THE IMPACT OF STOCK PRICE DISTRIBUTIONS ON SELECTING A MODEL TO VALUE SHARE-BASED PAYMENTS UNDER FASB STATEMENT NO. 123 (R)[1]

By Mike Burgess

The issuance of FASB Statement No. 123 (Revised), *Share-Based Payment,* in December 2004 quieted much of the controversy over whether share based payments should be recognized in a company's financial results. It did not specify a model for valuing these payments, however. The model and related assumptions used to value them can significantly affect the amount of costs measured and reported.

A stock's price distribution is a key assumption to any share-based valuation model. Recent research indicates that commonly assumed price distributions may be in error. If the distribution—or density function as it is known to mathematicians—is selected incorrectly, inaccurate or spurious values can be computed.

This article discusses facts and issues related to the selection of a stock's price distribution, including the following:

- Properties of a commonly assumed distribution.
- Empirical evidence regarding price distributions.
- Commonly used models for valuing share-based payments, and the impact of errors in distributions on valuing share-based payments.

First, a brief overview is provided on authoritative and regulatory guidance for model selection and types of assumptions required to value share-based payments.

AUTHORITATIVE AND REGULATORY GUIDANCE

Financial Accounting Standards Board

Aware of the complexity and variety of share-based payments, the Financial Accounting Standards Board (FASB) granted great latitude to the selection of a model for valuing these payments. FASB Statement No. 123 (R) does not require use of a specific model. It simply provides general guidance on this matter. Techniques mentioned in the statement include the Black-Scholes model, lattice or binomial models and Monte Carlo simulation methods, among others. These models are discussed later in this article. Assumptions required depend on the complexity of the plan, but under paragraph A18 of the statement must include, at a minimum, the following:

- The exercise price of the option.
- The expected term of the option, taking into account both the contractual term of the option and the effects of employees' expected exercise and post-vesting employment termination behavior.
- The current price of the underlying share.
- The expected volatility of the price of the underlying share for the expected term of the option.
- The expected dividends on the underlying share for the expected term of the option.
- The risk-free interest rate(s) for the expected term of the option.

The exercise price is simply the price at which the option can be transacted. If the exercise price for an option to purchase stock is above the current stock price, the option is out-of-the-money. If the reverse is true, the option is in-the-money.

The volatility of a stock is the amount by which its price is expected to fluctuate in a period of time. Volatility is generally measured as the annual standard deviation of the stock's daily price changes.

Although a stock's price distribution is not included in the list of required assumptions, it is inextricably linked to a model's design and assumptions about a stock's volatility. In fact, the Black-Scholes model explicitly

[1] All data referred to herein is courtesy of *Options as a Strategic Investment* by Lawrence G. McMillan, Wiley Trading.

CONTINUED ON **PAGE 18**

"In the SAB, the staff indicated it would not object to a company's choice of a model if the model meets the fair value measurement objective."

assumes a lognormal *distribution of prices.* This distribution is discussed in more detail below.

Assumptions about price distribution impact our perception of volatility. Smooth transitions from one price level to another are often associated with a normal distribution of prices, and a stable volatility percentage. Erratic price moves may indicate an uneven price distribution and a volatility percentage, where average volatility is a poor predictor of expected volatility.

United States Securities and Exchange Commission

The United States Securities and Exchange Commission (SEC) generally deferred to the FASB's guidance on the selection of models and assumptions for valuing share-based payments. SEC Staff Accounting Bulletin No. 107 (SAB No. 107) allows the use of the Black-Scholes model, lattice or binomial models and Monte Carlo simulation methods, among others. The SAB specifies three requirements for any valuation model used. The model should:

- Be applied in a manner consistent with the fair value measurement objective and other requirements of Statement 123R.
- Be based on established principles of financial economic theory and generally applied in that field.
- Reflect all substantive characteristics of the instrument.

In valuing a particular instrument, certain models may meet the first and second criteria but may not meet the third criterion because the techniques or models are not designed to reflect certain characteristics contained in the instrument. For example, for an option in which the exercise is conditional on a specific increase in the price of the underlying shares, the Black-Scholes closed-form model would not generally be appropriate. While it meets the first and second criteria, it is not designed to consider conditional market prices.

In the SAB, the staff indicated it would not object to a company's choice of a model if the model meets the fair value measurement objective. For example, a company is not required to use a lattice model simply because it is more complex than other models. However, the SAB contains many examples of situations in which lattice or other non closed-form models may be required to solve valuation issues. Some professionals have interpreted this as an implicit preference for these more complex techniques.

A COMMONLY ASSUMED DISTRIBUTION

Many market analysts and economic valuation professionals use the *lognormal distribution* as a proxy for the actual distribution of stock prices. The distribution is basically a bell curve skewed to the right. This skew is explained by the fact that stock prices cannot be below zero. In short, the distribution indicates that stock prices can never be less than zero, can rise to very high values and usually drift up and down.

The lognormal distribution is based on the historical volatility of a stock's price. This volatility is measured by the standard deviation in the stock's price, and would predict that a stock's price would remain within three standard deviations of its current price approximately 99 percent of the time.

The lognormal distribution is similar to the bell curve studied in basic statistics, and is therefore a comfortable concept for most users. It is a very rough approximation to the way stock prices behave *most of the time*. The lognormal distribution may be intuitively appealing, but it simply does not accurately describe the way stock prices behave. We have all been struck by how a stock that "just can't rise anymore" marches ever higher in price, and a quality stock that "can't go any lower" continues to plummet.

