negative) as a result of bad news or investor disagreement. Nevertheless, we find a significant increase in the number of trades in both cases. This appears to be consistent with the idea that much of the informed trading in these options takes the form of volatility trading. The impact of this on signed volume in options will not be readily observable, since it does not necessarily manifest itself in the form of a price shift in one particular direction.

Finally, it is worth noting some characteristics of our database. Since the exact moment at which the news was made public in the market is unknown, our trading volume measures (positive, negative or imbalance) add trading volume values before and after the news release and therefore can be considered noisy measures of informed trading. Although they may possibly incorporate other trading causes (such as exploiting the underreaction to news announcements, irrational momentum trading,...), we think that these variables are

[16] Unfortunately, we do not know whether trades are initiated by institutions or by individuals. Chakravarty (2001) shows that the root of *stealth-trading* lies in trades by institutions.

nevertheless useful proxies for informed trading. On the one hand, the significant results are found mainly in the OTM options that presumably exhibit the best conditions for promoting informed trading. On the other hand, we also find evidence of intentional and strategic stealth trading since the number of transactions significantly increases while the average size of transactions decreases. None of these results is easily explained by reasons other than informed trading.

6-Conclusions

In this article we have linked proxies for informed trading in the options market to exogenous news variables. Our aim was to test directly for the presence or absence of informed trading in the options market and to determine whether such trading has any price impact on the underlying stock index. In line with the seminal work by Nofsinger and Prucyk (2003) relating options trading volume to scheduled news, we have tried to explore the relationship between options volume and information by introducing factors such as the degree of moneyness in options and volume variables with enough impact on the underlying asset price to allow them to be used as proxies for the presence of informed trading. We have used all of the news items appearing in the financial press, most of which involve non-scheduled news. The analysis is performed in a much smaller market, with higher short sales constraints than the US market analysed by the cited authors, thus giving a complementary view of the phenomenon under research. Finally, the role of divergence of opinion deriving from the simultaneous presence of good and bad news at a given moment in time has also been considered.

The results have proved revealing. In partial coincidence with the arguments presented in the literature, potential informed trading is concentrated mainly in the highest leverage options (OTM). An exception to this is found in volatility trading, where investors mainly select ATM options for liquidity purposes. In both cases, the presence of informed trading is accompanied by stealth trading strategies, in which investors try to conceal their private information through the fragmentation of their transactions, thus causing an increase in the number of medium-size trades.

Divergence of opinion drives growth in trading volume, although this is concentrated mainly in OTM options. In such cases, the increase in the number of transactions, while relevant, is considerably lower that in the unequivocable presence of news. Its impact goes even more unnoticed when the focus is on average trade size.

These results suggest the need for further analysis of issues such as the impact of stock options trading on their respective underlying assets in the presence of specific firm news and research to determine how far some of these phenomena may differ. This study may also help to determine whether there are any further factors, such as specific types of firms or news, that might help to explain the complex relationships between informed trading volume, news and stock prices.

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Table 1: Descriptive statistics. Vol is the number of contracts purchased or sold over day intervals. Vol^+ is positive options volume (defined as volume of calls purchased plus volume of puts sold), Vol^- is negative options volume (defined as volume of calls sold plus volume of puts purchased). Trans is the number of transactions over day intervals. ATrans is average trade size over day intervals. ATM options are options with strike price ranging from 98% to 102% of the underlying asset price, and ITM call (put) options are options with strike price below 98% (above 102%) of the underlying asset price. The sample size is 496 observations.

Variable	**Mean**	**Median**	**Std.dev**	**Maximum**	**Minimum**
Aggregated data					
Vol	33659.79	23680.50	39885.75	417389.00	271.00
Vol^+	17612.19	11170.50	23865.19	262860.00	40.00
Vol^-	16047.60	10619.00	18489.71	154529.00	97.00
Trans	240.90	235.50	121.22	793.00	13.00
Atrans	125.63	101.26	120.38	1405.35	9.18
ATM options					
Vol	21071.88	14626.00	24155.47	214348.00	143.00
Vol^+	11002.24	7134.00	14130.86	147925.00	20.00
Vol^-	10069.65	6491.50	11212.11	79829.00	78.00
Trans	149.67	145.00	72.95	470.00	9.00
Atrans	124.77	101.21	110.90	1175.50	9.96
OTM options					
Vol	11337.23	7269.00	14786.03	201693.00	65.00
Vol^+	5969.85	3523.00	9187.77	128311.00	20.00
Vol^-	5367.37	3313.00	6938.47	73382.00	2.00
Trans	84.08	80.00	45.58	307.00	4.00
Atrans	126.08	96.29	173.50	2728.21	8.00
ITM options					
Vol	1250.67	62.50	6814.52	114386.00	0.00
Vol^+	640.09	21.50	3968.96	72692.00	0.00
Vol^-	610.57	21.50	3285.02	41694.00	0.00
Trans	7.14	4.00	10.80	134.00	0.00
Atrans	64.43	13.88	192.41	1810.00	0.00

