Volatility Trading in Option Market:

How Does It Affect Where Informed Traders Trade?*

Gunther Capelle-Blancard†

January 2001
(Preliminary version)

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Although it is widely accepted that options implied volatility is a good estimate of the markets expectation of the assets future volatility, relatively little work has focused on understanding the effect of this volatility expectation on market microstructure. The present article attempts to fill this gap by investigating the implications of volatility trading on the behavior of informed traders. We develop a multimarket sequential trade model, with asymmetric information, in which directional and volatility informed traders interact strategically. The major finding is that volatility traders evict directional traders from the option markets. Indeed, we provided conditions under which informed-volatility trades have a positive impact on option market bid-ask spread so that informed-directional traders choose the equity market. Although these results seem opposite to the fact that option returns lead stock returns, they are consistent with previous recent findings. The model predicts also that the informational role of stock price is greater when the uncertainty is great.

Keywords: Option Markets, Asymmetric Information, Volatility Trading.

JEL Classification: G.12, G.14.

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1 Introduction

Options, as forward looking indicator, have gained increasing attention in recent years as informative predictors of future asset price behavior. More specifically, as considerable attention has been given in the literature to forecasting volatility, a lot of empirical studies have examined the performances of implied volatility in forecasting future realized volatility. Despite some mixed results (Canina and Figlewski (1993), Day and Lewis (1992), Lamoureux and Lastrapes (1993)), several recent papers (Christensen and Prabhala (1998), Fleming (1998), Lin, Strong and Xu (1998)) report evidence of incremental information.[1] However, while researchers have paid substantial attention to the forecasting ability of implied volatility, relatively little work has focused on understanding the effect of this volatility expectation on market microstructure. But still if option prices can be used as a source of new information, it is because option markets is the place where forecast about volatility is made.

The purpose of this paper is to investigate the implications of volatility trading on the behavior of informed traders and on the microstructure of stock and option markets. This subject is motivated by previous studies that provide conflicting evidence about the question of whether informed traders trade in option markets. Indeed, despite the impressive range of empirical researchers (see for instance Manaster et Rendleman (1982), Anthony (1988), Vijh (1988), Kumar et Shastri (1990), Bhattacharya (1987), Stephan and Whaley (1990), Chang et al. (1993), Easley et al. (1998), Jarnecic (1999), Capelle-Blancard et al. (2001)), the result is still inconclusive. In fact, in most of cases, it seems that there are two effects. On one hand, as suggested by Black (1975), informed traders are expected to trade in derivatives markets given the higher leverage effect their offer relative to the stock market; in this case, they exploit at the most their advantage since derivatives require smaller capital outlays. On the other hand, the market with the lowest overall trading costs, i.e. the most liquid, will be more attractive and will lead the others.[2]

[1] Moreover, in recent years, there is a greater exploitation of the information content of option prices to derive the risk neutral distribution of the underlying asset. See for instance Jackwerth (1999) for a survey of the different methods.

[2] Other effects may also affect the price discovery process. First, the use of index derivatives allows investors to easily and rapidly carry out strategies on the basis of their expectations about the general market trends, without having to consider specific changes in each stock that constitutes the index. Second, following Biais, Foucault and Salanié

The sequence of conditional probabilities is common knowledge. A time 1, the state of nature, that is the mean and volatility of the stock return, is revealed to all participants. Hence, the call options market price can be determined using risk-neutral valuation. In fact, the choice of a log-normal distribution for the terminal stock price reduces the option price to its Black-Scholes-Merton value given the current stock price and volatility (this choice is not essential for the analysis).

$$C(S,\sigma) = SN\left(\frac{\ln(S/K) + \sigma^2 T/2}{\sigma\sqrt{T}}\right) - KN\left(\frac{\ln(S/K) - \sigma^2 T/2}{\sigma\sqrt{T}}\right) \qquad (1)$$

where $N(.)$ is the cumulative distribution function of the standard normal random variable.

There are two competitive risk-neutral marketmakers: a first who sets prices to buy or sell the security, a second who sets prices to buy or sell option contracts upon the security. We denote by $b_{i=s,c}$ and $a_{i=s,c}$ the bid and ask prices in the stock or the call option. Each market maker sets his bid and ask prices competitively and rationally so as to yield zero expected profit on each trade conditional on the information conveyed by the trade. We suppose that the marketmakers can monitor perfectly and simultaneously orders and trades in both markets. The prices at any time are conditional expected values given the history of trade in the two markets and a trade at that price in their specific market. Since the market makers share the same information set, there is no role for arbitrageurs.[7] The market makers cannot determine whether the agent is informed or not; the only signal they observe is the order placed by the agent.

