

# VALUING THE RELOAD FEATURES OF EXECUTIVE STOCK OPTIONS<sup>†</sup>

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**SYNOPSIS:** For options with a reload feature, the holder is automatically entitled to new options when the initial option is exercised. Under Statement of Financial Accounting Standards No. 123, the grant date value of executive stock options excludes the value of a reload feature because the Financial Accounting Standards Board believes it is not feasible to value a reload feature at the grant date. We show how the Binomial Option Pricing Model can be used to value options and the reload feature at the grant date. Ignoring the reload can substantially understate the value of the option. Accordingly, the Financial Accounting Standards Board may wish to reconsider the accounting for reload features.

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## INTRODUCTION

Stock options are an increasingly popular method for compensating executives. In addition, executive stock options often include unique features that are not found in exchange-traded options. One such feature, the reload, entitles the holder to automatically receive new options when the original option is exercised.<sup>1</sup> As we show, a reload feature can add considerably to the option's value, which may be one explanation for the increasing frequency of their use. It is important to measure the value that the feature adds to an option. Under SFAS No. 123, the reload feature is not valued at the initial grant date, but when the original option is exercised and the new reload options are issued. In 1995, the Financial Accounting Standards Board (FASB) recommended this delay in recording the value:

The Board continues to believe that, ideally, the value of an option with a reload feature should be estimated at the grant date, taking into account all of its features. However, at this time, it is not feasible to do so. Accordingly, the Board concluded that the best way to account for an option with a reload feature is to treat both the initial grant and each subsequent grant of a reload option separately. (Statement of Financial Accounting Standards No. 123, ¶186, p. 61)

As Arnason and Jagannathan (1994) show, it is feasible to value the executive stock options including its reload feature at the date of grant using the Binomial Option Pricing method.

In this paper, we examine how the value added by the reload feature depends on characteristics of the firm and the executive stock option. We then provide an algorithm

for valuing executive stock options with reload features. Our main example is a Norwest Corporation option grant with a single reload. The number of new options granted under the provision equals the number of shares tendered to pay the exercise price plus any taxes due on exercise. In this case, the reload feature adds 24 percent to the value of a comparable option without this feature. The value added by the reload provision varies with dividend yield, volatility, and terms of the feature. For example, if the reload feature for the Norwest option were changed to entitle the holder to new options equal to the number of shares tendered to pay the exercise price alone, then the feature would add 15 percent to the value of a comparable option without a reload feature. The impact of other factors is shown below. Accordingly, the Financial Accounting Standards Board may wish to reconsider its recommendation for reload options.

The next section reports on the prevalence and terms of reload features. We then present the value of our example option with a reload and an analysis of how the value of the reload feature varies with dividends, volatility, term to expiration, number of reloads allowed, and number of options granted at reload. After a discussion of some limitations of option pricing models, we conclude. For readers interested in applying the valuation technique, we provide three appendices. Appendix 1 describes how to value a conventional option in a simple 3-period example and how to add a single reload feature to that value. Appendix 2 describes the general mathematical model and extends it to the case of multiple reloads including an unlimited number of reloads. Appendix 3 provides Mathematica computer code for valuing reload options.

## PREVALENCE AND TERMS OF RELOAD OPTIONS

A reload feature automatically grants new options to an executive when the original options are exercised. The executive must relinquish shares of stock, instead of cash, to meet the exercise price. The exercise price of reload options is typically set equal to the firm's market price when the original options are exercised. They expire at the same time as the original options. A conventional option granted with a reload feature is called a first-generation option to distinguish it from the reload option granted when the first-generation options are exercised, which we label a second-generation option.

The number of reload options granted when first-generation options are exercised varies by firm. Commonly, one second-generation option is granted for each share tendered by the executive in payment of the exercise price on the original options.<sup>2</sup> Sometimes the second-generation options themselves may be reloaded; we refer to this case as multiple reloads. Hence, a comprehensive valuation procedure must incorporate both the number of times a reload is allowed and the number of second-generation options granted per first-generation option exercised.

An option with a reload feature (first-generation option) is more valuable than a comparable conventional option (i.e. an option without a reload feature). The holder of an option with a reload feature benefits from the ability to exercise existing options and lock in a gain, and still hold options for future exercise. Firms claim that reload options encourage stock ownership and help keep executives' compensation tied to firm performance (Gay, 1999).

The popularity of reload features is increasing in many industries. As reported in Table 1, from 1992 to 1997, a rising fraction of all option grants to executives are grants

of reload options (second- or later generation grants). These figures are a little misleading since firms are only required to report reload figures for second-generation grants. The number of options with a reload feature (first-generation grants) is included with conventional options in number of option grants. Hence, there must be more option grants with reload features that have not yet been triggered. Table 2 reports that executives who have second-generation options are employed by larger firms. In addition, grants of reload options are more common in financial services than in other industries. A financial services firm, Norwest Corporation, was the first to offer options with a reload feature (Gay, 1999).

**[Table 1]**

**[Table 2]**

The terms for reload features also vary across firms. Norwest Corporation allows only one reload, whereas First Bank System allows up to three reloads, and First Chicago places no limit on the number of times an option may be reloaded. The number of second-generation options granted under the reload feature also varies substantially across firms. Amgen offers new options equal in number to the shares tendered in payment of the exercise price, whereas First Bank System and Norwest Bank offer new options granted equal in number to the shares tendered to pay both the exercise price and any taxes that become due on exercise.

Both the number of reloads allowed and the number of new options granted per option exercised, affect the executive's choice of when to exercise, and the value of the

reload feature. Hemmer et al. (1998) show that, if the number of reloads allowed is unrestricted and a new option is granted for every share tendered in payment of the exercise price, then it is optimal to exercise whenever the current stock price rises above the exercise price. This is a useful observation on the optimal exercise policy in this special case, but practical questions regarding valuation and optimal exercise strategy cannot be addressed using their approach. Hemmer et al. do not address exercise policy when the options may only be reloaded a fixed number of times, or when the number of new options granted differs from the number of shares tendered in payment of the exercise price. In this paper, we provide an algorithm that determines the grant date value of an option with a reload feature for any number of reloads (including an unrestricted number), and for any prescribed formula of new options granted per option exercised. Computationally, this method differs from the one proposed in Hemmer et al., but provides the same result in the cases they consider.

## **VALUING THE RELOAD FEATURE OF AN EXECUTIVE STOCK OPTION**

In this section, we examine a particular executive stock option with a reload feature to illustrate our point that ignoring the reload feature can substantially understate the value of the option. We then demonstrate how dividends, volatility, term to expiration, the number of reloads allowed, and number of options granted at reload affect the value added by the reload feature.

We adopt the Binomial Option Pricing Model (Cox, Ross, and Rubenstein, 1979) rather than the Black-Scholes Model (Black and Scholes, 1973) because the Binomial

Option Pricing Model is more versatile in incorporating early exercise and additional features. Since a full explanation of how to value options with reload features is necessarily technical in nature, we have chosen to illustrate and explain it in the Appendices. A study of the material in the appendices is not necessary for the discussion that follows.

