AMERICAN ACADEMY *of* ACTUARIES

DRAFT
Valuation of Employee Stock Options
Practice Note
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Introduction

This practice note has been prepared by the Stock Options Task Force of the Pension Practice Council of the American Academy of Actuaries.[1] Our primary purpose is to provide guidance to actuaries and others performing **valuations** under the Financial Accounting Standards Board's (FASB's) Statement of Financial Accounting Standard (FAS) Number 123, *Share-Based Payments*, as amended in December 2004 (FAS 123R).

The guidance provided in this practice note is intended to assist actuaries in the evaluation and selection of valuation methodologies, the selection of actuarial assumptions, and the documentation and reporting of the results of stock option valuations and related analyses. It is not a definitive statement of generally accepted practice in this area, and it has not been promulgated by the Actuarial Standards Board. This guidance is not binding on any actuary.

It is important to note that the determination of **fair value** is the responsibility of the issuing company, and actuaries provide the company with recommended assumptions, models, and calculations. FAS 123R and the Security and Exchange Commission's (SEC) Staff Accounting Bulletin (SAB) 107 provide detailed guidance on setting assumptions and selecting models. This practice note is not intended to supplant these documents. The actuary should have a thorough understanding of these documents before making any recommendations to a client.

The task force and the practice council recognize that other professions have made substantial contributions to the body of knowledge and to the development of option valuation models. We expect this to continue as this practice area attracts increasing attention from financial economists, mathematicians, investment specialists, and others. We offer the guidance included in this practice note as our contribution to this multi-disciplinary effort.

Our desire is that the actuarial disciplines we identify in this practice note will be instrumental in promoting an environment of confidence, rigor, transparency, comparability and credibility to the valuation of employee stock options—whether the valuation work is done by actuaries or other professionals. Accordingly, we encourage other professions to consider the guidance as appropriate.

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[1] The American Academy of Actuaries is a national organization formed in 1965 to bring together, in a single entity, actuaries of all specializations within the United States. A major purpose of the Academy is to act as a public information organization for the profession. Academy committees, task forces and work groups regularly prepare testimony and provide information to Congress and senior federal policy-makers, comment on proposed federal and state regulations, and work closely with the National Association of Insurance Commissioners and state officials on issues related to insurance, pensions and other forms of risk financing. The Academy establishes qualification standards for the actuarial profession in the United States and supports two independent boards. The Actuarial Standards Board promulgates standards of practice for the profession, and the Actuarial Board for Counseling and Discipline helps to ensure high standards of professional conduct are met. The Academy also supports the Joint Committee for the Code of Professional Conduct, which develops standards of conduct for the U.S. actuarial profession.

The task force welcomes your comments and suggestions for additional questions to be addressed by this practice note. Please address all communications to Heather Jerbi, the Academy's senior pension policy analyst (Jerbi@actuary.org).

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Section 1: Background

The use of executive and broad-based stock options is widespread among U.S. corporations. Over the years, substantial value has been conveyed to executives and rank and file employees alike through stock option grants, as they have become an important component in many companies' compensation programs.

Until recently, sponsoring companies have booked the **grant date intrinsic value** of stock options as compensation expense, which is most often $0. There are many reasons for this accounting treatment, including:

- Uncertainty about the proper income statement recognition of long-term incentives that has value based on equity price movements occurring after the options are granted;
- Disagreement over the proper costing methodology;
- Reliance on assumptions regarding stock price behavior as well as employment and exercise behaviors;
- General skepticism that any reliable value can be placed on a compensation device that has value based on uncertain contingencies.

The FASB, after many years of studying this issue, concluded that **granting companies** should recognize an expense at the time an option is granted based on the **fair value** of the option. On March 31, 2004, the FASB released a proposed statement of accounting for *Share-based Payments (FAS 123R)*, which spurred the Pension Practice Council to form a group to study the issue of stock option expensing. Since then, the Stock Options Task Force has been examining the application of actuarial science to the valuation of stock options.

Early in its work, the task force realized that the calculation of stock option fair values closely resembles the valuation processes actuaries currently use with pensions, retiree life and health, and other long-term compensation and benefit plans. It recognized that actuarial methodologies and disciplines would be very effective in the valuation of stock option programs.

Since the valuation of stock options represents an *emerging* practice area for actuaries, there is little existing guidance specifically focused on this area. This practice note offers guidance to actuaries and others performing stock option valuations based on the experience and practice standards applicable to these similar and relevant practice areas. The authors of the practice note believe this note will evolve over time as more actuaries become better educated and our practice in this area becomes more refined.

The guidance given in this note is applicable to valuing employee stock options for financial reporting, as well as for providing useful information to the employer in option design and financial planning. It is written primarily focused on employee stock options. Other share-based programs exhibiting similar characteristics can be modeled using the same guidance, but there may be additional features that warrant considerations not addressed in this note.

Actuarial Standard of Practice (ASOP) 38 provides guidance on using models outside the actuary's area of expertise, in this case, stock option pricing models that have been developed and tested by academics

and other financial economic professionals. Therefore, looking to ASOP 38, we see several useful principles that apply to the valuation of employee stock options.

Through a deep understanding of financial liabilities with uncertain payoffs, the actuary should be well prepared to model employee stock options, but it is not expected that every actuary performing a stock option valuation will be considered an expert in the underlying mathematical formulations or accounting theory. Therefore, the actuary performing a stock option valuation should consider the following:

- Determine appropriate reliance on experts;
- Develop a basic understanding of all models considered;
- Evaluate whether a model is appropriate for the intended application;
- Determine that appropriate validation of the model has occurred; and
- Determine the appropriate use of the model.

Q1. What is the meaning of "valuation" as used in this practice note?

A. Among the general public and most other professions involved in the measurement of employee stock option values, the term "valuation" refers to running a particular mathematical model. This practice note will use the term "valuation" in the traditional actuarial sense, namely, as a package of processes and procedures, including:

- Collecting and validating underlying data
- Selecting an appropriate pricing model or methodology
- Setting assumptions
- Running the applicable model
- Documenting the results of the valuation
- Reporting the results of the valuation

Q2. What guidance is available with respect to stock option pricing/valuation?

A. *FAS 123R:* Establishes standards of accounting for transactions in which an entity exchanges its equity instruments for goods or services. It also addresses transactions in which an entity incurs liabilities in exchange for goods or services that are based on the fair value of the entity's equity instruments or that may be settled by the issuance of those equity instruments. FAS 123R focuses primarily on accounting for transactions in which an entity obtains employee services in share-based payment transactions.

SAB 107: Summarizes the views of the SEC staff regarding the interaction between Statement of Financial Accounting Standard 123 (revised 2004), *Share-Based Payment*, and certain SEC rules and regulations. It also provides the staff's views regarding the valuation of share-based payment arrangements for public companies.

ASOP 23 – Data Quality: Provides guidance to the actuary in the following: selecting the data that underlies the actuarial work product; relying on data supplied by others; reviewing data; using data; and making appropriate disclosures with regard to data quality.

ASOP 41 – Actuarial Communications: Provides guidance to the actuary with respect to written, electronic, or oral actuarial communications.

We also suggest the actuary consult *ASOP 38 – Using Models Outside the Actuary's Area of Expertise (Property and Casualty)*. While it's written specifically for property and casualty actuaries, it provides helpful guidance to any actuary working with models that incorporate specialized knowledge outside the actuary's own area of expertise.

Q3. What characteristics should be considered in the selection of stock option valuation models?

A. Stock options are derivative securities. Their payoff depends on the value of the underlying stock and the timing of exercise. Therefore, stock option valuations involve both modeling the underlying dynamics of the stock price process and the exercise patterns. Stock option valuation models differ in the algorithms and numerical procedures used to model these processes and patterns. Some of these computational procedures will permit different assumptions to be made about stock price movement and its correlation with employee exercise. Also, the form of the option — what features it includes — will determine which models are appropriate.

No model perfectly fits all parameters. Part of the stock option valuation is determining which model best fits the particular circumstances for the plan, considering the intended use and magnitude of the estimated option fair value, and the availability of relevant historical data for analysis in the assumption setting process. The actuary wants to select a model that best fits the situation without either over-fitting or under-fitting the data. In some cases, more than one model may have to be run, as output from one model may be used as input to another. The table at the end of this section gives a high-level overview of common models and their advantages and disadvantages.