Table 2: Results for the contemporaneous relationship between Ibex-35 return and option trading. The mean is multiplied by 1000.

$$\Delta P_t = \beta_{0,s} + \beta_{1,s}\Delta P_{t-1} + \beta_{2,s} X_{s,t} + u_{t,s} \quad \text{where } u_{t,s} \text{ follows } N(0,h_{t,s})$$

$$h_{t,s} = \alpha_{0,s} + \alpha_{1,s} u_{t-1,s}^2 + \varpi_{1,s} h_{t-1,s}$$

Regression s=1. $X_{1,t}$ is defined as the global trading volume
Regression s=2: $X_{2,t}$ includes two variables, positive volume and negative volume
Regression s=3: $X_{3,t}$ is defined as the imbalance

*Significant at the 10% level
**Significant at the 5% level
***Significant at the 1% level

	Regression 1	Regression 2	Regression 3
Intercept	5.76	5.72	1.78 ***
Lag 1 of return	130.73 ***	112.44 **	117.68 ***
Lag 0 of global volume	-0.38		
Lag 0 of positive volume		3.45 ***	
Lag 0 of negative volume		-3.88 ***	
Lag 0 of imbalance			$0.13 \cdot 10^{-3}$ ***
Variance			
α_0	$0.99 \cdot 10^{-5}$	$0.99 \cdot 10^{-5}$	$1.07 \cdot 10^{-5}$ **
α_1	0.13 ***	0.14 ***	0.13 ***
ω_1	0.83 ***	0.83 ***	0.83 ***

Table 3: Results of the regressions of unexpected positive ($UVol^+_t$) and negative ($UVol^-_t$) volume, as a function of good (GN) and bad (BN) news. OTM call (put) options are options with strike price above 102% (below 98%) of the price of the underlying asset, ATM options are options with strike price ranging from 98% to 102% of the underlying asset price, and ITM call (put) options are options with strike price below 98% (above 102%) of the price of the underlying asset. $\hat{R}_t$ is the news-adjusted return of the underlying asset. Estimated using the Newey-West variance and covariance matrix.

$$UVol_t^* = \lambda_0 + \lambda_1 GN_{t'} + \lambda_2 BN_{t'} + \lambda_3.\hat{R}_t + u_{t,UV}$$

$$UVol_t^* = Vol_t^* - E(Vol_t^* / \phi_{t-1}) \quad ; \qquad E(Vol_t^* / \phi_{t-1}) = ARMA(p,q)$$

Where $UVol_t^*$ is unexpected positive ($UVol_t^+$) or negative ($UVol_t^-$) volume, respectively.

*Significant at the 10% level
**Significant at the 5% level
***Significant at the 1% level

	ATM		OTM		ITM	
	$UVol^+_t$	$UVol^-_t$	$UVol^+_t$	$UVol^-_t$	$UVol^+_t$	$UVol^-_t$
λ_0	-0.03	-0.01	-0.08	-0.04	-0.11	-0.08
λ_1	0.04	-0.02	0.08	-0.01	0.21	0.19
λ_2	0.07	0.11	0.22	0.25 **	0.06	-0.02
λ_3	3.03	3.03	0.88	-0.84	6.05	7.04

Table 4: Results of the regressions of unexpected positive ($UVol^{+}_{t}$) and negative ($UVol^{-}_{t}$) volume as a function of the dummy variable for investor divergence of opinion DO. OTM call (put) options are options with strike price above 102% (below 98%) of the underlying asset price, ATM options are options with strike price ranging from 98% to 102% of the underlying asset price, and ITM call (put) options are options with strike price below 98% (above 102%) of the underlying asset price. $\hat{R}_t$ is the news-adjusted return of the underlying asset. Estimated using the Newey-West variance and covariance matrix.

$$UVol_t^* = \gamma_0 + \gamma_1 DO_{t'} + \gamma_2 \hat{R}_t + u_{t,UVD}$$

$$UVol_t^* = Vol_t^* - \mathrm{E}(Vol_t^* / \phi_{t-1}) \; ; \quad \mathrm{E}(Vol_t^* / \phi_{t-1}) = \mathrm{ARMA(p,q)}$$

Where $UVol_t^*$ is unexpected positive ($UVol_t^+$) or negative ($UVol_t^-$) volume, respectively.