### **A Reload Feature Adds Substantially to the Value of the Option**

To illustrate how the reload feature affects the value of an option, we use the example of Mr. R. Kovacevich, CEO of Norwest Corporation, who was granted 138,000 options to buy stock at \$14.53 per share in May 1991. The options became exercisable in 1994 and have a one-time reload option if Norwest stock is tendered in payment of the exercise price.

Norwest grants reload (second-generation) options equal to the number of shares tendered to pay the exercise price plus any taxes owed in connection with the exercise.<sup>3</sup> These reload options have the same expiration date as the original options and an exercise price equal to the stock price on the day the reload feature is triggered. Since only one reload is allowed, the reload options themselves do not have a reload feature.

If Kovacevich chooses to exercise the options upon vesting in 1994 when the stock price is \$26, he will pay to the corporation  $138,000 \times \$14.53 = \$2,005,140$  and receive 138,000 shares, each worth \$26 or \$3,588,000 in total. Assuming that the marginal income tax rate for Kovacevich is 48.1%, the tax payable upon exercising the options will be  $0.481 \times (\$26 - \$14.53) \times 138,000 = \$761,356$ . If Kovacevich pays the exercise price and taxes with shares he already owns (each worth \$26), he will have to

pay a total of  $\$2,005,140 + \$761,356 = \$2,766,496$  with 106,404 shares (i.e.,  $\$2,766,496$  divided by  $\$26$  per share). Thus, Kovacevich gives up his 138,000 options and 106,404 shares of stock to the company, and receives in return 138,000 shares of stock and 106,404 new options with an exercise price of  $\$26$  and 7 years to expiration. We can write the formula for the number of second-generation options received per first-generation option exercised as  $Z = [X + .481(S - X)] / S$  (where  $X$  is the exercise price and  $S$  is the current stock price at the time of exercise).

We need the following inputs for using our method (described in Appendix 2) to value the option at grant date: the current stock price at the date of the initial (first-generation) grant,  $\$14.53$ ; the exercise price,  $\$14.53$ ; the time to expiration, 10 years; the dividend yield, 3%; the annual stock price volatility, 27.3%; the risk-free rate, 7% simple interest; and Kovacevich's marginal tax rate, 48.1% (Appendix 2 in Arnason and Jagannathan, 1994). We represent stock price movements over the life of the option using a binomial tree with one step per month. The grant-date value of a conventional option with the above inputs is  $\$5.23$ . Adding the reload feature increases the option's value by 24% to  $\$6.49$ . If the executive only receives  $X/S$  new options per original option exercised (i.e., the number of new options granted is not increased by the amount of taxes the executive on exercise of the original grant), the reload feature adds 15% to the value of a conventional option.

Table 3 presents the value of a reload option granted-at-the-money for stock volatilities ranging between 20 and 50 percent per year, annual dividend yields ranging from zero to five percent, up to five reloads, and 5- or 10-year maturities. The holder is assumed to receive one second-generation option for each share of stock used to pay for

the exercise price (i.e. as described above, X/S second-generation options for each first-generation option exercised). An interest rate of 7% is assumed for all calculations. The values in the table are standardized by the grant-date market value of the stock. Thus, reading from the table, the grant-date value of a 5-year conventional option on a stock paying no dividend with a market value of \$17 and a volatility of 20% is  $\$17 \times .335$ , or \$5.70. Similarly, the grant-date value of an option that may be reloaded five times is  $\$17 \times .400$ , or \$6.80, which is 19% more than the otherwise identical option without reload.

### [Table 3]

#### **A Reload Feature Adds More Value When The Stock Pays More Dividends**

Dividends have a substantial impact on the value of the reload feature. While the value of the conventional option falls with increases in dividend payout, the value of the reload feature increases as a percentage of the value of the conventional option.

The ratio of reload option value to conventional option value is useful in assessing the conditions for which a reload feature is most valuable. Compare the value of adding a reload to an option when the dividend yield is 5% versus when there are no dividends. If the volatility is 20%, the increase in value from adding five reloads is  $[(.226/.177) - 1] = 28\%$  when dividend yield is 5% and  $[(.400/.335) - 1] = 19\%$  when no dividends are paid. Thus, the reload feature is worth more for options on high dividend yielding stocks.<sup>4</sup>

#### **A Reload Feature is More Valuable When The Underlying Stock is Volatile**

The table also reveals that reload features are more valuable for high volatility stocks. From the example above, for an option on a stock with volatility of 20% and

paying no dividend, the increase in value from adding five reloads is 19%. This increase in value is less than it would be for a higher volatility stock. For example, for a 5-year option with no dividends and underlying stock price volatility of 50%, the increase in value from adding five reloads is  $[(.640/.520) - 1] = 23\%$ .

### **The Reload Feature is Relatively less Attractive for Longer Lived Options**

Next, the table shows that the reload feature adds more to a conventional option's value for short-maturity options. Again as calculated above, for a 5-year option on a stock that pays no dividend and has a volatility of 20%, the increase in value from adding five reloads is 19%. For a 10-year option on the same stock, the increase in value from adding five reloads is  $[(.582/.523) - 1] = 11\%$ .

### **The Value Of A Reload Option Is Greater If More Options Are Granted At The Time Of Reload**

As mentioned earlier, firms differ in how many reload options are granted. In our example, the holder receives options equal to the number of shares surrendered to pay for the exercise price and any income taxes owing due to the exercise. In that case, the value of the option with a reload feature is \$6.49 or 24 percent higher than an otherwise similar conventional option. If Kovacevich received reload options equal in number to the shares required just to pay the exercise price, the value of such options would be \$5.99, only 15 percent higher than the conventional option.<sup>5</sup>

### **The Value Of An Option Increases As More Reload Grants Are Allowed**

Figure 1 shows that the value of an option increases with the number of times an option may be reloaded. Figure 1 is based on the stock parameters of Norwest and the reload factor,  $Z$ , of Kovacevich's options. An option that may be reloaded once is worth  $\$49 - \$5.23 = \$1.26$  more than a conventional option. Each additional opportunity to reload adds value to the option but at a decreasing rate: a second opportunity to reload is worth an additional  $\$0.47$  and a third opportunity to reload is worth  $\$0.22$  more. An option that may be reloaded an arbitrary number of times is worth  $\$7.37$ , or just  $\$0.20$  more than an option that can be reloaded only three times.

**[Figure 1]**

### **Exercise Behavior**

Figure 2 plots the optimal exercise region assuming a single reload is allowed on a stock that pays no dividends. The figure shows that exercise depends on both the stock price level and time remaining to expiration. The longer the time to expiration, the higher the threshold stock price at which exercise is optimal.

**[Figure 2]**

In summary, the reload feature adds 24% to the value of a conventional option in our example. In other cases, this amount may be more or less depending on the characteristics of the underlying stock and the terms of the option. The incremental value depends on the size of the dividend payout, the volatility of the underlying stock, the number

of years the option is outstanding, the number of times reloads are allowed, and the number of reload options.

