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Applying option Greeks to directional forecasting of implied volatility in the options market: An intelligent approach

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ABSTRACT

This paper examines movement in implied volatility with the goal of enhancing the methods of options investment in the derivatives market. Indeed, directional movement of implied volatility is forecasted by being modeled into a function of the option Greeks. The function is structured as a locally stationary model that employs a sliding window, which requires proper selection of window width and sliding width. An artificial neural network is employed for implementing and specifying our methodology. Empirical study in the Korean options market not only illustrates how our directional forecasting methodology is constructed but also shows that the methodology could yield a reasonably strong performance. Several interesting technical notes are discussed for directional forecasting.

1. Introduction

In general, there are two well-known ways to address future volatility in financial markets. The first method is to build the financial time series model with historical volatility and use it for calculation of future volatility. The second approach is to calculate implied volatility based on a mathematical financial model that handles future volatility in terms of the current value of financial instruments. Recently, research on utilizing the implied volatility to predict the financial derivative movement has been receiving increased attention. For instance, refer to Latane and Rendleman (1976), Malliaris and Salchenberger (1996) and Andreou, Charalambous, and Martzoukos (2008). In this article, we propose to use implied volatility directly, i.e., directional forecasting of implied volatility itself is our main concern. Directional forecasting (up-down forecasting) of implied volatility will clearly lead to enhanced investment techniques in the derivatives market by providing a useful standard. For example, if stock market implied volatility is expected to increase, it is best to buy options related to the stock market index because one can easily profit off the market with increased volatility from buying options. To the best of our knowledge, no research has been reported regarding directional forecasting of implied volatility.

An important step in the directional forecasting of implied volatility is the selection of input variables. Because implied volatility in options is theoretically determined by the current value of options, various parameters related to call and put options could be considered to be input variables. Among these parameters, option Greeks stand out for directional forecasting because they are the quantities representing the sensitivities of the price of options to a change in underlying financial instruments. In other words, option Greeks are usually defined in terms of mathematical derivatives supply, which is essential information for directional forecasting. Latane and Rendleman (1976) and Beckers (1981) used the Vega value of the option Greeks for regular forecasting of the option values.

For modeling implied volatility as a function of option Greeks, we use a sliding window (Kohzadi, Boyd, Kermanshahi, & Kaastra, 1996) as our major architecture because it enables us to implement a locally stationary model. A locally stationary model is needed here because implied volatility or option price tends to change its mechanism over time. A locally stationary model shows that the window width and sliding width of sliding window are two useful parameters for installing a locally stationary model. By choosing the two parameters, we may attempt various kinds of local stationary models and find an appropriate one. Detailed discussion of these models will be given in Section 3. As the main execution tool, an artificial neural network (ANN) is employed. Recently, artificial intelligence tools, including an ANN, have been used widely for financial market forecasting (see Ahn, Lee, Oh, and Kim (2009), Ye and Gu (1994) and Yao, Li, and Tan (2000) and others for examples). This approach has been employed because financial market movement is quite complicated, and artificial-intelligence tools are preferred to fit the complex relationship between input and output.

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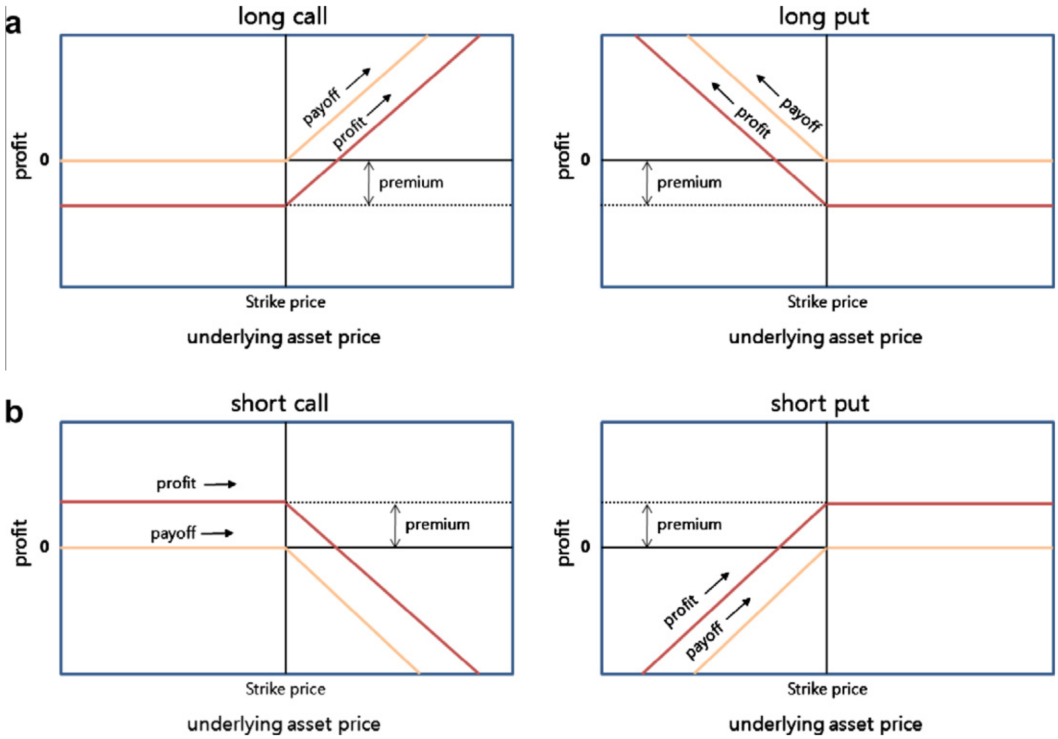