*Significant at the 10% level
**Significant at the 5% level
***Significant at the 1% level

	ATM		OTM		ITM	
	$UVol^{+}_{t}$	$UVol^{-}_{t}$	$UVol^{+}_{t}$	$UVol^{-}_{t}$	$UVol^{+}_{t}$	$UVol^{-}_{t}$
γ_0	-0.02	-0.01	-0.04	-0.02	-0.05	0.06
γ_1	0.16	0.09	0.27 **	0.17	0.31	-0.43
γ_2	3.00	3.06	0.81	-0.87	5.80	7.22

Table 5: Results of the regression analyses of the Number of Unexpected Trades (UT) and Average Size of Unexpected Trade (UTS) as a function of good (GN) and bad (BN) news. Where T is the number of transactions and TS is the average trade size. OTM call (put) options are options with strike price above 102% (below 98%) of the underlying asset price, ATM options are options with strike price ranging from 98% to 102% of the underlying asset price, and ITM call (put) options are options with strike price below 98% (above 102%) of the underlying asset price. $\hat{R}_t$ is the news-adjusted return of the underlying asset. Estimated using the Newey-West variance and covariance matrix.

$$UT_t = \delta_{0,T} + \delta_{1,T} GN_{t'} + \delta_{2,T} BN_{t'} + \delta_{3,T} . \hat{R}_t + u_{t,UT}$$

$$UT_t = T_t \text{ -E}(T_t / \phi_{t-1}) \text{ ; } \text{E}(T_t / \phi_{t-1}) = \text{ARMA(p,q)}$$

$$UTS_t = \delta_{0,S} + \delta_{1,S} GN_{t'} + \delta_{2,S} BN_{t'} + \delta_{3,S} . \hat{R}_t + u_{t,UTS}$$

$$UTS_t = TS_t \text{ -E}(TS_t / \phi_{t-1}) \text{ ; } \text{E}(TS_t / \phi_{t-1}) = \text{ARMA(p,q)}$$

*Significant at the 10% level
**Significant at the 5% level
*** Significant at the 1% level

	ATM		OTM		ITM	
	UT	UTS	UT	UTS	UT	UTS
δ_0	-6.70	3.06	-3.58	0.47	-0.07	-1.67
δ_1	7.14	-2.12	2.01	2.96	0.24	7.23
δ_2	17.86 **	-10.88	13.88 ***	-15.57 *	-0.19	-8.59
δ_3	-12.63	244.19	-167.90	47.47	89.70	546.87

Table 6: Results of the regression analyses of the Number of Unexpected Trades (UT) and Average Size of Unexpected Trades (UTS) as a function of the dummy variable divergence of opinion DO, where T is the number of trades and TS in the average trade size. OTM call (put) options are options with strike price above 102% (below 98%) of the underlying asset price, ATM options are options with strike price ranging from 98% to 102% of the underlying asset price, and ITM call (put) options are options with strike price below 98% (above 102%) of the underlying asset price. $\hat{R}_t$ is the news-adjusted return of the underlying asset. Estimated using the Newey-West variance and covariance matrix.

$$UT_t = \omega_{0,T} + \omega_{1,T} DO_{t'} + \omega_{2,T} \hat{R}_t + u_{t,UTD}$$

$$UT_t = T_t - E(T_t / \phi_{t-1}) \; ; \quad E(T_t / \phi_{t-1}) = ARMA(p,q)$$

$$UTS_t = \omega_{0,S} + \omega_{1,S} DO_{t'} + \omega_{2,S} \hat{R}_t + u_{t,UTSD}$$

$$UTS_t = TS_t - E(TS_t / \phi_{t-1}) \; ; \quad E(TS_t / \phi_{t-1}) = ARMA(p,q)$$

*Significant at the 10% level
**Significant at the 5% level
*** Significant at the 1% level

	ATM			OTM			ITM	
	UT		UTS	UT		UTS	UT	UTS
ω_0	-2.21		0.63	-1.58		-1.54	0.24	3.55
ω_1	14.92	*	-3.44	10.49	**	4.26	-1.70	-23.90
ω_2	-19.65		249.79	-173.90		47.12	90.26	559.83