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PRESENCE OF INFORMED TRADING IN OPTIONS MARKETS: AN EXPERIMENT USING MONTE CARLO SIMULATION

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Using Monte Carlo Simulation we show that informed trading take place in the options market. Our results indicate that at-the-money option contracts are less likely to be information based trades. Using Black-Scholes model to evaluate call and put options, we find that with positive and negative information shocks, informed investors are better off trading out-of-the-money and/or in-the-money-options. This is clear evidence that investors with inside or superior information would take advantage of options' leverage effect, Black (1975). Our analysis sheds light on the direction to revisit the models proposed by Easley et al (1998) and Chan et al (2002). We argue that, to examine the role of option volume, the out-of-the-money and/or in-the-money option volumes should be considered as well.

Introduction

The origin of the information models can be traced back in 1971, Bagehot (1971). Information production is costly. So producers of information (also known as traders with superior information) trade in financial markets with uninformed traders and/or market makers. The loss, for uninformed traders, arising from the trades with informed traders is the gain for the latter to recoup the cost of information production.

The effect of information takes on added dimension when there are multiple financial markets (like stock market, option market, and futures market) and multiple types of securities (like stock, call option with different strike prices, and put option with different strike prices, call and put options of different maturities, and futures contract etc). The market with the existence of information asymmetries reaches equilibrium in terms of all related securities in a sequential manner. That is, the true market price will not be discovered until all market participants' expectations are factored in. The presence of multiple markets may make the equilibrium process a little longer. Even though information may be public in one market, it may still remain unexplored by many market participants, and security prices in other related market may not reflect all public information.

The interest of research in this paper is to address the presence of information in option markets by using option volume and maturity and its impact on underlying securities for the maturity date. Current literature provides a mixed result regarding the information in different markets, lead-lag relationship between markets, and reflection of information trading.

Chan, Chung and Fong (2002) and Easley, O'Hara and Srinivas (1998) provide the first step investigating the role of volume in options markets and complements research by Blume, Easley and O'Hara (1994) on the information content of volume in equity markets. Easley et al. (1998), Cherian (1998), Cherian and Jarrow (1998), Cherian and Villa (1997), Back (1993), Kraus and Smith (1996), and John et al. (2000), find that informed traders might trade in the options market first. Manaster and Rendleman (1982), Bhattacharya (1987), and Anthony (1988) present evidence that the options market leads the stock market in terms of both price movements and trading activity. Easley et al. (1998) show that positive options volume and negative options volume have predictive power concerning the movement of the underlying stock. Cao, Chen, and Griffin (2003) show that firms that have experienced takeover announcements, higher pre-announcement volume on call options is predictive of higher takeover premiums. There is not much evidence that during normal time option volume predicts underlying stock prices. Sandeep Srivastava (2003) shows evidence that option volume improves the price discovery in underlying asset market in India.

Pam and Poteshman (2004) find strong evidence that option trading volume contains information about future stock price movements. Chae (2005) finds evidence of a decrease in the level of volume before scheduled announcement and followed by an increase after the scheduled announcements. Easley, O' Hara and Srinivas (1998), also find some differing result that overall total volume from the option market has no predictive power. Chan, Chung and Fong (2002) find that option net volume has no incremental predictive ability suggesting that informed investors initiate trades

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in stock markets but not in options markets.

The purpose of this research is to explore the information content of the trading activities in options markets and to examine the presence of information in option market and types of instruments that can hold information.

Information Search

We develop several scenarios to analyze the information contents of option trades. Two issues we bring into discussion to address our question: (1) simple trade and (2) moneyness of the trade. Simple trade focuses on the total volume attached in each trade.

Where as, moneyness addresses the value attached to the volume at each strike and its role in analyzing information. Consider that a stock is currently trading at \$50 (S=50) in a stock market, and there are call and put options available in the options markets with only 3 exercise prices, K_1=\$40, K_2=\$50, and K_3=\$60. Here, $K_1 < K_2 < K_3$. In terms of call options, these options with different strikes are known as In-the-money (ITM), At-the-money (ATM), and Out-of-the-Money (OTM), respectively. For put options, however, the order is just the opposite while keeping the ATM as same as call option.

There are four possible scenarios considered for simple trades. From daily trading, option volumes at each strike of call and put option can be generated and are shown in table 1.