Historical behavior should be considered when selecting models. For example, Company A's historical behavior may show that most employees exercise **in-the-money** options as soon as they are vested, regardless of **volatility** and stock price movement. Company B's employee exercise behavior may differ, showing that employees hold stock and don't exercise options until they are about to expire, or until they are forced to exercise due to termination or other events. An actuary might use different models, and different assumptions when valuing the plans of these two companies.

Section 2 covers model selection and Section 3 covers model validation. Section 4 covers analysis of historical data in setting assumptions.

Q4. What are the categories of stock option valuation models?

Models can be characterized by the computational techniques they employ to arrive at a solution.

- A **closed-form model** uses an equation to produce an estimated option fair value.
- A **lattice model** represents the evolution of stock prices at successive periods of time by nodes, and the fair value is calculated from node to node.
- A **Monte Carlo simulation model** generates random variables to simulate various random processes, most notably stock price dynamics.

Models can also be differentiated by how the stock price dynamics are modeled. For instance, the **Black-Scholes-Merton** (hereafter referred to as Black-Scholes) model assumes the stock price follows the **Geometric Brownian motion**.

Often, the theoretical construction of the model and its implementation cannot be easily separated because many models do not have a closed form solution. In such cases, solutions can only be found by computational procedures, or by simulation. Both aspects of the modeling process are important in model selection. The term modeling used in the following discussion refers to both aspects.

Summary of Common Stock Option Valuation Models					
Model Categories	**Model Name**	**Stock Price Dynamics**	**Exercise Behavior**	**Advantages**	**Disadvantages**
Closed form	Black-Scholes	Geometric Brownian motion (implicit)	One point of exercise assumed	Simple, well-known, works well with European options	Assumes single expiration date. Anomalies may cause false results Cannot handle (general basis): • market-related exercisability conditions • term structure of dividend yields • term structure of exercise behavior Cannot handle: (population basis): • term structure of volatility • term structure of risk-free rates
Lattice	Binomial (price can move up or down between nodes)	Assumed a risk-neutral arbitrage-free market. Upward/downward price movements are governed by underlying volatility, risk free rates and dividend yield.	Probability of exercise assigned to each node. Can be a single rate for the entire tree (e.g. 5 percent of remaining at each node) or can vary.	Can reflect: • term structure of volatility • term structure of risk free rates • term structure of dividend yields • impact of early exercise can be reflected • can match exercise behavior with corresponding	Computationally complex. Requires high degree of understanding for proper use.

				stock price movement • can incorporate symmetric or asymmetric stock price movement	
Lattice	Trinomial (price may move up, down, or remain level between nodes)	Same as binomial	Same as binomial	Same as binomial	Same as binomial
Lattice	**Finite Differences**	Same as binomial	Same as binomial	Same as binomial	Same as binomial
Stochastic	Monte Carlo Simulation	Use Monte Carlo simulation to model explicit stock price movements	Can use historical data to calibrate survival functions, which are then applied within the simulation to allow for early exercise.	Allows modeling the effect of stock price path on the decision to early exercise. Can be used to value exotic options that have a variety of vesting features that are tied to stock price appreciation.	Computationally complex.

Q5. What other assumptions must be set?

A. Stock option valuations have a number of assumptions that must be set. While the required assumptions depend on the model being used, common valuation methodologies call for assumptions about the stock price volatility, the **risk-free rate**, the stock's dividend yield, and an expectation for employee behavior (expected life of the option or other). As with other actuarial valuations, historical experience can play a role in the setting of those assumptions, although the user is cautioned to understand SEC and FAS 123R guidance on the use of historical data in setting assumptions for employee stock option valuation. Guidance on the analysis of historical data is given in Section 4. Volatility of stock price is a critical assumption that many actuaries might not have familiarity with, and that subject is covered in Section 5.

Section 2: Model Selection

Since most employee stock options are not transferable, and liquid markets for options with similar features typically do not exist, observable prices for these options are not available. To value employee stock options, or to analyze the cash flows associated with them, a model is needed. This section discusses some of the considerations appropriate for stock options model selection.

Q1. What are the necessary considerations for model selection?

A. When selecting a stock option valuation model the following factors need to be considered:

- Stock option features
- Employee exercise behavior
- Economic assumptions and stock return assumptions
- Significance and simplification

Q2. What stock option features should be considered?

A. Many employee stock option awards are designed with a multitude of **restrictions**, conditions for the options to be exercisable, and payoffs when the option is exercised. These unique features of an employee stock option should be captured in the valuation model selected. Unique features of an employee stock option include, but are not limited to:

- ***Vesting*** *or exercisability conditions*: The vesting conditions may be service related (e.g., completing a required number of years of service), performance related (e.g., reaching a certain earnings per share target), or market related (e.g., the 90-day moving average of the stock price reaches a certain level);
- *Restrictions*: The option award may contain a blackout period in which the option cannot be exercised. The blackout period may be required by governmental regulations.
- *Non-transferability*: The options cannot be bought or sold. If an employee terminates employment, the options must be exercised within a certain period of time.
- *Option payoff*: The **exercise price** of the option may be fixed or variable. Examples of variable exercise price include linking the exercise price to a stock index, basing the exercise price on a 90-day moving average of stock price, or allowing the exercise price to be the maximum price in the 30 days before the **exercise date**.

A closed-form model may be difficult to apply properly, especially when valuing employee stock options with unusual features. For instance, the standard Black-Scholes formula does not consider market-related exercisability conditions. (Note that other closed-form models have been developed, and will likely be developed in the future, that can be used to price different types of exotic options). If a characteristic of the option is considered substantive, then an appropriate valuation model should be selected to reflect it. If the model cannot explicitly reflect this feature, then analysis should be performed to demonstrate that any difference is not significant. This may involve performing additional pricing using other, more complex models.

A lattice model has the advantage of handling moderately complex structures, and lattice software may take very little time to execute once the model is customized to value a type of option. Careful construction can even handle certain situations where the exercise price of an option depends on stock prices before the exercise date. On the other hand, lattices based on non-recombining trees can present material computational challenges. Other situations may involve features where a lattice model is impossible or impractical. In such cases, a stochastic (simulation) model may be used.

If the vesting depends on a performance target, such as a target based on the sales of a particular product, an appropriate sales forecast may be needed in conjunction with the option valuation model selected. Decision on model selection will be affected by how easily the sales forecast can be integrated into the option valuation model.

Q3. What employee exercise behavior should be considered?

A. Employees may exercise options early to avoid option expiration because they terminate employment, they would want to diversify their holdings of employer stock, or they want to lock in gains in the employer's stock. They may exercise early due to the restrictive terms contained in the stock option awards. An employee may also exercise the option because it is optimal to do so, when the intrinsic value of the stock option is greater than the expected fair value of the option when the option is not exercised.

The model should be chosen that would capture the effect of the variables influencing the option exercises. These variables often can be determined by examining the actual experience of the employer or of the employer's industry.

For instance, if the option award is offered only to senior executives, and the executives usually hold the options until the end of the option term or until retirement, the Black-Scholes formula may be appropriate when applied to value each award individually, with the expected term equal to the full term of the option or time to expected retirement, assuming expected term is a reasonable approximation of the value obtained from a direct reflection of multiple exercise times.

On the other hand, employees in a broadly based stock options program often exercise options early for a wide range of reasons. A lattice model with multiple forces of decrement may be a better choice to model this situation because it has the flexibility to vary expected exercise behaviors from node to node.

Q4. What economic and stock return assumptions should be considered?

A. The model selected should be consistent with the overall economic and stock return assumptions. Key assumptions in this area are the risk-free interest rate and stock return volatility. If it is assumed that the risk-free rate and the volatility stay constant, then the Black-Scholes formula may be used. If the risk-free rate and volatility are time dependent, then the Black-Scholes formula may still be used, but the risk-free rate and volatility used should be the expected average value consistent with the expected life of the option. Expected average value approaches do not provide an exact solution for path-dependent options or a precise estimate when exercise behavior is path dependent. Other types of models can explicitly accommodate risk-free rates and volatility with more complex dynamics.

It is important to note that the computation procedure chosen also depends on these assumptions. For instance, if the volatility is allowed to vary with time, the nodes in a binomial lattice model may not recombine. In this case, a different lattice model would be needed, or the individual node fair values may be obtained by simulation.

Q5. How should significance and simplification factor into model selection?

