A StockOpter® *Insight* White Paper
From: Net Worth Strategies. Inc.

Volatility

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Executive Summary

The purpose of this executive summary is to answer the following question. What is volatility and why is it used in StockOpter Insight (SOI)? Selecting a reasonable and appropriate volatility input is paramount to properly estimating Black-Scholes Value (and hence Time Value (TV)) of an option and an option holder's Value-at-Risk (VaR). Please visit www.NetWorthStrategies.com for more information on Black-Scholes, Time Value and VaR. A more detailed discussion of volatility follows this executive summary.

What is volatility?

Volatility, as it is used in SOI, is an estimate of the future variance from the mean return expected for the stock underlying the client's employee stock options (ESOs). There is not a "correct" or "ideal" value for this input. After all, the future price, and therefore volatility, of a stock cannot be known. As a consequence, when setting up client data, the advisor must make an estimate of the expected future volatility that is appropriate for the stock in question. Because this input is an estimate, having a reasonable methodology for selecting this input is extremely important. For a more detailed discussion of how volatility is calculated, please review the introductory and advance sections of this white paper. In this executive summary, I will focus on the methodology for developing this estimate rather than the specific mathematics for how volatility is calculated.

As with developing any estimate, history can be quite informative. Thus, a review of the stock's *historical* volatility is an excellent starting point. For example, if it can be determined that the historical volatility of ABC Corp stock has ranged between the 52-week-high of 80% and the 52-week-low of 30%, then a reasonable range of outcomes is established. Because history is not necessarily indicative of the future, additional research may be appropriate. This research may include a review of what the option trading markets expect for the near-term volatility of the stock. This is indicated by the current *implied* volatility of the stock. For example, if the current implied volatility for ABC Corp stock is 55%, one might conclude that the market is

expecting "average" volatility in the forthcoming period, based on the historical range of 30%-80%. While this might be an overly simplistic conclusion, it does provide a framework for selecting an appropriate estimate to be used in the SOI model. To view this information for a publicly traded stock, visit www.iVolatility.com and enter the trading symbol of the stock you wish to review. Implied volatility will not be available if there are no marketable stock options traded for the stock in question. However, historical volatility information is usually available for guidance in selecting an appropriate estimate for the future volatility. In all cases, the advisor should consider including the client in this part of the planning process. After all, the client's expectations will be a significant factor in the perceived value of their ESOs.

Volatility and the Black-Scholes value:

It is important to bear in mind how this input will affect a SOI analysis. This is best illustrated through the use of an example. Sally Sample works for a major US beverage company. She has ESOs with vested in-the-money value (ITMV) of approximately $1,690,000. If a volatility input of 32% is used, the Black-Scholes value (BSV) of these same vested ESOs would be approximately $1,810,000. If the volatility input were changed to 85%, the BSV would become $2,200,000. As is seen in this example, the volatility input used can have a significant impact on the BSV. The importance of the BSV is that it provides the advisor and the client with an estimate of the Time Value (TV) remaining in the option. TV is the amount by which the BSV exceeds the ITMV and is an important criterion in the decision to exercise options. Therefore, selecting a reasonable and appropriate volatility input is paramount to properly estimating the TV component for the ESO holder.

Volatility and Value-at-Risk (VaR):

When demonstrating VaR to a client, the advisor must remember that volatility is a key component in this calculation. For example, if we assume the same facts as above, when the volatility is 32%, the VaR of Sally Samples **entire** company holdings (vested options and stock held) is approximately $770,000 out of total value of $4,000,000. If the volatility is increased to 85%, the VaR becomes $1,850,000 out of total value of $4,000,000. Again, the volatility input used, has a dramatic impact on the estimated outcome.

Conclusion:

Selecting a volatility input is more art than science. It is a function of the client's expectations and insights and, the advisor's intuition and experience. Most importantly, educating the client on the impact of this input and demonstrating the potential impacts of various inputs is the key to establishing this important input and using SOI effectively.

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INTRODUCTORY LEVEL

This document discusses what stock price volatilities are and how they are calculated. The volatility of the stock price is an input into StockOpter *Insight*'s calculations of option values (using the Black-Scholes option-pricing model), value-at-risk (VaR), and probabilities associated with various stock prices. For more discussion of the Black-Scholes option-pricing model and VaR calculations, please visit www.NetWorthStrategies.com. A discussion of probability calculations can also be found there, at the end of the ADVANCED LEVEL material on the lognormal random walk model for stock prices.