Table 1: Scenario Analysis for Volumes of Call Option and Put Option at Different Strike Prices

Call Option Market		
Scenario 1: Volume at (K= 60) =100	Volume at (K= 50) =100	Volume at (K= 40) =100
Scenario 2: Volume at (K= 60) =100	Volume at (K= 50) =10	Volume at (K= 40) =10
Scenario 3: Volume at (K= 60) =10	Volume at (K= 50) =100	Volume at (K= 40) =10
Scenario 4: Volume at (K= 60) =10	Volume at (K= 50) =10	Volume at (K= 40) =100
Put Option Market		
Scenario A: Volume at (K= 60) =100	Volume at (K= 50) =100	Volume at (K= 40) =100
Scenario B: Volume at (K= 60) =100	Volume at (K= 50) =10	Volume at (K= 40) =10
Scenario C: Volume at (K= 60) =10	Volume at (K= 50) =100	Volume at (K= 40) =10
Scenario D: Volume at (K= 60) =10	Volume at (K= 50) =10	Volume at (K= 40) =100

In a call option market, scenario 1 implies that there are equal numbers of volume of options traded at each strike price. Looking at the distribution of option volume, it appears that there is no majority in volume at any strike price that may contain some information. Investors are equally divided in terms of expected price of the underlying for the maturity date. So volume at ATM has the same expectations as volume at ITM and OTM. The same conclusion can be drawn from the volumes in put option market in scenario A as well. Both markets perhaps provide no information based trading. According to Easley et al (1998) and Chan et al (2002), the definition of total volume is the volume attached to the at-the-money strike and the economic meaning of our volume and that of Easley et al (1998) and Chan et al (2002) would imply be the same- no information.

Scenario 2 in a call option market is interesting and perhaps informative. It shows that there are 100 option volumes at OTM strike which is significantly higher than those of ATM and ITM. This heavy activity in the OTM strike may imply positive information trading. Scenario B in a put option market is also interesting and informative as well. It shows a heavy volume attached to the ITM options and significantly lower volumes in other strikes. Both markets offer positive information based trades. Easley et al (1998) and Chan et al (2002) discard these volumes from their volume analysis. That would be discarding pure information based trading and hence needs revisiting the volume analysis by incorporating these volumes.

Scenarios 3 and C from call and put option markets indicate heavy volume traded around ATM strike. These heavy volumes in both options markets echo the economic meaning that investors are unanimously in agreement that the underlying stock price would be around that strike price. These volumes in options markets are regarded as informative. Easley et al (1998) and Chan et al (2002) will find positive and or negative volumes which are informative volumes.

Finally scenarios 4 and D in call and put options markets offer significant negative information. Scenario 4 indicates that volumes are heavily concentrated around ITM strike. Scenario D in a put option market shows that volumes are significant at ITM strike. Both markets are indicating negative information trading in the options markets. However, Easley et al (1998) and Chan et al (2002) discard these volumes from their analysis. It is clearly evident from our experiment that these volumes must have clear attention to retrieve information from options markets.

Now consider the moneyness of options volumes. In order to do that we need the price of option for each strike of call and put options. Considering the same set of stock price, strikes, volumes of call and put options,

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we assume that prices of K_H=$60 are $1.00 for call, and $11.00 for put options. Prices of K_E=$50 are $3.00 for call and $2.75 for put options respectively. Finally, prices of K_L=$40 are $11.00 for call and $1.00 for put options respectively. Considering the moneyness of the volume we prepare table 2. They are calculated by taking product of the option price, number of volumes, and 100 (Option price *Volume* 100) together.

Table 2: Scenario Analysis for Moneyness of Volumes (MV) of Call Option and Put Option at Different Strike Prices

Call Option Market		
Scenario 1: MV (K= 60) = $10,000	MV (K= 50) = $30,000	MV (K= 40) = $110,000
Scenario 2: MV (K= 60) = $10,000	MV (K= 50) = $3000	MV (K= 40) = $1100
Scenario 3: MV (K= 60) = $1000	MV (K= 50) = $3000	MV (K= 40) = $1100
Scenario 4: MV (K= 60)= $1000	MV (K= 50) = $3000	MV (K= 40) = $110,000
Put Option Market		
Scenario A: MV (K= 60) = $110,000	MV (K= 50) = $27,500	MV (K= 40) = $10,000
Scenario B: MV (K= 60) = $110,000	MV (K= 50) = $3000	MV (K= 40) = $1,000
Scenario C: MV (K= 60) = $1100	MV (K= 50) = $27,500	MV (K= 40) = $1,000
Scenario D: MV (K= 60) = $1100	MV (K= 50) = $2750	MV (K= 40) = $10,000