A. Models should be selected based on the relevant factors influencing the fair value of an option. A more complex model may provide a richer set of possible scenarios, but the benefit and cost of such a model should be considered before adopting it. For instance, if employees exercise the options regularly, irrespective of the price movement of the employer's stock, a model of option exercises can exclude the impact of the employer's stock price. If the volatility of the employer's stock is expected to be stable for future years, a **stochastic volatility model** would not be necessary.

A model should be selected to fit its intended use. For instance, if a model is used to forecast the expected cash flow associated with the employee stock option program, a more refined study of exercise behavior is needed, but a precise modeling of the risk-free interest rate would not be needed. There may be insufficient data to develop the parameters and assumptions necessary for a more complex model. After some time, when more detailed historical data has become available, it may be appropriate to revisit the choice of model.

Over-fitting of models should be avoided. Over-fitting occurs when too many parameters are specified for the model. It may produce good results for inputs used to calibrate the model, but inaccurate results when using other different inputs.

The selection of a model should also consider how the model responds to uncertainly in the inputs. For instance, if a model for stock volatility involves many estimated parameters with significant uncertainty, it would be better to use a simpler volatility model instead.

Parameter selection can be a complex process, especially for **stochastic models** for which closed-form option prices do not exist. Using them may require two Monte Carlo runs: one to calibrate the model parameters and a second to carry out the valuation.

Also, the magnitude of the potential differences in option fair-value estimates under various models and assumptions should be considered. On the one hand, a less precise model with simple average assumptions may be appropriate for valuing options that are not significant, or not material (an accounting judgment) to the employer. On the other hand, although it may require much more time and administrative cost, even a small percentage change in estimated option fair value of a large award of employee options may be significant to the employer, requiring a more refined model and assumption setting process.

Q6. What are risk-neutral valuation models?

A. In a well-functioning financial market that admits no arbitrage opportunities, two securities that have the same payoffs must trade at the same price. A **risk-neutral valuation** then can be performed to arrive at a fair value. All models selected for valuation should be arbitrage-free. However, if markets are

incomplete and contingent claims cannot be replicated by self-financing strategies, then there is no unique risk-neutral valuation. For most employee option valuations, however, it should still be possible to establish values based on reasonable assumptions.

Q7. What is the relationship between a pricing model and the required input assumptions?

A. The stock option valuation model determines the assumption inputs needed for valuation. For instance, in general, a stock option pricing model will require an assumption regarding stock price volatility as an input. However, the model itself will determine the form the volatility assumption will take, whether it is constant, time-varying, a function of time and stock price, or stochastic.

This section deals with model selection; assumption setting is discussed more fully in Sections 4 and 5. However, frequently in the process of assumption setting, the model selected is either too general or too restrictive, and a decision is made to change the model. For example, the model may initially assume that the volatility of stock return is a constant. After examining the historical volatility and the **implied volatility** of exchange-traded options, the model for stock return volatility may be changed to a stochastic variable.

Q8. What are the steps in selecting a pricing model?

A. Selecting a model for stock option valuation involves decisions in the following areas:

- Modeling for the stock price process;
- Modeling for employees' exercise behavior;
- Modeling for other variables used to determine the payoff or exercisability of the employee stock option at option maturity.

The decisions made will lead to different procedures and algorithms used to implement them. The availability of adequate computational tools can also influence the decision made in the above steps.

Q9. How are stock prices modeled?

A. Stock prices are usually modeled by assuming the stock return has an expected drift rate along with additional variability. As would be expected, more sophisticated stock price processes entail more complex calculations. Reasonable valuation of typical employee options might not require the most sophisticated approaches. They might be considered more critical for options that are deep in-the-money or deep **out-of-the-money**, while most employee stock options are granted at the money.

A model of the dynamics of stock prices is implicit for closed-form expressions. The assumed stock price behavior should be considered when assessing the appropriateness of closed-form option valuation models. Lattice models and Monte Carlo simulation, on the other hand, make explicit the development of stock prices. Additional techniques are sometimes applied to Monte Carlo simulation in an attempt to converge on a result more quickly. These variance reduction techniques can be effective, but can also distort results if applied improperly.

Q10. How is employee exercise behavior modeled?

A. The factors that influence an employee's exercise of stock options include:

- Demographic factors such as termination, retirement and death;
- Restrictions placed on the stock option award, such as blackout period or vesting conditions;
- Performance conditions and service conditions on the stock option awards;
- Early exercise by the employees, for instance, immediately after vesting or when the option is deep in-the-money.

Actuarial multi-decrement models often can be used to model the employee's exercise behavior. Multiple forces of decrement can be applied in each time interval to arrive at the probability that an option will be exercised in the interval. The forces of decrement can be estimated from the experience of the employee stock options program, and can depend on the demographic factors, current and past stock prices, time elapsed since vesting, salary level or job classification, number of shares already owned, and the design of the employee stock option.

It is also necessary to determine how the model handles suboptimal exercises by employees. Early exercise by an employee can be either optimal or suboptimal. The early exercise is optimal if the intrinsic value of the stock option exceeds the fair value of the stock option if the option is not exercised. An option-pricing model usually assumes that the employee will exercise the options when it is optimal to do so. In other words, the probability of exercise will be 100 percent when it is optimal to do so. If it is decided not to impose this condition on the model, the probability will be less than 100 percent. Note that the price point where it is optimal to exercise an option early depends on the option valuation model itself.

A decision needs to be made as to how the multi-decrement model of option exercises is integrated with the rest of the option valuation model. The multi-decrement model can be integrated with the lattice model to value the options directly. At each node, forces of decrement can be determined and applied, and only the unexercised options will move to the successive nodes. A **fully integrated lattice model** should accurately reflect the effect of early exercises on the fair value. A multi-decrement model also can be used to determine the expected time to exercise, although this may have to be done in a model with an explicit stock price projection if the decrements vary by the increase in stock price.

The actual employee exercise experience should be reviewed before deciding on the model used to represent employee exercise behavior, and on the parameters the model requires.

Q11. What other variables are used in determining payoff and exercisability?

A. Other variables used in determining the payoff of the employee stock options depend on the design of the option award. For instance, if the **strike price** of the employee stock option is indexed to the S&P 500 index, an index return process and its correlation with the stock return process are needed. The same model can be used for both the index and the stock but with different parameters.

If the stock option award contains performance conditions in order to be vested (or exercisable), these conditions need to be reflected. Examples of performance conditions include exceeding a growth rate

target in earnings per share, attaining a certain market share for a product, and obtaining government approval for a certain pharmaceutical. The employer can often provide a forecast of the likelihood and timing of satisfying these conditions.