Trades arise from risk-neutral uninformed and informed traders. More precisely, as in Cherian (1996) and Cherian and Jarrow (1996), three types of risk-neutral traders trade options: liquidity traders, directional traders (μ-traders) and volatility traders (σ-traders). There is a fraction $(1-\alpha-\beta)$ of liquidity traders, a fraction α of directional traders and a fraction β of volatility traders.

The uninformed or noise traders are assumed to trade for liquidity-based reasons that are exogenous, like portfolio rebalancing or hedging. They do not recognize that their trades affect the prices. As usual, their presence is necessary to camouflage the informed trades; in our model of multimarket trading, this assumption is also intended to incorporate hedging behavior. We assume that the propensity of the uniformed to trade is determined by a stochastic process. Without loss of generality, we assume there is no trading history for the day prior the first trade of the day, so we have:

[7] In this model no lead nor lag would be likely to occur. But as pointed by Ealsey et al.(1998), in practice such immediaty is unlikely to be available so lead or lags can be found.

$$\begin{cases} \Pr\{\text{buy stock at time } t\} = a \\ \Pr\{\text{sell stock at time } t\} = b \\ \Pr\{\text{buy call at time } t\} = c \\ \Pr\{\text{sell call at time } t\} = d \end{cases} \qquad (2)$$

With probability α (β), the market order stems from one informed directional (volatility) trader. Though the future state of the world is currently unobservable, the directional-informed traders receive identical information related to the mean return of the stock μ, while the volatility traders receive identical information about its future volatility σ. That is, when an information event about the volatility occurs, only σ-traders know its existence, when an information event about the future trend occurs, only μ-traders know its existence. Informed σ-traders and μ-traders will buy if their valuations exceed the ask price and sell if their valuations are less than the bid price.

Directional-traders see trading opportunities in both the stock and option market and have the opportunity to choose where they are going to trade based on the profits available. For instance, a trader informed of good news could profit from buying the stock or the call option.[8] Informed traders are assumed to be risk neutral and competitive so there is no strategic behavior. The informed trader's decision problem can be specified as follows.

1. If the μ-trader knows that $\mu = \underline{\mu}$, then his profit is:

$$\pi\left(\underline{\mu},\sigma\right) = \begin{cases} \left(b_s - \underline{\mu}\right)\varphi & \text{if he sells the stock} \\ b_c - C\left(\underline{\mu},\sigma\right)\phi & \text{if he sells a call} \end{cases} \qquad (3)$$

2. If the μ-trader knows that $\mu = \overline{\mu}$, then his profit is:

$$\pi\left(\overline{\mu},\sigma\right) = \begin{cases} \left(-a_s + \overline{\mu}\right)\varphi & \text{if he buys the stock} \\ -a_c + C\left(\overline{\mu},\sigma\right)\phi & \text{if he buys a call} \end{cases} \qquad (4)$$

[8] In a more general setting, a trader informed of good news could profit from buying the stock, a future contract, a call option contract, or writting a put.

Directional-informed traders face a trade-off between trading too aggressively in either market and facing larger trading costs (bid-ask spreads) in that market. We denote by $\eta_{\Psi=L,H}$ the fraction of informed traders who choose to trade in the cash market. The values of η_L and η_H will be determined in the equilibrium.

Volatility traders has information regarding the future volatility of the price process of the risky asset but not the future asset price; i.e. they observe $\overline{\sigma}$ or $\underline{\sigma}$ but they cannot distinguish whether $\underline{\mu}$ or $\overline{\mu}$ occurs.