When volumes are weighted by their value attached, it is observed that information can be clearly extracted from option volume. Scenario 1 in call option market indicates that there is negative information about the underlying security and stock perhaps would be down at the maturity date. The put option market indicates the opposite results when trading higher strikes. It would imply largest dollar value attached with that strike and that is positive information based trading. Even though, there are equal volumes across strikes, the dollar value is higher for higher strike. Scenario C and Scenario 3 both indicate no information attached with volumes in both options market. This would be similar to volumes in Easley et al (1998) and Chan et al (2002) with no significance. Scenario 2 and scenario B both indicate strictly positive information based trading. Finally, scenario 4 and scenario D indicate strictly negative information based trading. These scenarios clearly demonstrate that information trade takes place at OTM and ITM options.

Price Forecast for Different Scenarios from Option Volume

We apply a methodology similar to Bhuyan (2002). Assume that there is a trading in the market and the stock price at time t is S_t and S_T at time T. Let $\{X_{-i}^C, i = 1, ..., K\}$ be the set of strike prices for calls and $\{X_i^P, i = 1, ..., L\}$ be the set of strike prices for puts. For any $t \in [T_0, T]$, let V_{it}^C be the volume for a call with the strike price of X_i^C at time t and similarly V_{it}^P be the open interest for a put with strike price of X_i^P. First, we define volume-based-predictor for call options, P_t^C.

$$P_t^C = \sum_{i=1}^{K} w_{it}^C X_i^C \text{, and} \quad w_{it}^C = \frac{V_{it}^C}{\sum_{i=1}^{K} V_{it}^C} \quad (1)$$

Where, w_{it}^C is the weight, defined as the proportion of volume for one strike with respect to the total volumes of all strikes, for a call option with exercise price of X_i^C. K is the number of call options with non-zero volume.

$$P_t^P = \sum_{i=1}^{K} w_{it}^P X_i^P \text{, and} \quad w_{it}^P = \frac{V_{it}^P}{\sum_{i=1}^{K} V_{it}^P} \quad (2)$$

Where, w_{it}^C is the weight, defined as the proportion of volume for one strike with respect to the total volumes of all strikes, for a call option with exercise price of X_i^C. K is the number of call options with non-zero volume. According to our definition, call and put volume based forecast prices (E(P)) are defined in table 3.

Table 3: Scenario of Call Volume Based Predictors Derived by Using Equation (1)

Call Option Market	Put Option Market
Scenario 1: E(P) = $50.00	Scenario A: E(P) = $50.00
Scenario 2: E(P) = $57.50	Scenario B: E(P) = $57.50
Scenario 3: E(P) = $50.00	Scenario B: E(P) = $50.00
Scenario 4: E(P) = $42.50	Scenario B: E(P) = $42.50

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In table 3, we utilize the information from table 1 to apply our methodology to forecast price for the underlying. As it becomes clear that our methodology offers quite clear and common results for information based trading and non information based trading. When positive information drives the volume heavy at OTM in Call and ITM in Put options markets, they both indicate higher future stock prices implying informed trading. When negative information drives the volume high at ITM in Call and OTM in Put options markets, they both indicate lower future stock prices implying informed trading again. The similar analysis can be drawn using the equation (2) as well. We would leave to readers to experiment if interested. However, we have the results that can be provided as well if requested.

A Monte Carlo Simulation

In this section we examine what types of trading that benefit investors most when private information exists. We assume that due to the reasons outlined at the beginning of the paper, informed investors could trade derivative securities. When it comes to choosing securities and markets, the informed investor has several choices. They can trade in the call options market or in the put options market. If they choose the call or the put market, they have a choice of strike prices. For positive information cases, for example, if they know the value of the information, i.e. how much the related stock price will jump by the maturity date, they can buy (out of the money) call option of different strikes, or sell (in the money) put option of different strikes where trades in call markets will require initial investments and trades in put markets will require no initial investment but will have certain margin requirements. The main focus of this simulation will be the effect of leverage on their payoffs when informed traders choose strike prices of a call or a put option.

