Monte Carlo Portfolio Planning with Employee Stock Options

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Introduction

Employee stock options remain a major feature of compensation structure at many U.S. firms. For management and executive staff, options are the most common equity-based incentive vehicle (*Long Term Incentive Grant Practice for Executives*, F.W. Cook, August 2005). Fully 90% of the 250 largest U.S. based companies continue to use stock options for long-term incentive grants. Despite the challenges associated with new requirements for expensing options, stock options remain a popular vehicle for compensation because they create such a powerful alignment between compensation and the performance of a company's stock.

Despite the prevalence of employee stock options as a form of compensation, employees who receive options grants will likely have a hard time valuing these grants and managing their portfolios of options as part of their overall investment planning.

Quantext's Retirement Planner (QRP) is a Monte Carlo portfolio management tool designed to be used for individual investors in managing their portfolios. One of the early questions that we received in showing QRP to financial advisors was whether we could incorporate stock options into a portfolio. In QRP Version 4.6, we have introduced the ability to simulate a portfolio that includes a set of stock options with varying strike prices and expiration dates. Based on discussions with financial advisors, this appears to be the first time that a portfolio management tool has been introduced for individuals that incorporated stock options into a Monte Carlo package.

Part I: Valuing Options as a Stand-Alone Investment

The basic problem of valuing stock options is quite standardized. We use the Black-Scholes model to calculate the value of an option. It is a good idea to start with valuing a set of options that are exchange traded to that you can calibrate the volatility that is used in the model. To begin, we will look at the example of valuing options on MSFT (Figure 1).

Retirement Planning Report

Prepared For:	Preparation Date:
John Doe	9/6/2005

Page 8: Stock Options

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Options for: MSFT

Recent Share Price:	**$27.02**

Strike Price	Shares	Expiration	Current Expected Value Per Share
$20.00	1000	01/18/08	$8.66
$25.00	1000	01/18/08	$5.04
$30.00	1000	01/18/08	$2.61
$35.00	1000	01/18/08	$1.24
$40.00	1000	01/18/08	$0.55
			Total Current Value: $18,096.73

Figure 1: Output using risk-calibrated results and 2 years of trailing data (through July 2005)

Using QRP's data retrieval and risk-return balancing feature, we have automatically retrieved two years of historical stock data and calculated the trailing volatility, Beta, and other parameters for MSFT. We then input the recent share price and a series of strike prices for the longest-dated exchange traded call options for MSFT (Figure 1). The QRP model calculates the current value of these options. We can easily compare the calculated values from Figure 1 to the most recent values traded in the market—and in this case they are very close (Figure 2).

In many cases, the trailing volatility (risk-balanced or pure historical) will not match the current market implied volatility nearly as closely as we see here. If the values do not match up well, the user has several choices. The first is to consider a different historical period. In this example we have looked at the trailing two years, but we might just as easily have looked at the trailing five years, for example. Also, the risk-balanced solution is impacted by the relationship between the overall market volatility in the historical period and the forward-looking market volatility specified for QRP. It is also not

unreasonable that the user may decide that the implied volatility in the current exchange traded options is not the value that he or she wishes to use as the basis for long-term volatility. As a general rule, the implied volatility is often a reasonable baseline for 'adjusting' the input value of standard deviation for an underlying equity.