1. If the σ-trader knows that $\sigma = \underline{\sigma}$, then his profit is:

$$\pi\left(\mu,\underline{\sigma}\right) = b_c - C\left(\mu,\underline{\sigma}\right)\phi \qquad \text{if he sells a call} \qquad (5)$$

2. If the σ-trader knows that $\sigma = \overline{\sigma}$, then his profit is:

$$\pi\left(\mu,\overline{\sigma}\right) = -a_c + C\left(\mu,\overline{\sigma}\right)\phi \qquad \text{if he buys a call} \qquad (6)$$

The information structure of the game and the choices of the market participants are summarized in Figure 2. The game has four stages. The first move of the game is nature's decision regarding the volatility level and the expected stock price. Following that determination, a trader is randomly selected to trade from the population of traders. A trade outcome occurs and the game reverts back to the trader selection process. The game continues from that point repeatedly throughout the trading day.

<Figure 2>

3.2 The determination of equilibrium prices

We analyze the optimal trading strategies of the informed traders and the equilibrium prices set by the market makers in three different settings:

1. Trading is allowed only in the stock market.
2. Trading is allowed only in the options markets
   (a) There are only directional-informed traders.

   (b) There are only volatility-informed traders (the Cherian (1998) and Cherian and Jarrow (1998) scenarios).
   (c) There are directional- and volatility-informed traders.
3. Trading is allowed in the stock and options markets
   (a) There are only directional-informed traders (the Easley et al. (1998) and John et al. (2000) scenarios).
   (b) There are only volatility-informed traders.
   (c) There are directional- and volatility-informed traders.

This setup allows us to examine the impact of volatility trading both on option market bid-ask spread and on the directional traders behavior. We show that when volatility traders are presents, directional-informed traders facing wider bid-ask spreads in option market. Hence, in equilibrium, they split their trades in such way that their profits are the same in both markets. Their optimal trading strategy depends on the percentage of liquidity traders and on the percentage of volatility traders in option markets. Consequently, bid and ask prices in both markets will also be functions of these percentage. We also find that the introduction of option trading does not improve unambiguously the efficiency of stock market.

We have to determine conditions under which informed traders choose to "pool" and trade in both market or to "separate" and trade in only one market. As usual, we first solve for the marketmakers' optimal prices given probabilities of informed trade. We then derive conditions under which the informed trader will choose to trade in only one market and conditions when the informed will mix between the two markets.

In equilibrium the following conditions are satisfied.[9] First the bid and ask prices the marketmakers set, contingent on his information and the order submitted, result in zero expected profit given their beliefs regarding the behavior of the informed.[10] Second, Equilibrium require that Given an opportunity to trade, the informed trader selects the trade that maximizes her profit given his information.

[9] This concept of equilibrium is common in microstructure theory. For similar developpement in finance, see Kyle (1985), Laffont and Maskin (1990), Rochet and Vila (1994), or Vila (1989).

[10] As ususal, the zero expected profit condition for the market makers stems from Bertrand competition between identical, risk-neutral agents.

3.3 Results

Traders, who are confident of the liability of the information they receive, and do not want to be detected, are expected to trade in the market that provides the highest profit, due to lower transaction costs or greater leverage effect. However, this choice is not straightforward. When directional-informed traders do not face volatility-traders, they split their trades between the stock and the option in order to maximize their profit like in Easley et al. (1998). But, when volatility traders are added to the picture, the larger trading costs (bid-ask spread) in option market may offset the leverage provided by the option and reduce or eliminate the informed traders' bias towards option trading.

We find also that the presence of volatility traders has an ambiguous effect on stock market efficiency. When volatility trading is not considered, even though the addition of option trading enhances the ability of informed traders to disguise and profit from their trades, the informativeness of the trading process is greater because the market can now infer private information from two sources - order flow in the stock and option markets. Now, when there are traders with private information about the future volatility, it make the interpretation of the information content of trades by the market makers more difficult and consequently reduce the informational efficiency.

Moreover, a comparison of the bid-ask spread reveals that the introduction of volatility trading increases not only the option market bid-ask spread, but also the stock market one. Indeed, some of the directional traders are evicted from the option market and trade in stock, then causing the market maker to set wider spreads. Therefore, introduction of the volatility traders has unambiguous consequences on the profitability of directional informed traders.

These results are consistent with empirical results that options trades have little predictive power about the future evolution of the stock. Indeed, Easley et al. (1998) find that option volume informationally-defined affects stock prices, while standard measures of option volume do not. Our analysis sheds some light on this issue, actually, since Easley et al. (1998) control for the presence of volatility traders before they find some significant lead-lag relationship. Our analysis can also be related to empirical studies of the effect of the introduction of options on the bid-ask spread in the stock market. For instance, Fedenia and Grammatikos (1992) find that the reaction of the spread is ambiguous as it can either increase or decrease after the introduction

of the option.