The whole simulation procedure is divided into two steps. In the first step, we simulate the terminal stock prices, and in the second step, we simulate random information shocks. By assumption, the normal distribution is used to simulate the terminal values. For information shocks, we assume that some investors have less than perfect inside information about a firm. The presence of such investors with some private information shock is represented by a uniform distribution. Then the option price will be derived by discounting the sum of the terminal price and this random shock. Through the simulation, we will show whether an investor, with positive (negative) information about the underlying stock, will buy/sell calls or puts. This simulation will also address the investor's possible choices of strikes in calls and puts. An optimal choice will be reached by ranking the possible returns from holding different strikes of calls and from selling different strikes of puts.

Table 4 provides the results of our simulation. The parameters used are: The current stock (underlying) price is 50, the number of steps is 500, number of simulation is 1,000, the time to maturity is half a year, the risk free rate is 5%, and the standard deviation of the underlying security is 20%. The first type of shock is drawn from a uniform distribution with parameters of a = -0.4, b = -0.1. The both negative signs mean bad news for investors. In other words, the shocks are drawn, with equal probability, from an interval [a,b]*S, where S is the current stock price.

Table 4: Monte Carlo Simulation Results of Benefits of Sorting Calls or Buying Put with Negative Inside Information

Panel A. Stocks and Call Options						
	Stock	80% of stocks and 20% of call (short call)				
		ATM	OTM	DOTM	ITM	DITM
mean	-0.227	-0.008	-0.001	0.005	-0.017	-0.051
std	0.171	0.120	0.159	0.353	0.098	0.068
Sharpe	-1.325	-0.066	-0.008	0.013	-0.172	-0.745
VaR	-0.606	-0.316	-0.332	-0.291	-0.285	-0.285
Panel B: Stocks and Put options						
	Stock	80% of stocks and 20% of put (long put)				
		ATM	OTM	DOTM	ITM	DITM
mean	-0.227	0.687	1.982	59.259	0.266	0.008
std	0.171	0.562	1.981	111.859	0.187	0.012
Sharpe	-1.325	1.222	1.001	0.530	1.420	0.635
VaR	-0.606	-0.190	-0.276	-0.437	-0.113	-0.016

The normal distribution is used to simulate the terminal stock prices, i.e., in a Black-Scholes' environment. The negative information is represented by a random shock with a uniform distribution with parameters of a = -0.4 and b = -0.1. The current stock price is 50 (S = 50), the number of steps is 500, number

of simulation is 1,000, the time to maturity is half a year which is the holding (investment) period as well, the risk free rate is 5%, and the standard deviation of the underlying is 20%. There are 5 exercise prices x = S*[0.7, 0.9, 1, 1.1, 1.3]. Thus, we have at-the-money (ATM), in-the-money (ITM), deep-in-the-money (DITM), out-of-the-money (OTM) and deep-out-of-the-money (DOTM) options for both call and put. We use 80% of stocks and 20% of options (eight call or put) and the benchmark is 100% stocks. The transaction cost is ignored. VaR is value at Risk and it is defined as 1% lowest portfolio return. Thus, VaR is 1% * number of simulation of the sorted portfolio returns.

For example, the investor knows that the shock would be in the range of (-0.4,-0.1)*50. That is, the negative shock will lie between short fall of $20 (maximum decline) and $5 (minimum decline) and any other number between these two bounds will have an equal probability. Further we assume that investors invest 80% on stocks and 20% on options, either selling call or buying put since it is bad news. In this table, panel A shows the results related to short selling calls and panel B shows the results for long put. Options prices are estimated using the Black-Scholes' model. Row 4 gives the expected portfolio returns for stocks only portfolio and stock-call portfolios. We can see that the expected portfolio return, 0.5%, is much better for the portfolio which includes the deep-out-of-the-money call options. For comparison, the expected return for stock-call portfolio which includes the at-the-money-option call is merely -0.8%. From the table, it is obvious that portfolios with both in-the-money call option and deep-in-the-money call are inferior to the portfolio with the deep-out-the-money options. The implication is that an investor with negative inside information would prefer calls with higher exercise prices. This provides clear evidence of the leverage effects.

The panel B shows the related expected return, risk expressed by standard deviation and VaR for the portfolios with stocks and put options. Here we long put options since we have bad news about the firms. Again the deep-out-the-money put options offer highest return. The second observation, based on the comparison of panels A and B, is that investors would prefer a long put position to a short call one since the former offers larger benefits when a negative information shock exists. If informed traders choose to trade in the puts market, it is also observed that they would prefer to buy out-of-the-money and at-the-money to increase profit levels.