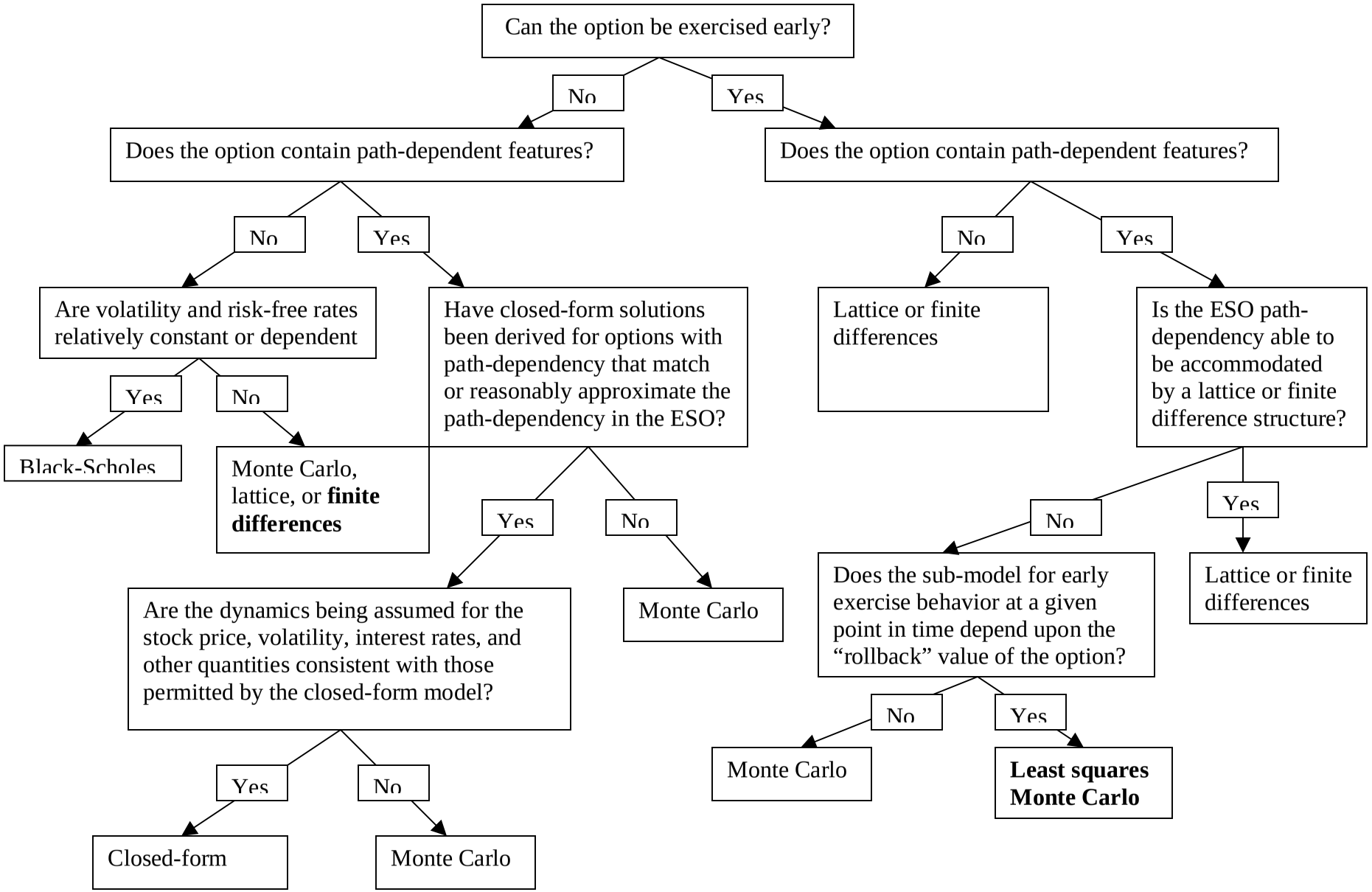
Note that FAS 123R treats the effect of performance conditions separately from the determination of fair value. The probability of satisfying these conditions and the requisite service period are revised to reflect changes in estimates, and adjusting accounting entries are recorded. An alternative modeling technique might have correlated the satisfaction of performance conditions with the stock price process, but this is not what the standard specifies.

Q12. What is the impact of stock price path dependence?

A. Path dependence can have an impact on both the payoff amount of the option upon exercise and the probability and timing of exercise. The probability and timing of exercise can be affected by stock price path, which in turn affects the value of the option. For example, if the stock increases dramatically in value, one could expect greater retention of employees holding options as the value of unvested options would be a disincentive to leave employment. And, a stock increase would tend to suggest business success and in turn better job stability. Valuation approaches that recognize path dependence, such as Monte Carlo simulation, tend to be significantly more complex.

The following diagram summarizes the option characteristics that are explicitly reflected in common valuation methods. This is one possible approach to selecting a valuation model, but the practitioner must also consider the cost/benefit tradeoff of the selection. Often a more simplistic model can be used appropriately through a more rigorous assumption development process, especially with respect to employee behavior assumptions. Note also that some option features may not be significant to the valuation under certain circumstances, and the judicious use of approximation or simplifications may be appropriate after considering the significance (materiality) of the potential differences in the option fair-value estimates. The selection of a model therefore requires the application of reasoned judgment.

Possible Decision Matrix for Choosing Models



Section 3: Model Review and Validation

A critical step in the valuation process is to review the results of the model and validate that the correct model has been selected and is working appropriately.

Q1. Why is model validation important?

A. In traditional actuarial processes, this is similar to doing an experience gain/loss analysis by source. It is particularly critical for the valuation of stock options under FAS 123R because the value of the option, once expensed, is not reversed if the option is cancelled, but only if it is forfeited.

Q2. What steps can be taken to validate a model?

A. After the model is selected, if practicable, a follow-up study should be performed to validate the model. The following analyses may be appropriate:

- Project the number of shares exercised from an earlier date and compare with the historical experience of the employer or of the industry;
- Compare the fair values of options obtained from an option valuation model with the exchange traded option prices. In particular, compare the implied volatility of exchanged-traded options with the volatility in the option valuation model;
- Compare the results using different models. If the results vary widely, more analysis is needed to understand the reasons; and
- Study the sensitivities to model inputs. This helps in establishing the limits of the models.

Q3. What situations necessitate a review of the selected model?

A. A model should be evaluated periodically to determine if it continues to meet the purpose for which it is intended. For example, an immediate review is indicated if the following occurs:

- A significant change has been made to the employee stock option program, such as broadening the employees eligible for option awards or changing the payoff of the option award;
- A significant event influencing the employees' exercise of options, such as mergers, planned layoffs, or a change in the employer's compensation philosophy;
- A structural change in the interest rate or stock return volatility;
- An advancement in option valuation methodologies; or
- A change in the prescribed requirement for valuations, for instance, when the rules of financial reporting changes.

Q4. What additional steps are needed if the model is changed?

A. The actuary should compare and reconcile the results between the valuation models, document the reasons for the change, and provide comparability to past valuation results.

Q5. Is it an unreasonable result if the value of the employee options exceeds the company's net worth?

A. Under many models, including those specified in FAS 123R, the value of the employee options can exceed the company's net worth.

Typical option formulas, including those specified by FAS 123R, are not specifically designed for options a company writes on its own stock. This can lead to results that may seem unreasonable, since the options of a company with no net worth should be of little value. Other modeling techniques would reflect the unique characteristics of options a company writes on its own stocks.[2,3]

For example, define the following variables:

T = time to maturity of employee stock option
MV(t) = the market value of company at time t
S(t) = stock price at time t
C(T) = value of a call option on the stock as of time zero when option expires at time T
Shares = number of shares outstanding
Options = number of options granted
r = risk-free rate of return
E = stock holder equity ignoring any claim of option holders to such equity

From risk neutral assumptions, the expected value of *MV(T)* just prior to option expiry is equal to:

$$E[MV(T)] = Shares * S(0) * \exp(rT) + Options * C(T) * \exp(rT)$$

Also,

$$MV(0) = E[MV(T)] * \exp(-rT)$$

A portion of *MV(0)* is associated with stock, but a portion is associated with options. The portion associated with stock is *Shares*S(0)* with the remainder being associated with the options. Simple algebra shows this to be equal to *Options*C(T).*

This approach gives us a convenient means to reflect the impact of options on the company. At the end of each accounting period, a portion of the company's equity should be allocated to the option holders. Algebraically, this equals:

$$E * Options * C(T) / (Options * C(T) + Shares * S(0))$$

[2] Evans, Mark D. J., "Expensing Employee Stock Options," Risks and Rewards, 45 (July 2004), Society of Actuaries, Schaumburg, IL, 18-19.
[3] Hull, John C., Options, Futures and Other Derivatives, 5th edition, Prentice Hall, Upper Saddle River: New Jersey, 2002, 249-250.

This amount would then be set up as a liability. The change in the liability would flow through earnings in each accounting period. If *E* is negative, then the liability is zero since the presence of options cannot increase the net worth of a company.

Section 4: Analysis of Historical Data

"Historical experience is generally the starting point for developing expectations about the future. Expectations based on historical experience should be modified to reflect ways in which currently available information indicates that the future is reasonably expected to differ from the past. The appropriate weight to place on historical experience is a matter of judgment, based on relevant facts and circumstances." (FAS 123R, paragraph A21)

Q1. What historical data is typically collected and analyzed?

A. To develop a baseline understanding of historical experience, at a minimum, it is necessary to collect all historical stock option grant, exercise, and cancellation information. Therefore, as a starting point, we believe the data requirements are the following:

Grant information
- Employee ID
- Option ID
- **Grant date**
- Grant price
- **Grant type**
- **Strike price**
- Number of options granted
- Term date of option
- **Vesting** date of option (options with graded vesting schedules will need to be illustrated as such)

Exercise information
- Employee ID
- Option ID
- **Exercise date**
- **Exercise price**
- Number of options exercised
- Employee termination date, if applicable
- Option contractual expiration date

Cancellation/**forfeiture** data
- Employee ID
- Option ID
- Cancellation rate
- Number of options cancelled or forfeited
- Vested or not vested
- Reason for cancellation or forfeiture (i.e., expiration, retirement, termination, death, disability – if possible)

Q2. Why is it important to distinguish cancellation data from forfeiture data?

