Global Finance Journal 24 (2013) 119–128

Contents lists available at ScienceDirect

Global Finance Journal

journal homepage: www.elsevier.com/locate/gfj

Impact of volatility estimation method on theoretical option values☆

Bolesław Borkowski [a], Monika Krawiec [a], Yochanan Shachmurove [b,*]

[a] Warsaw University of Life Sciences, Poland
[b] The City College of the City University of New York, United States

ARTICLE INFO

Available online 17 July 2013

JEL Classifications:
C0
C2
C58
D53
G0
G13

Keywords:
Historical volatility
Option premium
Index options
Black–Scholes–Merton model
Chicago Board of Options Exchange

ABSTRACT

The volatility of an asset price measures how uncertain we are about future asset price movements. It is one of the factors affecting option price and the only input into the Black–Scholes model that cannot be directly observed. Thus, estimating volatility properly is vital. Two approaches to calculating volatility are historical and implied volatilities. Using index options listed on the Chicago Board of Options Exchange, this paper focuses on historical volatility. Since numerous methods of estimating volatility may provide different results, this paper assesses the impact of volatility estimation method on theoretical option values.

1. Introduction

The volatility of an asset price is a measure of how uncertain one is about future asset price movements. It is a key parameter to calculate Value at Risk, to optimize portfolio and to value derivatives. Volatility is one of the factors that determines option price. The premiums of both call and put options increase as volatility increases. Therefore, overestimated volatility values produce overestimated option premiums. Moreover, volatility is the only input used in the Black–Scholes (1973) model that cannot be

☆ Authors thank the University of Pennsylvania Wharton Research Data Services (WRDS) for providing the options data used for this research.

* Corresponding author at: The City College of the City University of New York, Department of Economics and Business, 160 Convent Avenue, New York, NY 10031, United States. Tel.: +1 212 650 6202; fax: +1 215 573 2057.

E-mail address: yshachmurove@ccny.cuny.edu (Y. Shachmurove)

1044-0283/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.gfj.2013.07.004

observed in the market or a priori determined in a contract. Thus, properly calculating volatility becomes extremely important. There are two basic ways to estimate volatility. The first method uses historical prices, while the second technique, known as implied volatility, employs option prices to find the option's market estimate of the underlying asset standard deviation.

In order to evaluate implied volatility, iterative techniques are applied. Generally, the method used for computing implied volatility works as follows. First, a rough guess is made as to what the implied volatility could be. This guess is used along with other input parameters to compute the Black–Scholes value of the option with respect to the guess volatility. After comparing the guess of the Black–Scholes value to the market price of the option, the guess is modified to produce a new guess of volatility, and consequently a new Black–Scholes value that is closer to the market price than the first one. The procedure is stopped when a Black–Scholes price is satisfactorily close to the market price of the option. Two basic iterative methods are used to calculate implied volatility: the method of bisections and the Newton–Raphson method. Their descriptions are given by Chriss (1997), Haug (2007) and Rouah and Veinberg (2007). Moreover, Rouah and Veinberg suggest using both methods simultaneously and propose a modification called the Newton–Raphson-bisection method (Rouah & Veinberg, 2007).

This paper focuses on a concept called historical volatility. There are several methods of estimating volatility, such as standard deviation of return provided by an asset, the exponentially weighted moving average (EWMA), the autoregressive conditional heteroscedasticity (ARCH) model, or the generalized autoregressive conditional heteroscedasticity (GARCH) model, which may each provide different volatility estimations. As such, the aim of the paper is to analyze the impact of volatility estimation method on theoretical option values obtained from the Black–Scholes model. The research is based on actual prices of options on Standard & Poor's 500 index listed on the Chicago Board Options Exchange. As the options are European index options, the Black–Scholes–Merton model – a modification of the classical Black–Scholes model – is appropriate for their pricing.[1,2]

2. Methods for estimating historical volatility

There are several methods used to estimate historical volatility. In the literature the following four techniques are discussed:

- Standard deviation,
- Exponentially weighted moving average volatility (EWMA),
- Autoregressive conditional heteroscedasticity (ARCH) (q) model,
- Generalized autoregressive conditional heteroscedasticity (GARCH) (p, q) model.

Calculation of the annualized standard deviation is the most widely used method for estimating historical volatility. The first step is to calculate periodic returns expressed in continually compounded terms:

$$u_t = \ln\left(\frac{S_t}{S_{t-1}}\right), \tag{1}$$

where S_t is stock price observed at fixed intervals of time (typically every day).The usual estimate of the standard deviation of the u_t's is given by (Hull, 2008):

$$s = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}(u_t-\overline{u})^2}, \tag{2}$$

where n is the number of observations and $\overline{u}$ is the mean of the u_i's.Assuming 252 trading days in a year, the annualized volatility is

$$\sigma = s \cdot \sqrt{252}. \tag{3}$$

[1] European option can be exercised only at the end of its life.
[2] See Black and Scholes (1973) and Merton (1973).