## **LIMITATIONS OF THE USE OF OPTION PRICING MODELS**

We have made several assumptions in using that the Binomial Option Pricing Model to value an executive stock option:

- that the executive's risk aversion is the same as that of an average trader in the market who holds the stock,
- that the executive will remain employed with the firm throughout the option life, and
- that neither liquidity needs, risk aversion, nor behavioral decision biases will cause the executive to exercise the option earlier than our model determines is optimal.<sup>6</sup>

Thus, our method values a hypothetical tradable option that has the reload feature. The value to the executive need not be the same as the value of a hypothetical tradable option since the executive cannot trade his options; instead he must exercise while the holder of a traded option could sell. In addition, an executive typically has a large portion of their wealth tied to the stock of their firm and cannot diversify away the unsystematic risk in these options as an independent trader could do. These differences imply that theoretical models designed to value traded options yield valuations strictly greater than the value to the executive (Huddart, 1994).

On behalf of the corporation, the net cost of the options may also be less than the value to an independent trader. If the executive is likely to exercise the option for any of

the reasons listed above, then the fair value of the option to the corporation is reduced. In addition, the purpose of granting options often is to provide incentives to the executive to increase the value of the firm. In essence, the shareholders give up some share of the pie in order to increase the overall value of the pie. This paper is silent on these issues. Instead, we calculate the value of an option with a reload feature ignoring potential feedback from incentives provided by options to the stock price process.

The method can readily be modified to handle vesting and stock performance restrictions on exercise.<sup>7</sup> For instance, in the case of time-based vesting restrictions, in those periods that the options are not exercisable, the value of the option is just the holding value; the value from exercising is ignored. It is also possible to modify the model to account for the executive's risk preferences, liquidity needs, and the probability of employment termination. The difficulties presented by these latter three factors lie in reliably estimating parameters that capture risk aversion, liquidity needs, and the likelihood of termination, not in implementing the valuation when these parameters are known.

These limitations to analytical valuation methods apply to reload options and conventional options alike. SFAS 123 suggests estimating the time to expiration of options based on historical patterns of exercise.<sup>8</sup> However, as Kulatilaka and Marcus (1994) point out, this approach can lead to biased estimates of the value. Hemmer, Matsunaga and Shevlin (1994) show that use of an expected time to exercise can impart substantial upward bias in the estimated option value. The Binomial Option Pricing Model can be adapted to incorporate optimal early exercise in the valuation, avoiding the

bias introduced by estimating expiration dates (Carpenter, 1998 and Cuny and Jorion, 1995).

## CONCLUSION

SFAS 123 states, "... ideally, the value of an option with a reload feature should be estimated at the grant date, taking into account all of its features ..." (§ 186, p. 61). However, the FASB believes that valuation is not feasible and recommends delaying recognition of the value of the reload feature until a reload (second-generation) grant is issued (i.e., when the original option is first exercised). This paper demonstrates a feasible method to value both the option and the reload feature at the time of the initial grant. We also show that the reload feature is gaining in popularity and potentially adds considerable value to the underlying option. In view of this, the Financial Accounting Standards Board may wish to reconsider its recommendation regarding the timing of valuation for the reload feature.

Our algorithm also characterizes the optimal exercise policy for options with the reload feature, as we show in figure 2. Knowledge of the optimal exercise policy obviously has value to the holders of reload options.

Compensation consultants may wish to understand how the value of the reload feature varies with the terms of the options and the characteristics of the underlying stock. Consultants could use the algorithm to assist firms in customizing the terms of a reload feature and in deciding whether reload features are attractive to their executives. Firms can increase the relative value of a reload feature by reducing the term to maturity, by increasing the number of second-generation options granted, by increasing the number

of opportunities to reload, and by reducing the exercise price of the first-generation options. In addition, reload features are relatively more valuable for executives in high dividend or high volatility firms.

## APPENDIX 1. USING THE BINOMIAL OPTION PRICING MODEL

The appendix illustrates the application of the Binomial Option Pricing Model to the valuation of reload options.

The main steps are: (1) calculate the stock price tree, (2) value a conventional option, (3) value the opportunity to reload the option one time by scaling the values calculated in step (2), and (4) value the option with a reload feature by adding the value of a reload option to the proceeds from exercise at each node.

For expositional convenience, we value an option to buy one share at an exercise price of \$10.00 with three years to expiration. The grant date stock price is \$10.00, the annual volatility is 30%, the firm pays no dividends, and  $N = 3$  periods. Following Cox et al. (1979), the stock price tree is constructed from an up factor,  $u = \exp(.30 \times 1) = 1.35$ , a down factor,  $d = 1/1.35 = .741$ , and the risk-neutral probability of an uptick,  $p = .54$ .

### Calculate the Stock Price Tree

Table A1 presents the array of possible stock prices for the 3 periods. The stock price  $i$  periods before expiration given  $j$  net upticks since the grant date is  $S_i^j = \$10.00 \times u^j$ . At node A, the current stock price,  $S_3^0$  is \$10.00 per share. Thus, stock price at node B,  $S_2^1$ , is  $\$10.00 \times 1.35 = \$13.50$  and at node C,  $S_2^{-1}$ , price is  $\$10.00 \times .741 = \$7.41$ , and so on.

[Table A1]

## Value a Conventional Option

Now assume that you have an option to purchase one share for \$10.00 within the next 3 time periods. The value of this option,  $C_i^j$ , at a given node, described by the remaining time to maturity,  $i$ , and the net number of upticks since the grant date,  $j$ , is determined by computing the value at expiration,  $i = 1$  and then working backward to  $i = 1$ ,  $i = 2$ , and so on. At each node, the holder has the choice of exercising or holding the option. The value of exercising,  $V^x$ , is the greater of 0 and the difference between the market price and the exercise price. Thus, at expiration node G, the exercise value of the option,  $V^x$ , is  $\$24.60 - \$10.00 = \$14.60$  and at expiration node I, the exercise value of the option,  $V^x$ , is  $\$0.00$  since exercising would result in a loss of  $\$7.41 - \$10.00 = -\$2.59$ .

The value of holding the option is determined by the expected payoff from holding the option for one more period

$$V^h = \frac{pC_{i-1}^{j+1} + (1-p)C_{i-1}^{j-1}}{1+r}.$$

where  $p = .54$  is the probability of an uptick and  $r = 7\%$  is the risk-free interest rate.

The calculations at node D in table A1 are

$$V^h = \frac{.54 \times \$14.60 + .46 \times \$3.50}{1.07} = \$8.87,$$

and

$$V^x = \$18.23 - \$10.00 = \$8.23.$$

Thus,  $C_1^2 = \$8.87$  because  $V^h > V^x$ . Hence, it is optimal to hold rather than exercise the option at node D. Exercise is worthwhile only at expiration nodes G and H. In the

absence of dividends, the value of exercising a conventional option before expiration is always less than the value of holding.