A. It is important to distinguish between the terms "cancellation" and "forfeiture." The term cancellation refers to all post-vesting events that may lead to an employee option not being exercised. These events, which occur once employees vest, need to be considered when developing the **expected term assumption** because compensation cost for vested awards is not reversed under FAS 123R. In contrast, because previously recognized compensation cost is reversed for awards that are forfeited prior to vesting, a company would not consider pre-vesting option forfeitures in determining the expected term assumption.

All of the above information is generally tracked within a company's equity administration system or in-house system, and can generally be exported or downloaded with relative ease.

Q3. Should demographic data be collected?

A. As it is required to understand to what extent the future will differ from the past, it is important to capture additional demographic information on the option grantee population. For purposes of this analysis, an actuary should capture general demographic information for the historical and current grantee population. Generally, this can be a more challenging data collection process, as this information is not maintained within equity administration systems. A sample but not all-inclusive listing is below:

Demographic Data (tied to all historical grants)

- Employee ID
- Salary grade/job title of option holder
- Gender of option holder
- Date of birth of option holder
- Date of hire of option holder
- Date of retirement eligibility, if applicable
- Country of option holder

Q4. How should historical data be analyzed?

A. Regardless of the type of valuation model, an actuary should begin developing the expected term assumption by analyzing historical data. This assumption is widely recognized by plan sponsors. To do so, an actuary can (1) calculate a weighted average option life of historical exercises and post-vesting cancellations; (2) develop probabilities of exercise and cancellation; or (3) look at normative data.

Companies should make adjustments for potential bias due to recently granted unexercised options to account for what is called the partial life cycle effect. For example, if a company typically issues options with a contractual term of 10 years, the only exercise data covering a full life cycle is for options issued 10 or more years ago, as some options from more recent grants would, in all likelihood, remain unexercised (and not yet cancelled or forfeited). If the company does not make some adjustment for these outstanding options and instead calculates the average holding period based on partial exercise and post-vesting cancellation data, the expected term assumption and resulting fair value will be too low.

Different exercise and termination assumptions may be appropriate for different segments of the population. For instance, the exercise and termination behavior for executives may be different from rank-and-file employees.

After studying historical behavior, the actuary should modify the historical analysis to the extent that the future is reasonably expected to differ than the past, and must also justify such modifications with substantive evidence.

Q5. How should historical exercise be weighted?

A. From the SEC Staff Accounting Bulletin 107, question 5, page 33:

"A company may also conclude that its historical **share option** exercise experience does not provide a reasonable basis upon which to estimate expected term. This may be the case for a variety of reasons, including, but not limited to, the life of the company and its relative stage of development, past or expected structural changes in the business, differences in terms of past equity-based share option grants, or a lack of variety of price paths that the company may have experienced.

Statement 123R describes other alternative sources of information that might be used in those cases when a company determines that its historical share option exercise experience does not provide a reasonable basis upon which to estimate expected term. For example, a lattice model (which by definition incorporates multiple price paths) can be used to estimate expected term as an input into a Black-Scholes closed-form model. In addition, FAS 123R, paragraph A29, states '…expected term might be estimated in some other manner, taking into account whatever relevant and supportable information is available, including industry averages and other pertinent evidence such as published academic research.'

For example, data about exercise patterns of employees in similar industries and/or situations as the company's might be used. While such comparative information may not be widely available at present, the staff understands that various parties, including actuaries, valuation professionals and others are gathering such data."

Q6. What modification to historical data may need to be considered?

A. The following modifications may need to be considered:

- *Any changes in the award's terms made during the historical period*. This modification can be modeled through adjusting the probabilities of exercise in a lattice model, or alternatively capping the historical data at the new contractual term for the Black-Scholes model.

- *The demographic profile of the current option holders that are being valued*. One approach to modeling changes in demographic profile is to create a historical distribution of exercise behavior by each demographic variable (date of birth, gender, salary grade, among others) and project the current demographic profile onto that history. The effect will yield an expectation of change in the future that the current demographic profile will have on the past data.

- *If certain events and policy shifts have affected exercise behavior in the past*. Companies should consider whether exercise patterns are affected by shifting risk-preferences among employees and other effects that are due to external conditions. The most important external condition is stock-price movement. Accordingly, a company should not base the expected term of new options on historical data that excessively reflects a bull or a bear market in the company's stock-price history, as bull markets tend to generate estimates that understate the expected term while the bear markets tend to generate estimates that overstate it. Also, employees may be influenced by specific environmental factors that vary from employee to employee, such as tax rules that vary by jurisdiction.

Q7. What if there is not enough representative data?

A. If there is not sufficient representative data to establish a weighted average option life, or probabilities of exercise or cancellation, the actuary may want to consider one or more of the following when developing a data source:

- The expected term assumption for similar options granted by similar peer companies;
- National averages, industry averages, or averages for similar companies;
- Studies or published tables of average option holding period; and
- Studies of the effects that award features and granting company characteristics have on the expected term.

The actuary may also consider applying the expected life shortcut provided in SEC guidance. However, this method is only available for use through the end of 2007.

Section 5: Setting the Expected Volatility Assumption

Professional judgment is required to determine the most appropriate assumption for expected volatility. FAS 123R and SAB 107 provide detailed guidance on setting the volatility assumption and should be reviewed in conjunction with this practice note.

Q1. What is the volatility assumption?

A. Option pricing models require an assumption for the expected future volatility of the price of the equity shares underlying the options over the life of the option. The trading process and the impact on trading from new information are the primary causes of volatility in share prices. The higher the volatility, the greater the chance the share price will move significantly higher or lower over time. Since the owner of a stock option benefits from share prices above the exercise price but has no downside risk for prices below the exercise price, the greater the expected volatility (other things being equal), the greater the option value.

Q2. How is volatility expressed?

A. Generally, volatility is expressed as the **annualized standard deviation** of the stock price return measured on a continuously compounded basis. This is the basis used by most option valuation models.

Q3. What is the objective when setting the volatility assumption?

A. FAS 123R, paragraph B86, states "…the objective is to determine the assumption about expected volatility that marketplace participants would be likely to use in determining an exchange price for an option."

In other words, the volatility assumption should be based on the expectations held by marketplace participants at the time the options are granted. It is important to keep in mind that this may not be the same as the actuary's own best estimate of the expected future volatility of the share price. The objective is to estimate the marketplace participants' expectation for future volatility.

Q4. How is the volatility assumption generally set?

A. The volatility assumption for valuing an entity's share-based options is typically based on the observed historical volatility of share prices and, when appropriate, the implied volatility suggested by market prices of traded options on the entity's shares or other securities issued by the entity with equity option-like features, such as **convertible bonds**. For new companies with little or no trading history, FAS 123R suggests that the expected volatility assumption may have to be developed by estimating the average expected volatility of a sample of similar companies in terms of industry, stage of life cycle, size, and financial leverage.

The volatility assumption can be developed as either a constant value over the life of the option, a time-varying volatility, or as a stochastic function that may depend on time, stock price, or other factors. The volatility assumption may also reflect **mean reversion**. The Black-Scholes closed-form model requires a

constant volatility assumption. Lattice and simulation models can accommodate more complex assumptions.

Q5. Does FAS 123R specify a method to develop the volatility assumption?

A. No. FAS 123R does not specify a method for estimating expected volatility. Instead, paragraph A32 lists several factors that should be considered:

- Historical volatility of the share price;
- Implied volatility determined from market prices of traded options or other securities with option-like features;
- Length of time shares have been publicly traded;
- Appropriate and regular time intervals for price observations;
- Corporate and capital structure of the entity whose shares underlie the options.

Paragraph A20 states there is likely to be a range of reasonable estimates for expected volatility, and if no one estimate within the range is more likely than another, then the average of the amounts in the range should be used. Paragraph A34 states that the method chosen to estimate expected volatility should be applied consistently from period to period.

The SEC has precluded the use of methodologies that weight recent periods of history more heavily than earlier periods for awards with longer terms. The GARCH model is an example of a model that may be inappropriate.

Q6. How is historical experience considered?

A. Empirical research has shown that the volatility of a company's share price tends to change over time rather than remain constant. While a time-varying volatility assumption that might also reflect mean reversion or a stochastic volatility assumption may allow the actuary to capture this feature, these models require special expertise to develop and require more sophisticated option-pricing models to accommodate them. The factors, as discussed in this note, to consider in developing expected volatility apply to both constant and time-varying assumptions, but careful consideration should be used in how to apply them in a time-varying manner.[4]

Q7. How is historical volatility calculated?