4 Conclusion

It is widely accepted that options implied volatility is a good estimate of the market expectations of the assets future volatility, although some studies (Canina and Figlewsi (1993) for instance) refute that view. But this fundamental aspect of the option market has not been explicitly considered in theoretical models, except by Cherian (1998) and Cherian and Jarrow (1998). The present article attempt to fill this gap by analyzing how the introduction of volatility traders affects information revelation, quotes and informed trader behavior. In doing so, we are able to evaluate the interaction between two types of information asymmetries.

In this article we have developed a multimarket sequential model that considers the effect of allowing the presence investors with private information about the volatility of the asset. In the absence of volatility-traders, directional-informed traders are likely to split their trades between the stock and the option, depending on the leverage provided by the option relative to the stock. But when directional-informed traders do face volatility-traders, they move to the stock market. Indeed, in the latter case, it leads to wider the option bid-ask spreads.

Our result casts doubt on the price discovery argument between stock and option market. When market makers are not subject to volatility trading, option market play an important role in optimal trading strategies of informed directional traders. But in a more realistic setting, where traders do face informed volatility traders, informed directional traders do use both stock and option markets.

These results are consistent with previous results of Easley et al. (1998) since they report, on the one hand, evidence of feedback and, on the other hand, that negative and positive volumes contain information about future stock price. In doing so, they only focus on directional trade and confirms in a way our findings. However, as the impact of volatility trading on stock markets is an issue of considerable interest, one should test empirically our model's predictions in order to disclose directly trades based on volatility information.

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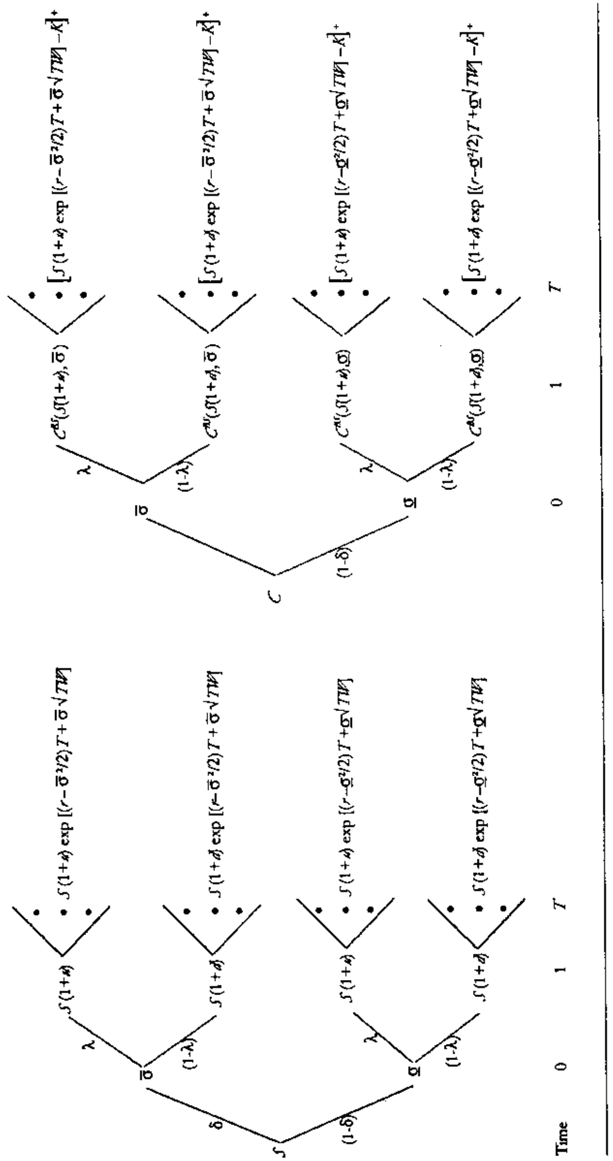
Figure 1. Stock Price and Volatility Tree with Prior Beliefs



Note: W is normally distributed with mean 0 and variance 1. $(1 + u) > 1 > (1 + d)$, and $\bar{\sigma} > \underline{\sigma}$.

Figure 2. Information Structures and Action Choices of Market Participants at Time 0