## Value the Opportunity to Reload the Options

Now assume that the holder gets a reload grant of one share for each original option when he exercises the option prior to expiration. Using the notation in the body of the paper, these assumptions correspond to  $Z = 1$  and  $m = 1$ . The value of the reload option at node D is the same as the value of a conventional option granted at node D with an exercise price of \$18.23 and 1 period to expiration. Table A2 shows the value trees for the reload options issued at nodes D and B. The calculations for the holding value of a reload option at node D (see panel 1) are

$$V^h = \frac{.54 \times \$6.37 + .46 \times \$0.00}{1.07} = \$3.21$$

$$V^x = \$18.23 - \$18.23 = 0, \quad \text{and}$$

$$C_1^0 = \$3.21.$$

### [Table A2]

Since the holder receives one option for each option exercised, the value,  $V^R$ , of the reload option at node D is \$3.21. If the holder received a fraction of a reload option for each original option exercised, then the value of the reload would be that fraction times the value of one reload option. The calculations are similar for the value of the

reload option issued at node B. Table A3 shows the value of a reload option issued at each node.

**[Table A3]**

### **Value of the Option with a Reload Feature**

To value the original option with the reload feature, the value of a reload option,  $V^r$ , is added to the exercise value of the original option for the same node, consistent with equation (2). The value of the option at that node is still the maximum of the holding value and the exercise value including the value of a reload option. One still works backward from the value at expiration. Thus, the holding value of an option with a reload feature differs from the holding value of a conventional option because the former depends on the value of reload options at successor nodes.

Table A4 presents the value of an option that may be reloaded once. The values at expiration do not change from the value of a conventional option because both the original and the reload options expire at  $T = 0$ . At node D, the exercise value of the option is now  $\$8.23 + \$3.21 = \$11.44$ . Thus, the value of exercising is greater than the value of holding and the option value at node D is  $\$11.44$ . This increases the holding value at node B from  $\$5.24$  to  $\$6.53$ .

**[Table A4]**

The value of the option with a reload feature is  $\$3.68$  at node A. The value of the same option without a reload feature is  $\$3.03$  at node A. The difference is  $\$.65$  or a 21.5% increase in value due to the addition of a reload feature. Also note that the addition

of a reload feature leads to early exercise at node D whereas early exercise was never optimal without the reload feature.

## APPENDIX 2. MATHEMATICAL MODEL AND EXTENSION TO MULTIPLE RELOADS

### Overview

Our algorithm is a variation of the standard Binomial Option Pricing Method.<sup>9</sup> Fundamental to Binomial Option Pricing Model is the idea that stock price movements are well approximated by assuming the stock price can only move to two possible values in a short interval of time. The first step is to construct a price tree that probabilistically describes future stock price movements over time. The time from the grant date to the expiration of the options is divided into short periods. Over each period, the stock price is assumed to either rise or fall by a fixed factor with a fixed probability. Every node in the tree corresponds to a particular time to expiration and stock price level. Each node in one time period is connected to two nodes in the next time period, representing a rise or fall in the stock price by a fixed factor. Next, the value of the option is calculated at each node, working backwards recursively from the expiration date. At expiration, valuing the option is straightforward. At each earlier node, the value of the option can be determined from a particular recursive equation that depends only on the (already computed) values of successor nodes and parameters used to describe the stock price tree. The value of the option at every node is determined by computing the value at expiration, and then working backward to nodes one period prior to expiration, then two periods prior to expiration, and so on.

The recursive equation compares the value of holding the option for one more period to the value of exercising the option immediately and sets the value at that node to the larger of these quantities. The value from immediate exercise is the difference

between the market price and the exercise price, plus the expected value of reload options received on exercise. The value of holding the option until the next period is the discounted and weighted sum of the value of the option if held one more period in the case the stock price rises and, the value of the option if held one more period in the case the stock price falls. The weights reflect the likelihood the stock will rise (or fall). The discount factor is one plus the riskless interest rate. The value of the option on the grant date is the value at the starting node of this tree. Optimal early exercise is incorporated by assuming that the holder will exercise whenever the value of exercising is higher than the value of holding. Since the decision to exercise or hold is made at each node, optimal early exercise is embedded in the valuation. By including the value of reloaded options in the exercise value, the reload feature is embedded in the valuation as well.

### Model

The Binomial Option Pricing Model uses the Black-Scholes (1973) option valuation assumptions. In particular, the riskless rate of interest,  $r^*$ , is assumed to be constant and asset prices are assumed to be lognormally distributed with a constant volatility rate,  $\sigma$  (Cox and Rubinstein, 1985). Certain notation and definitions facilitate the description of the binomial method. Let  $X$  be the option's exercise price. Define  $N$  to be the total number of time steps during the life of the option, and  $T$  to be the option's time to expiration, in years. At each step, the asset return is either  $u = \exp(\sigma \sqrt{T/N})$ , with probability  $p = (1+r-d)/(u-d)$ , or  $d = 1/u$ , with probability  $1-p$ , where  $r = (1+r^*)^{T/N} - 1$ . Let  $S_i^j$  denote the stock price  $i$  time steps before expiration when the stock price has risen  $j$  times (net) since the grant date.<sup>10</sup> For a stock that pays no dividends, the stock price at node  $(i, j)$  is  $S_i^j = S_N^0 u^j$  where  $S_N^0$  is the stock price at node  $(N, 0)$ , which

corresponds to the grant date. For a dividend-paying stock, this expression generalizes to  $S_N^0 f(i, j)$  where  $f(i, j) \equiv u^j (1 - y)^{d(i)}$ ,  $y$  is the quarterly dividend expressed as a constant fraction of the stock price, and the exponent  $d(i)$  is the number of dividend payments made since the grant date up until time  $i$ .

Let  $C_i^j$  be the value of a conventional call option value at node  $(i, j)$ . Working backward from the end of the call option's life,  $C_i^j$  is the maximum of the proceeds from immediate exercise and the expected present value of the possible option values at  $i - 1$ .

$$C_i^j = \max \left\{ \begin{array}{l} S_i^j - X, \\ \frac{pC_{i-1}^{j+1} + (1 - p)C_{i-1}^{j-1}}{1 + r} \end{array} \right. \quad (1)$$

By moving backward through time and repeating these computations, the current value of an American-style option is determined.

This basic method has been used to value conventional options for twenty years. To generalize the valuation method to handle reloads, one determines the total value from exercise by adding the value of second-generation options granted as a result of the reload provision to the proceeds from exercise. The recursive equation then values an option at time  $i$  as the greater of the total value from exercise and the expected payoff from holding the option until the next period,  $i - 1$ .