A. To calculate historical volatility for an entity's equity shares:

1. Observe the share price at regular intervals (e.g., daily, weekly, or monthly) over an appropriate time period (discussed below).
2. Compute the return over each interval:

[4] For a detailed treatment of these issues see *Options, Futures, and Other Derivatives (5th Edition)* by John C. Hull and *Black-Scholes and Beyond* by Neil A. Chriss.

For daily intervals, if the closing price on day *i* is S_i and the closing price on day *i-1* is S_{i-1}, then the one-day continuously compounded return can be expressed as

$$r_i = \ln\left[S_i / S_{i-1}\right]$$

If day *i* is an ex-dividend date, then the per share dollar amount of the associated dividend, D_i, should be added to the numerator:

$$r_i = \ln\left[\left(S_i + D_i\right) / S_{i-1}\right]$$

Note: The amount of the dividend is added to S_i to adjust for the fact that the share price typically drops by approximately the amount of the dividend at the start of trading on the ex-dividend date.

3. Calculate the sample mean of the one-day returns:

$$\bar{r} = \left(r_1 + r_2 + ... + r_N\right) / N$$ where N is the number of one-day returns.

4. Calculate the sample standard deviation of the one-day returns:

$$\sigma_{daily} = \left\{\left[\left(r_1 - \bar{r}\right)^2 + \left(r_2 - \bar{r}\right)^2 + ... + \left(r_N - \bar{r}\right)^2\right] / (N-1)\right\}^{1/2}$$

Note that (N-1) and not N is in the denominator. This is because the mean $\bar{r}$ is being estimated.

5. Annualize the one-day volatility:

$$\sigma_{annual} = \sigma_{daily} \times (\text{the number of trading days in a year})^{1/2}$$

Empirical research suggests that the number of trading days should be used to annualize volatility as opposed to 365 (i.e., ignore days when the markets are closed). A common assumption for the number of trading days in a year is 252.[5] If weekly or monthly returns are used, then multiply the weekly standard deviation by $(52)^{1/2}$ or the monthly standard deviation by $(12)^{1/2}$.

Q8. How long a time period should be used to calculate historical volatility?

A. This is ultimately a matter of judgment. Other things being equal, the more data the better. However, it is important to use share price data from historical time periods that are believed to be representative

[5] See *Options, Futures, and Other Derivatives (5th Edition)* by John C. Hull.

of future expected volatility. If company-specific past events, such as mergers or acquisitions, contributed to a period of unusually high or low volatility such and these events are not expected to repeat in the future, then the price data from those periods might be excluded or discounted. SAB 107 states that it expects these situations to be rare.

FAS 123R, paragraph A32, suggests as a starting point that historical volatility be examined "over the most recent period that is generally commensurate with (1) the contractual term of the option if a lattice model is being used to estimate fair value or (2) the expected term of the option if a closed-form model is used."

The SEC's SAB 107 states that a company could use data from a longer time period than the expected or contractual term if the company believes the additional data will improve the estimate of expected volatility.

Identification of recent overall market or industry-specific volatility levels and cyclical trends may be helpful. Looking at historical measures of company volatility ending at different points in time may help assess how volatility has changed over time and help identify mean reversion tendencies. Recent events may influence future volatility. A recently completed merger that significantly increases the size of the company may, for example, reduce expected levels of future volatility.

Q9. How frequently should prices be observed when calculating historical volatility?

A. Sufficient price observations should be used to determine historical volatility. Therefore, for publicly traded securities, daily, weekly, and perhaps even monthly price observations will be appropriate and it may be useful to consider all three measures. For **thinly-traded** shares or shares of nonpublic entities, weekly or monthly prices might be necessary if an insufficient amount of trading activity makes daily observations unreliable.

Q10. What if an entity's shares have been traded for only a short period of time?

A. If an entity's shares have been trading for a period shorter than the expected or contractual term of the option, the actuary will have to use judgment to decide whether to use the available price data and/or look at similar companies to estimate expected volatility. The SEC's SAB 107 suggests that at least two years of daily or weekly price data could provide a reasonable basis on which to base an estimate of expected volatility if a company has no reason to believe that its future volatility will differ significantly during the expected or contractual term. Until sufficient price data is available, the actuary should base the expected volatility assumption on the historical, expected, or implied volatility of similar entities whose share or options prices are publicly available or some combination of this data with the company's limited share price history. In selecting similar entities, the actuary should consider the industry, stage of life cycle, size, and financial leverage of other entities. An index of similar companies should not be used because of the volatile effects of diversification present in an index. Instead, a measure such as the simple average or an appropriate weighted-average of the individual volatilities of the similar companies should be used.

Q11. What is implied volatility and how is it calculated?

A. For a traded equity option with a market price, the implied volatility is the constant volatility assumption that, when used as an input to the Black-Scholes model, would cause the model to calculate a price for the option equal to its market price (generally measured as the average of bid and ask prices). In other words, if the market price of an option is known, the volatility assumption can be solved for iteratively using the Black-Scholes formula. The other inputs to the formula (stock price, exercise price, time to maturity, dividends, and risk-free interest rate) are known.

Implied volatility is defined with respect to a given option. Different options on the same stock are likely to have different implied volatilities. Traders and researchers have broken down the implied volatility structure of market-traded options into an exercise price effect and a time-to-maturity effect. The exercise price effect has become known as the **volatility smile,** or volatility skew, and measures the way implied volatility varies by exercise price for a given time-to-maturity. The expression volatility smile came from the frequently observed smile shape of a graph showing implied volatility as a function of strike price. Low strike price options (deep-in-the-money calls and deep-out-of-the money puts) tend to have higher implied volatilities than high strike price options (deep-out-of-the-money calls and deep-in-the-money puts).

The time-to-maturity effect is referred to as the **term structure of volatility** and measures the way implied volatility varies by time-to-maturity for at-the-money options. If implied volatility for short-dated options is at historically low levels, long-dated options may trade at higher implied volatilities because traders expect volatility to increase. Conversely, if implied volatility for short-dated options is at historically high levels, long-dated options may trade at lower implied volatilities because traders expect volatility to decrease.

Since employee stock options are typically at-the-money when granted and have long contractual terms, the actuary should be most concerned with the implied volatility of at-the-money options with the longest maturities (assuming the options are actively traded — see below). However, the information extracted from the volatility smile and term structure may be useful in setting the long-term volatility assumption and reconciling differences between historical and implied volatility.[6]

In some cases, implied volatility can also be inferred from the market prices of other equity option-like securities issued by the same entity, such as convertible bonds. This approach involves separating the convertible bond into a **nonconvertible bond** and a call option (technically a **warrant**) on the common stock of the issuer. By subtracting the estimated value of the nonconvertible bond from the market price of the convertible, the value of the warrant can be estimated. Then the implied volatility can be found iteratively as with equity options.

Models used by convertible bond specialists for pricing tend to be very sophisticated and may include interest rate as well as equity sub-models. The credit risk of the issuer is another important factor. Many convertibles contain other features, such as early conversion, callability by the issuer, and putability by the holder. Unless the actuary has expertise in convertible securities, the sophistication of pricing models and the complex structure of some convertibles may make this approach impractical.

[6] For more on the volatility smile and term structure see, for example, *Options, Futures, and Other Derivatives (5th Edition)* by John C. Hull. For more on pricing convertible bonds see, for example, "Valuing Convertible Bonds with Credit Risk" by Kostas Tsiveriotis and Chris Fernandes. *The Journal of Fixed Income* September 1998.

Q12. When should implied volatility be used to develop the expected volatility assumption?

A. The SEC's SAB 107 suggests that heavy reliance could be placed on implied volatility for those entities whose shares have actively traded options. SAB 107 states that the entity should consider the following factors in determining the degree to which implied volatility appropriately reflects the market's expectations for future volatility:

- *The volume of trading in the entity's options and shares.* Actively traded securities are more likely to reflect the market's expectations.

- *Synchronization of the variables*. Prices for the options and the underlying shares should be measured at the same point in time and as near to the option grant date as possible.

- *Similarity of the exercise prices*. At- or near-the-money traded options generally should provide a better measure of expected volatility. An average of the implied volatilities for traded options with exercise prices above and below the exercise price of the employee share option could be used if an at-the-money traded option is not available.