The ease with which descriptive statistics may be computed for this distribution, users' familiarity with it and its general intuitive appeal may explain why this distribution is so commonly used to value share-based payments. This distribution may be useful for many purposes, but its application to valuing share-based payments is suspect.

EMPIRICAL EVIDENCE REGARDING STOCK PRICE DISTRIBUTIONS

Actual market prices routinely rise or fall more than three standard deviations. Some prices change as much as eight standard deviations. The lognormal distribution would predict these moves to be extremely rare. In fact, these moves are not rare at all.

The following table lists price changes for selected stocks on April 5, 1999, a volatile but not abnormal day:

Stock	Last Sale	Change	Standard Deviations
Aspect Devt (ASDV)	$ 8.00	$ -14.38	- 31.2
Axent (ANT)	8.00	-12.00	- 11.2
Ameritrade (AMTD)	91.63	29.00	8.6
CheckPoint (CHKP)	28.75	-10.75	- 8.4
Sabre Gp (TSG)	55.00	8.50	8.0

The lognormal distribution would indicate that the probability of eight standard deviation moves would be 0.000000000000000629, or once in many billions of events. No, this is not a typographical error. It is graphic empirical evidence of the way stock prices behave. Other substantial moves occurred that day. In fact, 58 stocks had price changes of over four standard deviations on that day.

Many periods have been studied to determine the frequency of these asymmetrical changes.

For a 30-day period beginning on Oct, 22, 1999, price changes on 2,888 optionable stocks were computed. The following table lists the number of stocks which moved by the respective number of standard deviations (σ). σ is the Greek letter sigma which mathematicians often use to indicate standard deviations.

10/22/99–12/7/99:					
Price Movements					
	3σ	4σ	5σ	> 6σ	Total
Up Moves	309	116	44	47	516
Down Moves	69	29	15	19	132

A period of low stock market volatility was also studied (July 1993). Fewer optionable stocks existed during this period, and only 588 stocks were examined. This is a smaller, but statistically valid sample.

7/1/93–8/17/93:					
Price Movements					
	3σ	4σσ	5σσ	> 6σ	Total
Up Moves	14	5	1	1	21
Down Moves	28	5	3	4	40

In these and other confirming studies, the results indicate the frequency of price moves far exceeds a nearly zero percent probability the lognormal distribution would predict. Some studies have indicated a 4σ move is as much as 20 times more likely than would be expected if prices were normally distributed. The stocks sampled were not low-price, obscure penny stocks priced at $1 per share; they are highly recognized companies. The lognormal distribution is simply a poor predictor of the frequency and magnitude of large price changes, and these studies confirm this point.

CONTINUED ON **PAGE 20**

COMMONLY USED MODELS FOR VALUING SHARE-BASED PAYMENTS

Typically, investors use one of three types of models to value stock options: the Black-Scholes model, Binomial or Lattice models and Monte Carlo models. Economic Valuation experts also use these models to value share-based payments. The implications of the stock price distributions on which their computations are based for valuing share-based payments are discussed below

The Black-Scholes Model

The Black-Scholes model is a closed-form model for valuing an option. The model is characterized as "closed" because a user cannot adjust the paths followed by a stock's price for known aberrations or trends. The technique assumes stock prices are lognormally distributed. Subject to a user's selection of input parameters, the underlying algorithm for computing option values is fixed. (The required parameters are those listed above under the *Financial Accounting Standards Board section*). If price paths cannot be introduced into the computations, the model may significantly over or understate an option's value. As indicated in the previous section, the likelihood of price trends or asymmetric changes in price is far higher than the lognormal distribution would predict.

If the fair values used to record compensation cost are over or understated, then compensation cost is also over or understated. As indicated in the previous section, the major distortions in probabilities occur in the "tails" of the distribution. Outlying prices are the points at which mildly to deeply "out-of-the-money" options become profitable. These types of options are often associated with cash constrained, growth-oriented industries, start-ups and corporate spin-offs. Such companies liberally issue "out-of-the-money" executive stock options to conserve cash, and attract talent with the potential for outsized rewards. These companies are also very sensitive to small changes in reported earnings. As a result, it may not be advisable to use the Black-Scholes model to value "out-of-the-money" options issued by these companies.

Binomial or Lattice Models

Binomial or lattice models are simply decision trees, and may be used to value options. A user sets a point of origin, and then specifies events and subsequent events that may occur. The origin is typically the stock's price on the day of analysis—for options used as investments—or the grant date when valuing a share-based award. Each event explicitly includes a potential outcome in the model, and is assigned a probability of occurrence. Option values are determined at the terminal points of the tree based on these events, and the expected payoffs of the stock price paths followed.

Binomial or lattice models are not constrained to use a particular stock price distribution. They can be as simple or complex as the price history, development time and financial resources available to develop them. In the right situations, this added complexity can result in better estimates of option prices. However, These models require extensive history to develop and are expensive to create. Although these models can be designed to account for an array of stock price distributions, the expense and data requirements to develop them may make their use prohibitive for smaller public companies with a shorter trading history. However, they may be suitable for larger companies as a means to account for their actual stock price distributions.

Monte Carlo Models

The Monte Carlo approach is a simulation method. Basically, the user defines an event or outcome that he is trying to simulate and the related assumptions, and inputs these to a software program. The program completes thousands or perhaps millions of "trials" based on this information, and reports the resulting distribution of results. From this resulting distribution, the expected outcome is measured.