Elaborating on the notation above, let  $C_i^j(m, S_N^0, X)$  be the value of an option that may be reloaded  $m$  times, has grant date stock price  $S_N^0$  and strike price  $X$ , at node  $(i, j)$  in a binomial tree. The value of the an option at node  $(i, j)$  is the maximum of the value of the option if exercised, including the value of any reload options; and, its value if held

for one more period, which is a weighted discounted sum of the option's value given either an uptick or downtick. This value can be expressed recursively as

$$C_i^j(m, S_N^0, X) = \max \begin{cases} S_i^j - X + ZC_i^0(m-1, S_i^j, S_i^j) \\ \frac{pC_{i-1}^{j+1}(m, S_N^0, X) + (1-p)C_{i-1}^{j-1}(m, S_N^0, X)}{1+r} \end{cases} \quad (2)$$

where  $Z$  is the number of second-generation options granted per first-generation option exercised. When the number of new options granted equals the number of shares needed to pay the exercise price,  $Z = X / S_i^j$ . Since  $m = -1$  implies that no more reloads are allowed, it is understood that  $C_i^j(-1, S_i^j, S_i^j) = 0$  for all  $i$  and  $j$ . At expiration, the option must be exercised, so for all  $j, k, m$ , and  $X$

$$C_0^j(m, S_k^0, X) = \max(0, S_0^j - X).$$

To reduce the number of binomial trees that must be constructed and evaluated, it is computationally efficient to standardize by the strike price  $X$ . Define

$$c_i^j(m, x) \equiv C_i^j(m, S_N^0 / X, 1) = \frac{C_i^j(m, S_N^0, X)}{X}$$

where  $x \equiv S_N^0 / X$ , the ratio of the stock price at the date of grant to the exercise price. In practice, the exercise price of most grants is equal to the stock price on the date of grant; hence,  $x = 1$ . For premium options (i.e., those that are out-of-the-money on the date of grant),  $x$  is less than one. In this notation, the grant date value of an option struck at-the-money that cannot be reloaded (i.e., a conventional option) is written  $Xc_N^0(0,1)$ . The function  $c$  is interpreted as the value of an option per dollar of the strike price. Analogous to equation (2), the option's value, per dollar of the initial strike price, is conveniently rewritten as

$$c_i^j(m, x) = \max \left\{ \begin{array}{l} x f(i, j) - 1 + Z^* c_i^0(m-1, 1), \\ \frac{p c_{i-1}^{j+1}(m, x) + (1-p) c_{i-1}^{j-1}(m, x)}{1+r} \end{array} \right. \quad (3)$$

where  $Z^* \equiv Z S_i^j / X$  is the number of new options granted per old option exercised multiplied by the ratio of the stock price at time  $i$  to the strike price of the existing option. In the case where the number of new options granted is equal to the shares tendered to pay the exercise price,  $Z^* = 1$ .

### Extension to an Unrestricted Number of Reloads

If the number of times the option can be reloaded is unrestricted, a modification of the recursive equation (3) is required. Let  $c_i^j(A, x)$  denote an option that may be reloaded an arbitrary number of times. Simply substituting  $c_i^j(A, \cdot)$  in (3) wherever  $c_i^j(m, \cdot)$  or  $c_i^j(m-1, \cdot)$  appears yields a system that cannot be solved recursively. This is because  $c_1^0(A, 1)$  is expressed as a function of itself, as are option values at other nodes in the tree. The key simplification comes from observing that

$$c_i^0(A, 1) = \frac{p c_{i-1}^1(A, 1) + (1-p) c_{i-1}^{-1}(A, 1)}{1+r}$$

since the executive is indifferent between holding and exercising an at-the-money option that can be reloaded an unrestricted number of times. Substituting the right hand side of this equality wherever the left-hand side appears in equation (3) yields

$$c_i^j(A, x) = \max \left\{ \begin{array}{l} xf(i, j) - 1 + Z * \frac{p c_{i-1}^1(A, 1) + (1 - p) c_{i-1}^{-1}(A, 1)}{1 + r}, \\ \frac{p c_{i-1}^{j+1}(A, x) + (1 - p) c_{i-1}^{j-1}(A, x)}{1 + r}, \end{array} \right.$$

which can be solved recursively since  $c_i^j(A, x)$  is expressed in terms of successor nodes in the tree for all  $i$  and  $j$ . So, the grant date value can be determined by computing the values of nodes in a single binomial tree, working backwards from the expiration date. This means the valuation of an option that may be reloaded an arbitrary number of times is no more complex computationally than valuing a conventional option using the binomial method.

### Frequency of Steps in the Algorithm

The accuracy of the valuation increases with the number of times each year that the binomial tree allows the stock price to vary. All calculations in this paper are based on binomial steps of one month, i.e., the stock is modeled as varying twelve times per year. This represents a good tradeoff between accuracy of the valuation and the processing resources required to compute values. As the number of times the option may be reloaded grows large, the computation time required to value the option also grows because each time the option can be reloaded requires an additional tree to be generated. Even for 10 reloads the computational demands are not excessive – all values presented in this paper were computed on a desktop computer. Appendix 3 provides the Mathematica computer code to implement this algorithm.

## APPENDIX 3. MATHEMATICA PROGRAM

A Mathematica notebook for this program is available from the authors.

### Valuation of Reload Stock Options

#### ▪ Program description

This program values reload options assuming the value of the firm's stock evolves according to a binomial process. With probability  $p$ , firm value increases by factor  $f$  each period. With complementary probability, firm value falls by factor  $1/f$ . The initial value of the stock is  $s$  and the strike is  $x$ .

Dividends are assumed to be a constant fraction of the stock price, paid quarterly.

#### ▪ Initialization

`ClearAll[d,div,f,n,m,mts,p,s,sx,t,tax,v,x,OptionValue]`

#### ▪ Parameters

##### ▪ Initial stock price

`s=14.53`

##### ▪ Dividend yield

`div=.03`

##### ▪ Strike price

`x=14.53`

##### ▪ Time to expiration of the option, in years

`t=10`

##### ▪ Number of option reloads allowed

Choose `m=99` if the number of reloads is unrestricted.

`m=1`

##### ▪ Tax rate on which options are reloaded

`tax=.481`

##### ▪ Annual volatility of stock returns

`v=.273`

##### ▪ Number of periods in binomial tree per year

`n=12`

- **Discount factor, per period**  
 $d=(1+.07)^{(1/n)}$

- **Factor by which stock price increases**  
 $f=\text{Exp}[v*\text{Sqrt}[1/n]]$

- **Probability of an uptick**  
 $p=(d-1/f)/(f-1/f)$

- **Recursive Formula for Option Value**

- **Price dynamics**

Market-to-strike ratio at node (i, j) given the market to strike ratio at the grant date was sx

$$\text{mts}[sx\_i\_j\_]:= \text{mts}[sx,i,j]=sx*f^j*(1-\text{div}/4)^{\text{Floor}[4*(t-i/n)]}$$

- **Value of an option with m reloads remaining and market to strike ratio sx at node (i, j)**

$$\begin{aligned} \text{OptionValue}[m\_sx\_i\_j\_]:= \\ \text{OptionValue}[m,\text{Round}[10000*sx]/10000,i,j]= \\ \text{If}[i==0,\text{If}[\text{mts}[sx,i,j]>1,\text{mts}[sx,i,j]-1,0], \\ \text{Max}[(p*\text{OptionValue}[m,\text{Round}[10000*sx]/10000,i-1,j+1] \\ + (1-p)*\text{OptionValue}[m,\text{Round}[10000*sx]/10000,i-1,j-1])/d, \\ \text{mts}[sx,i,j]-1+(1+(\text{mts}[sx,i,j]-1)*\text{tax})*\text{OptionValue}[m-1,1,i,0]]] \end{aligned}$$

- **Termination conditions**

The reload value of an option with no reloads left is zero.