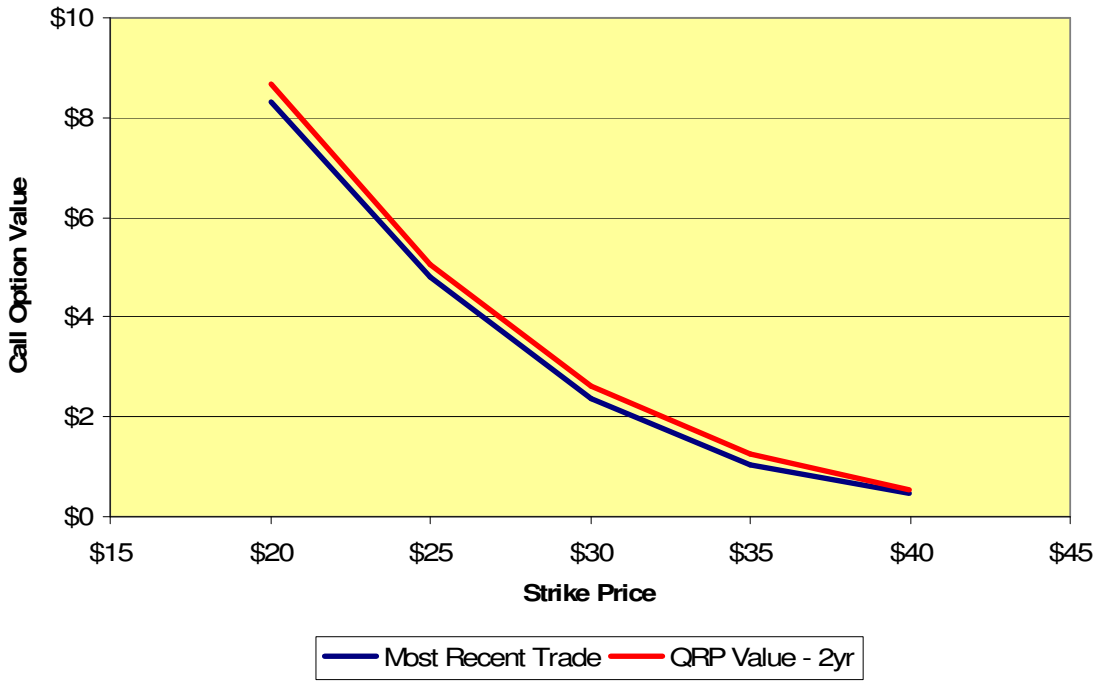

Figure 2: Graphical comparison of value of call options expiring in January 2008 between market quotes and the risk-balanced QRP values with no adjustment

Because the current market's implied volatility and the risk-balanced historical volatility calculated by the QRP are very similar, the values of the long-dated call options agree very well in this case. We may now feel some confidence in changing the options expiration dates and strikes to the longer-term periods of employee stock options.

Part II: Managing the Total Portfolio Impact of Options

To examine the value of a series of long-dated stock options, it is helpful to examine a specific scenario---let's call him John Doe:

Retirement Planning Report

Prepared For: **Preparation Date:**

John Doe **9/6/2005**

Page 1: Basic Input and Projections

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Current Age	40
Date of Retirement	2030
Age at Retirement	65
Annual Contribution (2005 Dollars)	$14,000
Current Portfolio Value	$100,000
Inflate Contributions at inflation?	Yes
Inflate Income Draw?	Yes
Income in Retirement (2005 Dollars)	$80,000

Assumed Inflation Rate (Annual) 3.00%	Annual Standard Deviation of Market Return (% of normal) 70.00%
Annual Standard Deviation	10.55%
Delta Return -1.00%	Average Annual Return of Market 9.30%

Note: Delta Return is your estimate of the difference between annual return in the future and historical annual return from the S&P500

Figure 3: Basic parameter for John Doe and market assumptions

The first page of the QRP Retirement Planning Report enables the user to specify basic inputs for time until retirement, savings rates, inflation, performance of the market as a whole (average return and standard deviation), current portfolio value, and desired future income in retirement (Figure 3). Once we have specified these inputs, we must next specify the portfolio allocation (Figure 4). This portfolio is an arbitrary example for purposes of illustration. It is allocated across a series of stocks and funds, and has a focus in socially responsible investment (SRI) funds, as well as having a concentration in Microsoft stock.

Retirement Planning Report

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Page 4: Fund Mix Using Beta

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Fund Name	Beta	Standard Deviation (Annual)	Alpha (Annual)	Check
MSFT	30.2%	18.16%	8.83%	OK
VFINX	96.4%	10.61%	-1.07%	OK
WAIDX	94.0%	11.73%	-0.29%	OK
PRBLX	62.9%	8.11%	0.81%	OK
DSEFX	102.6%	11.62%	-1.15%	OK
CSIEX	88.4%	10.35%	-0.45%	OK
AQEIX	107.2%	12.42%	-1.18%	OK
WAGEX	99.9%	11.67%	-0.86%	OK
HCC	121.1%	24.50%	3.52%	OK
ENR	77.2%	29.50%	10.07%	OK