- *Similarity of length of terms*. Implied volatilities for traded options with term-to-maturities close to the expected term of the employee share option would be most relevant. However, there will rarely be a traded option with a maturity to match the typical expected term of employee share options. Although SAB 107 states that the entity could rely entirely on implied volatility if actively traded options with a term of at least one year are available, it may be more prudent to place equal weight on long-term mean historical volatility for employee options with expected terms that are longer than the traded options. If traded options with a term between six months and one year are the longest available, SAB 107 suggests that the entity should also consider other relevant information in estimating expected volatility.

The actuary should take great care in using implied volatility to develop the assumption for expected volatility. Markets for traded options experience supply and demand imbalances that cause traded prices to deviate from their Black-Scholes theoretical prices and periods of slow trading where the last trade or quote update may have occurred hours or days before closing prices are obtained for the implied volatility calculation. Moreover, option traders don't all use the Black-Scholes model to develop prices. Other risks and costs not explicitly captured in the Black-Scholes model are usually implicitly reflected in implied volatility. For these reasons, the resulting implied volatility may not represent the market's true expectation for future volatility.

Section 6: Reporting and Disclosure

FAS 123R provides specific disclosure requirements for financial statements regarding the valuation of share-based payment awards. However, these disclosures, while appropriate for investors, may fall short of the level of detail needed to effectively audit, or otherwise professionally appraise, the validity and reasonableness of an ESO valuation. This section does not cover requirements under FAS123R, but it does cover the actuary's professional responsibility in communicating methodology and results to those who are relying on the actuary's work product.

We separate the requirements for financial statement disclosures from the appropriate level of disclosure to audit, or professionally appraise, because these functions serve different purposes. The main purpose of financial statements is to provide information that is useful in making business and economic decisions (FASB Concept Statement 1). Management, auditors, and others who use the actuary's work product should have a complete understanding of the actuary's process to fulfill their professional responsibilities.

Beyond FAS 123R, stock option valuations may be performed for various reasons, such as plan design analysis or economic forecasting, and may be performed internally or by consultants. Nevertheless, the results of these valuations may also affect business decisions, and thus reporting and disclosure is appropriate for valuation of any type of share-based instrument.

It is most effective to present the results of a valuation in a comprehensive report that details data, methods, and assumptions in addition to the results themselves. ASOP 41 includes guidance for reporting actuarial findings and disclosing methods and assumptions that could be applied to stock option valuation reports. The standard specifies that "in addition to the actuarial findings, the report should identify the data, assumptions, and methods used by the actuary with sufficient clarity that another actuary qualified in the same practice area could make an objective appraisal of the reasonableness of the actuary's work as presented in the actuary's report."

Q1. What data should be included in any valuation report?

A. *Plan features*. The valuation report should disclose all significant design features for each different grant being valued. The actuary should use professional judgment in determining which plan features are significant, including but not limited to:

- Option term
- Vesting period and vesting schedule
- Blackout dates
- Intrinsic value at grant (grant price and exercise price)
- Features triggered by termination of employment, disability, death and retirement
- Other substantive features

The valuation report should also provide relevant details for the grants being valued as required in FAS 123R disclosure. If historical grants were used in the data analysis, any plan feature differences should also be disclosed.

Employee data. The use of employee-specific data in a stock-option valuation might take one of two forms:

- An experience study performed on historical employee exercise patterns to develop valuation assumptions, or
- A valuation performed on current participants using **seriatim data**.

Experience study results can be effectively disclosed within the valuation assumption disclosures, as these results will be used to justify various valuation assumptions.

If the valuation itself uses seriatim data, with valuation assumptions that vary on employee demographics, the actuary should provide relevant summary statistics on this data. These statistics should identify all factors that are used to apply assumptions.

Seriatim data may be grouped for valuation purposes. Grouping may be based on any number of data items such as age, salary or grade level, and location. Reporting should indicate how the classifications were determined and the data summary should be provided for each group.

Q2. What details should be included regarding the valuation model?

A. Reporting and disclosure detailing the valuation model should not only provide a description of the model or method used to value the options, but also justification for the model selected. Section 2 of this practice note describes considerations for choosing a model. From this section, actuaries should consider disclosing the following information to justify their selection of a model:

- Appropriateness of the model given expected exercise behavior and plan design
- Other models considered and the cost/benefit trade-offs
- Ability to select appropriate assumptions for the model chosen

A description of the model could be quite simple if an academically validated and widely used model, such as the Black-Scholes formula or the **binomial model**, is employed. In this case, appropriate disclosures may consist only of naming the model and summarizing the assumptions used or built into the model.

In the event that an alternative methodology is employed, the actuary may use professional judgment in providing a sufficient level of detail on the model itself, so that another actuary or professional qualified in the practice area could reasonably assess the appropriateness of the model and the validity of the valuation. The actuary may want to consider disclosing the following information, if applicable, when using a model other than Black-Scholes or binomial:

- "Alternative" model features including any estimates used to simplify calculations; adjustments to calculations/results to account for blackout periods; use of assumptions that vary by employment category, geography, salary level or other individual characteristics.
- Path dependency.
- Stochastic components.
- Variants within the "lattice" family.

- Adjustments to accepted methodology (i.e., "factors" applied to binomial).

As the practice of stock option valuation develops, some standardized methods and assumptions may be developed. Use of such standard methods and assumptions should be disclosed. When client-specific assumptions or methods are developed, actuaries should report on the basis for their determination.

Q3. What is the appropriate means of disclosing valuation assumptions?

A. The assumptions required for a stock option valuation depend on the valuation model chosen, but for each individual assumption, the actuary should disclose the value selected, the methodology used to calculate that value, and the appropriate justification for the selection.

For the Black-Scholes formula, the choice of risk-free rate and dividend yield should be straightforward. A more rigorous disclosure of methodology should be provided for the selection of volatility assumption and the development of expected term.

The binomial model could potentially have thousands of assumptions, considering the ability to build in node-specific decrements and exercise triggers. Full disclosure of every single assumption should not be necessary to assess the validity of the valuation. Decrement assumptions and voluntary exercise assumptions can be effectively summarized in select and ultimate tables if they vary based on employee demographics. However, assumptions must be disclosed in enough detail such that another actuary may assess their appropriateness and relevance.

Q4. What is the appropriate means of disclosing valuation results?

A. Effective reporting of stock option valuation results depends on the purpose of the valuation.

Where modeling techniques or assumptions vary by group it may be necessary to provide subtotals for each group.

The actuary may also consider disclosing the varying impact of assumptions on the valuation, such as the effect of volatility changing by 10 percent.

The actuary signing the report should indicate if applicable actuarial standards were followed. The report should also indicate any accounting or other standards that were applicable to the work.

Q5. What documentation should be maintained?

A. According to ASOP 41, "The actuary should create records and other appropriate documentation supporting an actuarial communication and, to the extent practicable, should take reasonable steps to ensure that this documentation will be retained for a reasonable period of time (and no less than the length of time necessary to comply with any statutory, regulatory, or other requirements). The actuary need not retain the documentation personally; for example, the actuary's employer may retain it. Such documentation should identify the data, assumptions, and methods used by the actuary with sufficient clarity that another actuary qualified in the same practice area could evaluate the reasonableness of the

actuary's work. Unless the actuary has issued an actuarial report that reasonably satisfies the need for documentation, such documentation should also be available to the principal."

Upon completion of a report, the actuary should maintain any supporting material as needed to verify results.

Q6. What methods and assumptions should be disclosed?

A. The valuation of stock options requires the adoption of certain methods that should be disclosed when preparing reports. Examples of such methods include:

- The method for determining volatility
- The method for determining risk free rate
- The method for determining active employee exercise patterns
- The method for determining dividend yield

All assumptions that are needed to complete the valuation should be disclosed. These include:

- Risk free rates
- Volatility
- Exercise patterns
- Employee decrements such as retirement, death, disability and turnover (both voluntary and involuntary)
- Active employee exercise behavior
- Dividend yields

Glossary of Terms

Annualized standard deviation
See Section 5, question 7

Convertible bonds
A bond that can be converted into shares of the issuing company or its parent. (Global Investor Glossary)

Exercise date
The date an option is exercised; purchase of underlying stock. (PNC Glossary)

Exercise price
The price at which an option holder can buy or sell the underlying instrument (e.g., shares). Also referred to as the strike price. (Global Investor Glossary)

Expected term assumption
Input into a closed-form model that represents the length of time an employee is expected to hold an option before exercising it. This is an output from a lattice model and applies only under plans that allow for early exercise.

Experience data
All information and knowledge about historical events and processes within option activities that can be described by data, structured information, and/or qualitative descriptions.