$$\text{OptionValue}[-1,sx\_i\_j\_]:= \text{OptionValue}[-1,sx,i,j]=0$$

- **Unrestricted reloads**

This code handles the case when an arbitrary number of reloads are allowed. Such cases are coded by setting m=99.

$$\begin{aligned} \text{OptionValue}[99,sx\_i\_j\_]:= \\ \text{OptionValue}[99,\text{Round}[10000*sx]/10000,i,j]= \\ \text{If}[i==0,\text{If}[\text{mts}[sx,i,j]>1,\text{mts}[sx,i,j]-1,0], \\ \text{Max}[(p*\text{OptionValue}[99,\text{Round}[10000*sx]/10000,i-1,j+1] \\ + (1-p)*\text{OptionValue}[99,\text{Round}[10000*sx]/10000,i-1,j-1])/d, \\ \text{mts}[sx,i,j]-1+(1+(\text{mts}[sx,i,j]-1)*\text{tax})* \\ (p*\text{OptionValue}[99,\text{Round}[10000*sx]/10000,i-1,1] \\ + (1-p)*\text{OptionValue}[99,\text{Round}[10000*sx]/10000,i-1,-1])/d]] \end{aligned}$$

- **Option Value**

$$x*\text{OptionValue}[m,s/x,t^n,0]$$

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**Table 1**  
**Prevalence of Reload Option Grants<sup>a</sup>**

Year	Number of Option grants	Number of Reload grants	Reload grants as a Percent of option grants
92	4,488	246	5.5
93	6,884	353	5.1
94	7,599	397	5.2
95	7,719	397	5.1
96	9,642	931	9.7
97	9,673	1,135	11.7

<sup>a</sup> Source—Standard & Poor’s Execucomp Database. The number of reload grants is the total number of second-generation options issued as a result of a reload feature. Firms do not report conventional options separately from options with a reload feature (i.e. first-generation options). Thus, the number of options with a reload feature is unknown.

**Table 2**  
**Prevalence of Reload Option Grants by Industry<sup>a</sup>**

Industry	Number of Firms with No reload <sup>b</sup>	Median sales  ( <i>millions \$</i> )	Number of Firms with at Least 1 reload <sup>c</sup>	Median sales  ( <i>millions \$</i> )
Primary industry	83	1,080	4	7,509
Transportation	42	1,483	2	26,031
Trade	257	826	13	1,128
Food and Drug	83	2,405	5	8,741
Services	52	339	2	4,964
Oil and gas	79	496	5	2,656
Financial services	176	690	27	3,863
Manufacturing	173	620	10	3,498
Computers	234	448	8	666
Health care	20	353	0	NA
Utilities	114	1,491	6	6,887
SIC code changes	<u>395</u>	756	<u>23</u>	2,691
All industries	1,708	749	105	2,926

<sup>a</sup> Source—Standard & Poor's Execucomp Database.

<sup>b</sup> Includes all firms granting at least one executive option grant during 1992-1997.

<sup>c</sup> Includes all firms that granted second-generation options when an option with a reload feature was exercised.

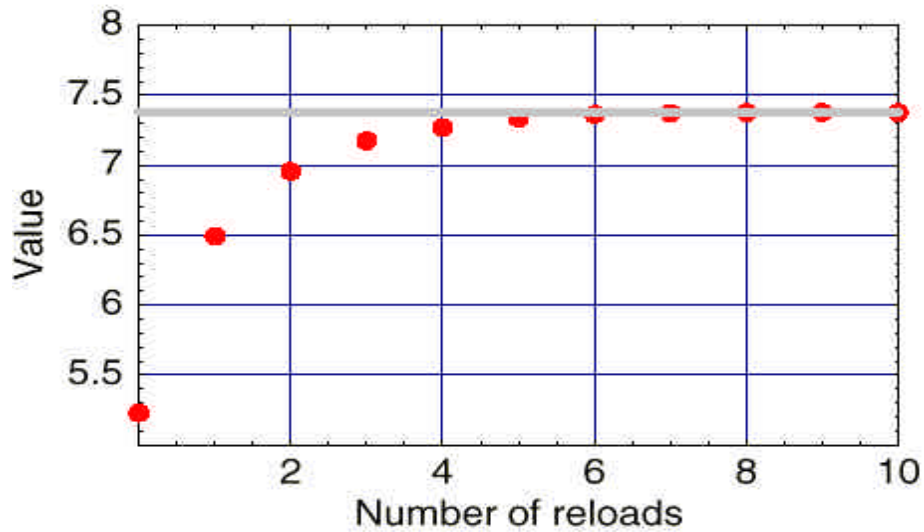
**Table 3**  
**Reload Option Values <sup>a</sup>**

Volatility	Number of Reloads Allowed	Dividend Yield											
		5-year Options						10-year Options					
		.00	.01	.02	.03	.04	.05	.00	.01	.02	.03	.04	.05
.20	0	.335	.295	.259	.227	.200	.177	.523	.437	.365	.305	.259	.221
	1	.363	.321	.286	.256	.230	.207	.547	.464	.398	.343	.297	.259
	2	.378	.332	.296	.267	.241	.219	.561	.474	.409	.356	.311	.273
	3	.388	.338	.301	.271	.245	.223	.571	.478	.413	.360	.315	.277
	4	.395	.341	.303	.273	.248	.226	.577	.480	.415	.363	.318	.281
	5	.400	.343	.304	.274	.249	.226	.582	.481	.416	.363	.319	.281
	unrestricted	.419	.344	.305	.275	.249	.226	.604	.482	.417	.364	.319	.281
.30	0	.394	.357	.323	.293	.268	.247	.580	.499	.433	.381	.339	.304
	1	.437	.400	.368	.339	.314	.293	.618	.546	.487	.437	.395	.358
	2	.459	.418	.385	.357	.332	.310	.638	.563	.504	.456	.414	.378
	3	.472	.428	.393	.364	.338	.317	.650	.572	.512	.464	.422	.385
	4	.481	.434	.398	.368	.343	.321	.659	.576	.516	.468	.426	.390
	5	.487	.437	.400	.370	.345	.322	.664	.578	.518	.470	.428	.391
	unrestricted	.511	.442	.402	.372	.346	.323	.690	.581	.520	.471	.429	.392
.40	0	.457	.421	.389	.361	.336	.314	.643	.566	.505	.457	.416	.382
	1	.511	.476	.446	.419	.394	.372	.690	.625	.570	.524	.484	.449
	2	.536	.499	.468	.441	.416	.394	.712	.646	.592	.547	.508	.473
	3	.551	.512	.479	.451	.425	.403	.725	.656	.602	.557	.517	.481
	4	.561	.518	.484	.456	.431	.408	.733	.661	.607	.562	.522	.487
	5	.568	.523	.488	.459	.433	.411	.740	.664	.610	.564	.525	.490
	unrestricted	.593	.530	.491	.461	.435	.412	.765	.668	.612	.566	.526	.491
.50	0	.520	.483	.453	.426	.402	.380	.705	.631	.574	.527	.489	.454
	1	.580	.547	.518	.492	.469	.447	.754	.695	.645	.601	.564	.529
	2	.607	.573	.543	.517	.494	.472	.776	.718	.669	.626	.589	.556
	3	.623	.587	.556	.528	.504	.482	.789	.728	.680	.637	.600	.566
	4	.633	.594	.562	.535	.511	.488	.797	.734	.684	.642	.605	.572
	5	.640	.599	.566	.538	.513	.491	.803	.737	.688	.645	.608	.575
	unrestricted	.665	.607	.570	.541	.515	.492	.825	.741	.690	.647	.610	.576

<sup>a</sup> Values are computed using the Binomial Option Pricing Model for grants of options with varying restrictions on reloads, volatilities of the underlying stock, dividend yields, and times to expiration. All options have strike prices equal to the market price on the grant date. Assumes one new option is granted on reload for each share of stock surrendered in payment of the exercise price, and an annual interest rate of 7%. Zero reloads correspond to a conventional employee stock option. Values are as at the grant date, and are expressed per dollar of stock price on the grant date. The binomial trees used to produce these estimates have one step per month.