Table 5 shows the impact of positive information shocks. The setup is exactly the same as that of table 4, except that two pairs of parameters of [a,b] are [0.1, 0.5] and [0.2, 0.4]. Again a uniform distribution is used to mimic the insider information. From the table, we can make three major observations. First, from panels A and B, when an investor possesses positive information, buying a call option is preferred to selling a put since percentage "gains" are higher for all call options. Second, if a positive inside information holder (investor) intends to buy call options, the investor would choose options with high exercise prices, i.e., prefer out-the-money options. The reason is that with the same level of uncertainty of future positive information shocks, these out-of-the-money options offer higher benefits. Third, the higher the precision of inside information, i.e., the range of distribution is narrower (b-a is smaller), the higher the gain in terms of buying call or selling put. The Sharpe ratios are higher for high precision cases than the results from lower precisions except one case (DOTM).

Table 5: Monte Carlo Simulation for Positive Inside Information with Different Precision of the Shock

Panel A	Stock	80% of stocks and 20% of call [a=0.1,b=0.5]				
		ATM	OTM	DOTM	ITM	DITM
mean	0.328	1.017	1.678	5.854	0.696	0.458
std	0.185	0.678	1.342	8.172	0.422	0.265
Sharpe	1.769	1.501	1.251	0.716	1.647	1.728
VaR	-0.050	-0.240	-0.240	-0.240	-0.165	-0.082
Panel B	Stock	80% of stocks and 20% of put [a=0.1,b=0.5]				
		ATM	OTM	DOTM	ITM	DITM
mean	0.328	0.456	0.461	0.462	0.448	0.417
std	0.185	0.167	0.151	0.148	0.181	0.207
Sharpe	1.769	2.729	3.064	3.119	2.476	2.019
VaR	-0.050	-0.064	0.160	0.160	-0.133	-0.098
Panel C	Stock	80% of stocks and 20% of call [a=0.2,b=0.4]				
		ATM	OTM	DOTM	ITM	DITM
mean	0.327	1.011	1.643	5.036	0.694	0.457
std	0.157	0.581	1.172	7.181	0.359	0.225
Sharpe	2.080	1.741	1.402	0.701	1.936	2.032
VaR	0.005	-0.181	-0.196	-0.196	-0.040	-0.004
Panel D	Stock	80% of stocks and 20% of put [a=0.2,b=0.4]				
		ATM	OTM	DOTM	ITM	DITM
mean	0.327	0.461	0.462	0.462	0.456	0.425
std	0.157	0.128	0.126	0.126	0.140	0.172
Sharpe	2.080	3.597	3.671	3.671	3.266	2.467
VaR	0.005	0.204	0.204	0.204	0.018	-0.014

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The second information shocks can be estimated more accurately than that of the first type of information shock, i.e., [0.4-0.2] = 0.2<0.4 = [0.5-0.1]. For the case when the exercise is $45 (OTM, fourth column) and fifth rows (first type of shock) and 17th row (second type of shock), we have Sharpe ratio of 1.251 and 1.402, respectively. This means that for the second information shock, the benefit of buying a call with exercise price of $45 is about 15% more profitable than that of buying a call when the first type of shock exists. This pattern is true for all cases of selling put options.

Concluding Remarks

Traders with valuable private information find the options instruments more attractive than its underlying due to the leverage effect. Traders, in general, in the options markets seem to have better understanding of the future price movements of the underlying securities than traders in the stock market. When trading activities are investigated across different strikes it can be observed that options traders have better predictive ability of the underlying security's future price movements for the maturity date. When all strikes of call and put options are considered in searching for information, it is obvious that informed trading take place in options markets due to the leverage effect. The scenario analysis conducted in this paper on call and put options markets validate our hypothesis about the presence of information trading in options markets. The Monte Carlo simulation also shows the incentives towards trading in options markets and the types of options informed traders would trade. If one has to address whether a particular market is the venue for information trading, then discarding a range of strikes and their respective volumes are quite wrong. Information trading may or may not take place on the set of strikes taken into consideration. If information trading took place in strikes that were not considered in conducting research, then one would come to a wrong conclusion.

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