Fig. 1. The option payoff and profit diagrams: (a) payoffs and profits from long call and long put, (b) payoffs and profits from short call and short put.

In this study, we test our forecasting methodology against the Korean options market because it usually records the highest number of trades in a year among the options market around the world. Furthermore, easy access to abundant data makes the Korean options market an attractive experimental venue. Our study is organized as follows. Section 2 discusses the research background, and Section 3 presents our forecasting methodology for implied volatility in detail. Section 4 illustrates and discusses our experiment results in Korean options market. Conclusions are drawn in Section 5.

2. Background

2.1. Options market

An option is a security giving the right to buy or sell an asset within a specified period, subject to certain conditions. There are two types of options: the American Option, which can be exercised at any time up to the date that the option expires, or the European Option, which can be exercised only on a specified future date. An option that conveys the right to buy something is known as a call; an option that conveys the right to sell is called a put. The price that is paid for the underlying asset when the option is exercised is called the exercise price or strike price. The last day on which the option may be exercised is called the expiration date or maturity date. In options markets, investors can take two positions: a long position or a short position. An investor buys the option in a long position, while selling an option is a short position. The seller of the option (writer) has the obligation to exercise an option upon the request of the buyer. The option writer receives cash upfront (or option premium), i.e., the option price, as compensation for the risk taken. This transaction means that the seller of the option at the beginning of the transaction knows the maximum profit. Fig. 1 presents option payoff and profit diagrams.

The simplest kind of option is one that gives the right to buy a single share of common stock, which is referred to as a call option. In general, a higher stock price correlates with a greater call option value. When the stock price is much greater than the exercise price, the option will be exercised. The current value of the option will thus be approximately equal to the price of the stock minus the price of a pure discount bond that matures on the same date as the option, with a face value equal to the striking price of the option. Conversely, if the price of the stock is much less than the exercise price, the option is almost sure to expire without being exercised; therefore, its value will be near zero in that case.

2.2. Implied volatility of options

The implied volatility of an option is the volatility implied by the current price of the option based on an option pricing model. Therefore, implied volatility is a forward-looking measure that is different from historical volatility, which is calculated from known past prices of a security. The Black-Scholes option pricing model derives a theoretical value for an option with a variety of inputs in which the value of an option depends on an estimate of the future realized volatility, σ, of the underlying value. To make this statement mathematically:

$$C = f(\sigma, \cdot) \tag{1}$$

where C is the theoretical value of an option, and f is a pricing model with σ and other inputs as its arguments. The function f is monotonically increasing with σ meaning that a higher value of volatility σ results in a higher theoretical value C of the option. Conversely, by the inverse function theorem, there can be, at most, one value for σ that when applied as an input to $f(\sigma, \cdot)$, will result in a particular value for C. More precisely, assume that there is some inverse function $g = f^{-1}$ such that

$$\sigma_{\overline{C}} = g(\overline{C}, \cdot) \tag{2}$$

where $\overline{C}$ is the market price for an option. Next, the value $\sigma_{\overline{C}}$ is the volatility implied by the market price $\overline{C}$, or the implied volatility. In