**Figure 1**

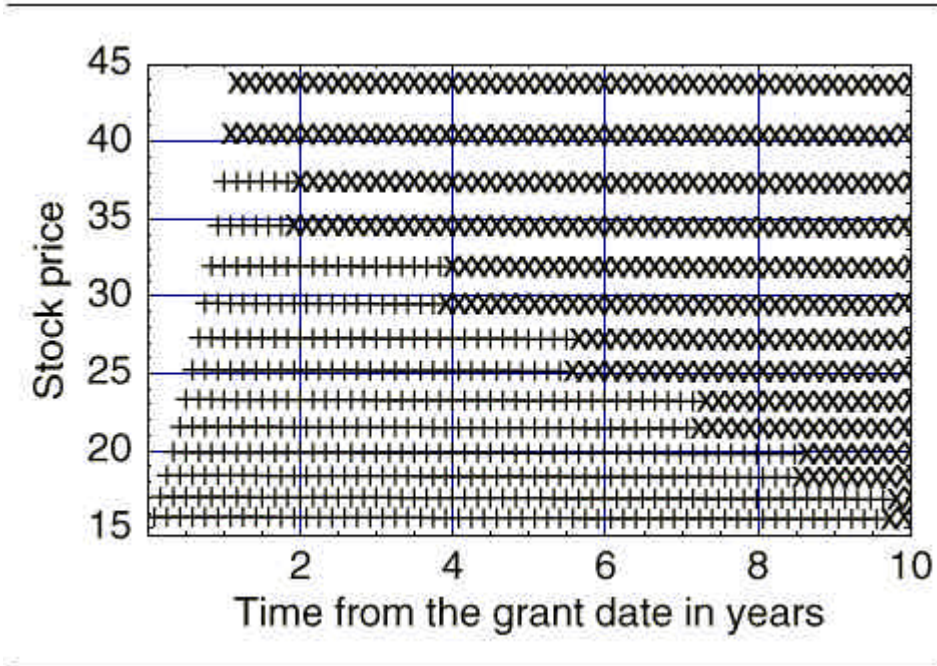
**Option Value as a Function of the Number of Reloads**



This figure plots grant-date value in dollars as a function of the number of times the option may be reloaded. Options have a strike price equal to the grant-date stock price of \$14.53 and a 10 year life. The stock parameters are those of Norwest (i.e., a 3% dividend yield and volatility of 27.3%). A 7% interest rate is assumed. The reload factor,  $Z$ , corresponds to Kovacevich's options as described in the text. The horizontal line in the figure is the value of options that may be reloaded an arbitrary number of times. The binomial trees used to produce these estimates have one step per month.

Figure 2

**Optimal exercise region for an option  
that may be reloaded once**



Assuming no dividends, volatility of 27.3%, an interest rate of 7%, strike and grant date stock prices of \$14.53, and the reload factor,  $Z$ , of Kovacevich's options, this figure plots the optimal exercise region in a binomial tree for an option that may be reloaded once. Optimally, exercise occurs when the stock price first passes into a node coded 'x'. In regions coded '+', it is optimal to hold the option until the next period. Since it is not optimal to exercise when the option is out of the money, stock prices below the strike price are not plotted. The binomial trees used to produce these estimates have one step per month.

**TABLE A1**

**Array of Exercise and Holding Values of a Standard Option**

i=3	i=2		i=1		i=0
					<b>Node G:</b> S=\$24.60 <b>V<sup>x</sup> = \$14.60</b>
	<b>Node B:</b> S = \$13.50		<b>Node D:</b> S=\$18.23 V <sup>x</sup> = \$8.23 <b>V<sup>h</sup> = \$8.87</b>		<b>Node H:</b> S=\$13.50 <b>V<sup>x</sup> = \$3.50</b>
<b>Node A:</b> S = \$10.00 V <sup>x</sup> = \$0.00 <b>V<sup>h</sup> = \$3.03</b>	V <sup>x</sup> = \$3.50 <b>V<sup>h</sup> = \$5.24</b>		<b>Node E:</b> S = \$10.00 V <sup>x</sup> = \$0.00 <b>V<sup>h</sup> = \$1.77</b>		<b>Node I:</b> S=\$7.41 <b>V<sup>x</sup> = \$0.00</b>
	<b>Node C:</b> S = \$7.41		<b>Node F:</b> S = \$5.49 V <sup>x</sup> = \$0.00 <b>V<sup>h</sup> = \$0.00</b>		<b>Node I:</b> S=\$4.07 <b>V<sup>x</sup> = \$0.00</b>
	V <sup>x</sup> = \$0.00 <b>V<sup>h</sup> = \$ 0.89</b>				

The option is issued at period  $i=3$  with a strike price equal to the current stock price of \$10.00 and a term to maturity of 3 periods. In each period, the stock price,  $S$ , can increase by a factor of  $u=1.35$  or decrease by a factor of  $d=1/u=.741$ . At each node,  $V^h$  is the value of the option if held one more period and ( $V^x$ ) is the value of the option if exercised this period. The value of the option, shown in bold, is the larger of the holding and exercise values.

**TABLE A2**

**Values for Reload Options Issued at Nodes B and D**

**Panel 1:** Value of a reload option issued at node D with an exercise price of \$18.23 and 1 period to expiration:

t = 2	t = 3		
<b>Node D:</b> S = \$18.23  V <sup>x</sup> = \$0.00 <b>V<sup>h</sup> = \$3.21</b>	<table border="1"> <tr> <td style="text-align: center;"><b>Node G:</b> S = \$24.60  <b>V<sup>x</sup> = \$6.37</b></td> </tr> <tr> <td style="text-align: center;"><b>Node H:</b> S = \$13.50  <b>V<sup>x</sup> = \$0.00</b></td> </tr> </table>	<b>Node G:</b> S = \$24.60  <b>V<sup>x</sup> = \$6.37</b>	<b>Node H:</b> S = \$13.50  <b>V<sup>x</sup> = \$0.00</b>
<b>Node G:</b> S = \$24.60  <b>V<sup>x</sup> = \$6.37</b>			
<b>Node H:</b> S = \$13.50  <b>V<sup>x</sup> = \$0.00</b>			