Fair value
The price that would be received to sell an asset or paid to transfer a liability in an *orderly* transaction between market participants at the measurement date. (FAS 123R)

Forfeiture
The risk of forfeiture occurs when rights to stock options are contingent upon future services. For example, if an employee receives stock from an employer but is required to return the stock if employment is terminated within a specified period of time (before the end of the vesting period).

Grant date
The date at which an employer and an employee reach a mutual understanding of the key terms and conditions of a share-based payment award. The employer becomes contingently obligated on the grant date to issue equity instruments or transfer assets to an employee who renders the requisite service. Awards made under an arrangement that is subject to shareholder approval are not deemed to be granted until that approval is obtained unless approval is essentially a formality (or perfunctory), if, for example, management and the members of the board of directors control enough votes to approve the arrangement. Similarly, individual awards that are subject to approval by the board of directors, management, or both are not deemed to be granted until all such approvals are obtained. The grant date for an award of equity instruments is the date that an employee begins to benefit from, or be adversely affected by, subsequent changes in the price of the employer's equity shares. (FAS 123R)

Grant type
For stock options, indicates whether a grant is for tax-advantaged incentive stock options for U.S. federal tax purposes, tax-advantaged stock options in a country other than the U.S., or non-qualified stock options.

Granting companies
Companies that issue stock options as part of the compensation program.

Implied volatility/implied volatility function
The volatility of a publicly traded option implied by the option's price on the open market.

In-the-money
The term is used to describe share options whose exercise price is less than the market price of the underlying share. (FAS 123R)

Intrinsic value
The amount by which the fair value of the underlying stock exceeds the exercise price of an option. For example, an option with an exercise price of $20 on a stock whose current market price is $25 has an intrinsic value of $5. (A nonvested share may be described as an option on that share with an exercise price of zero. Thus, the fair value of a share is the same as the intrinsic value of such an option on that share.) (FAS 123R)

Mean reversion
The tendency of a stochastic process to remain near, or tend to return over time to a long-run average value.

Nonconvertible bond
A bond that does not allow conversion into shares of the issuing company or its parent.

Non-fixed exercise price
The price at which an option holder can buy or sell the underlying instrument (e.g., shares) is not known at the grant date, and may vary with performance, market or other conditions.

Out-of-the-money
The term is used to describe share options whose exercise price is greater than the market price of the underlying share. (FAS 123R)

Path dependence
A property of certain exotic options whose terminal value depends upon the path taken by the underlier share value during the life of the option.

Restriction
A contractual or governmental provision that prohibits sale (or substantive sale by using derivatives or other means to effectively terminate the risk of future changes in the share price) of an equity instrument for a specified period of time. (FAS 123R)

Risk-free rate (or risk-free interest rate)
An assumption, called for in option-pricing models, which takes into account the time value of money, among other things. A U.S. entity issuing an option on its own shares must use as the risk-free interest rates the implied yields currently available from the U.S. Treasury zero-coupon yield curve over the contractual term of the option if the entity is using a lattice model incorporating the option's contractual term. If the entity is using a closed-form model, the risk-free interest rate is the implied yield currently available on U.S. Treasury zero-coupon issues with a remaining term equal to the expected term used as the assumption in the model. (FAS 123R, paragraph A25)

Seriatim data
Use of "seriatim data" refers to performing separate calculations for each individual rather than performing one calculation for a group of individuals. Some grouping of data may be done for individuals that have the same significant features (e.g., group by age, gender, salary).

Share option
A contract that gives the holder the right, but not the obligation, either to purchase (to call) or to sell (to put) a certain number of shares at a predetermined price for a specified period of time. Most share options granted to employees under share-based compensation arrangements are call options, but some may be put options. (FAS 123R)

Strike price
See *exercise price.*

Term structure of volatility
A curve describing volatility as a function of expiration for a given strike.

Thinly-traded
Securities for which there are few offers to buy and sell.

Valuation
This practice note uses the term "valuation" in the traditional actuarial sense, namely, as a package of processes and procedures, including:

- Collecting and validating underlying data
- Selecting an appropriate pricing model or methodology
- Setting assumptions
- Running the applicable model
- Documenting the results of the valuation
- Reporting the results of the valuation

Vest, Vesting, or Vested
To earn the right to exercise an option. A share-based payment award becomes vested at the date that the employee's right to receive or retain shares, other instruments, or cash under the award is no longer contingent on satisfaction of either a service condition or a performance condition (i.e., no longer forfeitable). Market conditions are not vesting conditions for the purpose of this Statement. (FAS 123R)

Volatility
A measure of the amount by which a financial variable such as a share price has fluctuated (historical volatility) or is expected to fluctuate (expected volatility) during a period. Volatility also may be defined as a probability-weighted measure of the dispersion of returns about the mean. The volatility of a share price is the standard deviation of the continuously compounded rates of return on the share over a specified period. That is the same as the standard deviation of the differences in the natural logarithms of the stock prices plus dividends, if any, over the period. The higher the volatility, the more the returns on the shares can be expected to vary – up or down. Volatility is typically expressed in annualized terms. (FAS 123R)

Volatility smile
The pattern of implied volatilities forms a "smile" shape when graphed.

Warrant
Securities issued by a company, which give their owners the right to purchase shares in the company at a specific price at a future date. Warrants are tradable in their own right, and their value will go up and down as the price of the shares to which they relate goes up and down. (Global Investor Glossary)

Types of Models

Actuarial multi-decrement model
Multiple forces of decrement (death, retirement, termination and disability) are applied in each time interval to arrive at the probability of survival to a point in time.

Binomial model
See *Lattice model.*

Black-Scholes-Merton model
The Black-Scholes-Merton (a type of closed-form model) formula assumes that option exercises occur at the end of an option's contractual term, and that expected volatility, expected dividends, and risk-free interest rates are constant over the option's term. If used to estimate the fair values of instruments in the scope of this Statement, the Black-Scholes-Merton formula must be adjusted to take account of certain characteristics of employee share options and similar instruments that are not consistent with the model's assumptions (for example, the ability to exercise before the end of the option's contractual term). (FAS 123R, paragraph A15)

Closed-form model
A valuation model that uses an equation to produce an estimated fair value. The Black-Scholes-Merton formula is a closed-form model. In the context of option valuation, both closed-form models and lattice models are based on risk-neutral valuation and a contingent claims framework. The payoff of a contingent claim, and thus its value, depends on the value(s) of one or more other assets. The contingent claims framework is a valuation methodology that explicitly recognizes that dependency and values the contingent claim as a function of the value of the underlying assets(s). One application of that methodology is risk-neutral valuation in which the contingent claim can be replicated by a combination of the underlying asset and a risk-free bond. If that replication is possible, the value of the contingent claim can be determined without estimating the expected returns on the underlying asset. The Black-Scholes-Merton formula is a special case of that replication. (FAS 123R)

Finite differences
A numerical approximation where the solution to a continuous differential equation is estimated using a discrete difference equation.

Fully integrated lattice model
Over each time interval forces of decrement can be determined and applied to arrive at the probability that an option will be exercised in that interval. Only the unexercised options will move to the successive nodes

Geometric Brownian motion model
A model where a continuous-time stochastic process in which the logarithm of a randomly varying quantity (e.g., stock price) follows a Brownian motion. It is used in the field of option pricing because a quantity that follows a Geometric Brownian Motion may never take on negative values and only the fractional changes of the random variate are significant.

Lattice model
A model that produces an estimated fair value based on the assumed changes in prices of a financial instrument over successive periods of time. The binomial model is an example of a lattice model. In each time period, the model assumes that at least two price movements are possible. The lattice represents the evolution of the value of either a financial instrument or a market variable for the purpose of valuing a financial instrument. In this context, a lattice model is based on risk-neutral valuation and a contingent claims framework.

Monte Carlo
Any numerical method that employs statistical sampling to solve a problem. Used to model exotic options where the stock price path affects the decision to exercise early.

Monte Carlo (least squares)
A numerical method regressing option payoffs as the dependent variable and one or more earlier stock prices as the dependent variable(s), all from stochastic paths generated by a Monte Carlo process. Often used to model early exercise behavior.

Risk-neutral valuation model
See Section 2, question 6

Stochastic model
A model that utilizes the probabilities of independent variables to determine the probabilities of dependent variables.

Stochastic volatility model
An option-pricing model that treats both the underlier value and its volatility as stochastic processes.