Volatility Defined

The volatility of a stock price is a measure of its variability. It is defined as the annualized standard deviation of the change in ln of the stock price (ln is the natural, or base *e*, logarithm of a number). For why change in ln is an appropriate measure, see the discussion of the lognormal random walk model for stock prices at www.NetWorthStrategies.com.

When the change in ln is small, the change in ln of the stock price is approximately the same as the percent change in the stock price. It is probably due to this that volatilities are normally expressed as percents. For example, if the annualized standard deviation of the change in ln of the price of a stock is 0.3, by convention we say that the stock's volatility is 30%.

Historical Volatility

All of the ways in which StockOpter *Insight* uses volatility are forward-looking. However, the future volatility of a stock is likely to resemble its past volatility, especially if one compares the near future to the recent past. Historical volatilities are calculated from historical prices. They are normally calculated from day-to-day price changes, though they are expressed on an annualized basis.

There are tradeoffs involved in how far back to look. The further back one looks in time, the more data one has to work with, and the less one has to worry about uncertainty in the estimate of the volatility due to small sample size. On the other hand, the world changes, and the volatility of the price of a stock several years ago may not be a very good guide to the volatility of the price of that stock today. Generally, six months of data seems to be a good compromise.

One might want to use somewhat less historical data if one wanted to avoid using data from some past period that there is reason to believe is not representative of what to expect in the future. One would want to distinguish here between the near future and the more distant future. One might not expect a past period of high variability to be repeated in the next month, for example, yet consider it highly likely that some such periods would be seen over a long time horizon.

Implied Volatility

The volatility of the stock price is an input in calculating the value of an option using the Black-Scholes model. An implied volatility is calculated by turning this on its head; one starts with the value of the option as an input, and solves the Black-Scholes model for the volatility. It turns out that one cannot actually solve the equation; an iterative trial-and-error procedure is used to determine the volatility that produces the observed price.

An option trader must have a forward-looking view of volatility, based only in part on the volatility seen in the recent past. Option traders use their estimates of future volatilities to price options. One can, in turn, calculate the implied volatility of an option to see what the trader pricing the option thinks the volatility of the stock price will be over the tenor of the option. Traders do this too; they want to know what other traders are thinking.

All of the purposes for which StockOpter *Insight* uses volatility would seem to be best served by implied rather than historical volatility, due to the forward-looking nature of implied volatility. However, there are several potential problems with using implied volatilities. These include:

- Liquidity can be a problem. An estimate of future volatility based on only a few traded options can hardly be called a market consensus. Options will typically have greater liquidity for shorter tenors than for longer tenors.
- Employee stock options typically have much longer tenors than the tenors of any regularly traded options.
- The prices of options that are very far in the money or out of the money are not very sensitive to the volatility input, so implied

volatilities calculated from the prices of such options are not very reliable.

- One must be careful to exclude profit from the price for an option used to calculate an implied volatility. One can approximate this by averaging bid and ask prices.

ADVANCED LEVEL

Differing Time Intervals

One problem in using historical data is what time interval to use. Although we ultimately want the standard deviation of year-to-year changes, we don't want to use annual prices as inputs, due to the very small number of observed prices that we would be using. Historical volatilities are normally calculated from daily prices, collected at a consistent time of day (generally at closing). One calculates the ln of each price, then calculates the difference in ln of each price, starting with the second price in the sample, from that of the day before, and then calculates the standard deviation of these differences.

However, the result is the standard deviation of daily changes in price, and what we want is the standard deviation of annual changes in price. We can convert by making use of the fact that the standard deviation is proportional to the square root of the time interval. For an explanation of why this is the case, see the discussion of the lognormal random walk model for stock prices (Part II) at www.NetWorthStrategies.com.

Thus, we can calculate the volatility by dividing the standard deviation of daily changes in ln by the square root of a one-day interval expressed in years. However, we need to be careful about the "expressed in years" part. The vast majority of change in price takes place during trading hours. As a result, we should use the fraction that one trading day is of one trading year. A common convention is that there are 252 trading days in a year. Thus, we calculate the volatility by dividing the standard deviation of daily changes in ln by the square root of 1/252, or, what is mathematically equivalent but easier, multiplying it by the square root of 252.