**Panel 2:** Value of a reload option issued at node B with an exercise price of \$13.50 and 2 periods to expiration:

i=2	i = 1	i = 0							
<b>Node B:</b> S=\$13.50  V <sup>x</sup> = \$0.00 <b>V<sup>h</sup> = \$2.83</b>	<table border="1"> <tr> <td style="text-align: center;"><b>Node D:</b> S = \$18.23  V<sup>x</sup> = \$4.73    <b>V<sup>h</sup> = \$5.60</b></td> <td style="text-align: center;"> <table border="1"> <tr> <td style="text-align: center;"><b>Node G:</b> S = \$24.60  <b>V<sup>x</sup> = \$11.10</b></td> </tr> <tr> <td style="text-align: center;"><b>Node H:</b> S = \$13.50  <b>V<sup>x</sup> = \$0.00</b></td> </tr> <tr> <td style="text-align: center;"><b>Node I:</b> S=\$7.41  <b>V<sup>x</sup> = \$0.00</b></td> </tr> </table> </td> </tr> <tr> <td style="text-align: center;"><b>Node E:</b> S=\$10.00  V<sup>x</sup> = \$0.00    <b>V<sup>h</sup> = \$0.00</b></td> <td></td> </tr> </table>	<b>Node D:</b> S = \$18.23  V <sup>x</sup> = \$4.73 <b>V<sup>h</sup> = \$5.60</b>	<table border="1"> <tr> <td style="text-align: center;"><b>Node G:</b> S = \$24.60  <b>V<sup>x</sup> = \$11.10</b></td> </tr> <tr> <td style="text-align: center;"><b>Node H:</b> S = \$13.50  <b>V<sup>x</sup> = \$0.00</b></td> </tr> <tr> <td style="text-align: center;"><b>Node I:</b> S=\$7.41  <b>V<sup>x</sup> = \$0.00</b></td> </tr> </table>	<b>Node G:</b> S = \$24.60  <b>V<sup>x</sup> = \$11.10</b>	<b>Node H:</b> S = \$13.50  <b>V<sup>x</sup> = \$0.00</b>	<b>Node I:</b> S=\$7.41  <b>V<sup>x</sup> = \$0.00</b>	<b>Node E:</b> S=\$10.00  V <sup>x</sup> = \$0.00 <b>V<sup>h</sup> = \$0.00</b>		
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S is the stock price for that node. In each period, the stock price, S, can increase by a factor of  $u=1.35$  or decrease by a factor of  $d=1/u=.741$ .  $V^h$  is the value of the option if held one more period and ( $V^x$ ) is the value if the option is exercised this period. The option value, shown in bold, is the larger of the holding value and the exercise value.

**TABLE A3**

**Array of Values of a Reload Option Issued at each node**

$i = 3$	$i = 2$	$i = 1$	$i = 0$
			<b>Node G:</b> S=\$24.60 $V^r = \$0.00$
		<b>Node D:</b> S=\$18.23 $V^r = \$3.21$	<b>Node H:</b> S=\$13.50 $V^r = \$0.00$
	<b>Node B:</b> S = \$13.50 $V^r = \$2.83$	<b>Node E:</b> S = \$10.00 $V^r = \$1.77$	<b>Node I:</b> S=\$7.41 $V^r = \$0.00$
<b>Node A:</b> $S_x = \$10.00$ $V^r = \$3.03$	<b>Node C:</b> S = \$7.41 $V^r = \$1.55$	<b>Node F:</b> S = \$5.49 $V^r = \$0.97$	<b>Node I:</b> S=\$4.07 $V^r = \$0.00$

S is the stock price. In each period, the stock price, S, can increase by a factor of  $u=1.35$  or decrease by a factor of  $d=1/u=.741$ .  $V^r$  is the value of a reload option issued at that node. The reload option has an exercise price equal to the market price for that node and expires at  $i=0$ .

**TABLE A4**

**Array of Exercise ( $V^x$ ) and Holding ( $V^h$ ) Values of an Option with a one-time Reload Feature**

i = 3	i = 2	i = 1	i=0
			<b>Node G:</b> S=\$24.60 $V^x = \$14.60$
	<b>Node B:</b> S = \$13.50	<b>Node D:</b> S=\$18.23 <b><math>V^x = \\$11.44</math></b> $V^h = \$8.87$	<b>Node H:</b> S=\$13.50 $V^x = \$3.50$
<b>Node A:</b> $S_x = \$10.00$ $V^x = \$0.00$ <b><math>V^h = \\$3.68</math></b>	$V^x = \$6.33$ <b><math>V^h = \\$6.53</math></b>	<b>Node E:</b> S = \$10.00 $V^x = \$1.77$ <b><math>V^h = \\$1.77</math></b>	<b>Node I:</b> S=\$7.41 $V^x = \$0.00$
	<b>Node C:</b> S = \$7.41 $V^x = \$0.00$ <b><math>V^h = \\$0.89</math></b>	<b>Node F:</b> S = \$5.49 $V^x = \$0.00$ <b><math>V^h = \\$0.00</math></b>	<b>Node J:</b> S=\$4.07 $V^x = \$0.00$

S is the stock price for that node. In each period, the stock price, S, can increase by a factor of  $u=1.35$  or decrease by a factor of  $d=1/u=.741$ .  $V^h$  is the value of the option if held one more period.  $V^x$  is the value if exercised this period and includes both the gains from exercise and the value of a reload option issued at that node. The option value, shown in bold, is the larger of the holding value and the exercise value.

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<sup>1</sup> Other terms for reload options include restoration options, replacement options, continuation options, replenishment options, and accelerated ownership options.

<sup>2</sup> Under some plans, the stock used to pay the exercise price must have been held by the employee for a minimum specified time. Firms may use this feature to induce executives to hold some of their wealth in stock in periods before the executive exercises his options. Some reload plans also require executives to hold shares acquired on exercise for some time after exercise. See Hemmer et al. (1996).

<sup>3</sup> The difference between the market price of the stock on the date of exercise and the exercise price is income to the employee on the date of exercise. See Huddart (1998).

<sup>4</sup> Reload features are more common in larger companies and financial services businesses. These firms tend to pay higher-than-average dividends.

<sup>5</sup> Using the same kind of analysis it can be shown that reload features are a higher fraction of total option value for discount options (i.e., options where the strike price is below the grant-date stock price) than for premium options.

<sup>6</sup> Nevertheless, these factors are likely to be important. See Heath et al. (1999) for a discussion of behavioral factors.

<sup>7</sup> A typical executive option cannot be exercised prior to vesting. Thus, the option is forfeited if the executive leaves the firm prior to vesting.

<sup>8</sup> Huddart and Lang (1996) document patterns of exercise and their association to volatility, past stock price movements, and the lapsing of vesting restrictions.

<sup>9</sup> See Cox and Rubinstein (1985) for an excellent discussion of the use of Binomial Option Pricing Model for valuing other complex options.

<sup>10</sup> Negative values of  $j$  mean the stock price has fallen since the grant date. For example, if three periods after the grant date there have been two down moves and one up move, then the stock price is

$$S_{N-3}^{-1} = u^{-1} S_N^0.$$