Annual Return = Beta x (Annual Return on S&P500)+Alpha

Note: This definition for Alpha has rolled in the risk-free rate of return

Fund Name	Percentage of Funds	Average Annual Return
MSFT	20.0%	11.63%
VFINX	10.0%	7.86%
WAIDX	10.0%	8.46%
PRBLX	5.0%	6.63%
DSEFX	10.0%	8.35%
CSIEX	10.0%	7.72%
AQEIX	10.0%	8.75%
WAGEX	10.0%	8.42%
HCC	10.0%	14.75%
ENR	5.0%	17.23%
Sums to	100.0%	

Simulated Portfolio Beta: 84.33%

Portfolio Stats

Average Annual Return	Standard Deviation (Annual)
9.95%	10.24%

Historical Data

Start:	End:
7/31/2003	7/31/2005

Average Annual Return	Standard Deviation (Annual)
12.23%	8.06%

Historical Beta: **84.01%**

Market Index (S&P500)

Average Annual Return	Standard Deviation (Annual)
9.30%	10.55%

Calculator by Quantext

Figure 4: Portfolio allocation for John Doe

The Quantext Retirement Planner retrieves historical data for the securities chosen by the user for the period specified—in this case the last two years. QRP then calculates all of the required statistical parameters for simulating these securities as part of the overall portfolio (Beta, Standard Deviation, and Alpha). The user can then select either pure historical parameters or what we call 'risk-return balanced' parameters. This is explained in the documentation. In short, the risk-return balancing adjusts the projected risk and return associated with a security to be consistent with (1) assumed future market performance, and (2) observed balance between risk and return in the market. These parameters are simply estimates and users are encouraged to adjust these parameters as they wish. For this analysis, however, we have used the risk-return balanced parameters generated by the QRP.

The analysis from the Monte Carlo engine projects that this portfolio has a Beta of 84% and that the historical Beta over the historical period used is very close to this value (Figure 4). We can also see that our projected average annual return for the portfolio is lower than the average annual return that this portfolio has delivered over the past two years. This occurs because the SRI funds in the portfolio are those that have had the highest recent returns and the risk-balancing feature of QRP lowers the projected future annual return because we cannot expect these funds to outperform indefinitely.

It is on top of this portfolio that we will value the stock options that John Doe holds (Figure 5). We have a series of five options grants, with a total present value of $17,584. Note that three of the options grants are 'out of the money.' We can still easily calculate their current value. Because they are dated so far into the future, they have considerable value. We can also calculate the projected value of this portfolio of options at John's retirement in 2030, but we must make certain assumptions about how and when he will exercise the options. In QRP, the baseline assumption is that John will wait until the options expire to exercise them and that he will invest the proceeds (after taxes) in his overall portfolio allocation (Figure 4). The *Projected Value at Retirement* is the median value of the portfolio of options and the proceeds invested after expiration. In this case, the projected future value of this set of options is $217,000 (Figure 5).

The QRP Report also shows the projected 'survival' for the portfolio with and without the stock options (bottom of Figure 5). The overall impact of the stock options on John's future retirement income is notable, but it requires some consideration. The stock options provide limited protection against the really extreme cases—in which John runs down his portfolio by age 80-82. The stock options with subsequent re-investment of proceeds provide an additional five years of retirement income at the higher percentiles—the more likely cases.

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Strike Price	Shares	Expiration	Current Expected Value Per Share
$20.00	500	01/18/06	$7.24
$25.00	500	01/18/07	$4.00
$30.00	700	01/18/12	$5.90
$35.00	700	01/18/14	$5.52
$30.00	500	01/18/16	$8.49

Total Current Value:
$17,854.98

Tax Rate at Expiration:	35%

Projected Value at Retirement:
$217,001.40

Annual Draw	$80,000	
	Portfolio with Options	Portfolio without options (page 5)
Probability of Running Out of Money	**Age**	**Age**
10%	82	80
15%	84	82
20%	87	85
25%	91	86
30%	95	90
35%	100	95
40%	Not Found	101
45%	Not Found	Not Found
50%	Not Found	Not Found

Figure 5: Sample portfolio of employee stock options

Discussion

The overall portfolio impact of adding stock options to a portfolio allocation strategy is a function of the specifics of the individual's situation. While it is fairly easy to calculate the current value of the options, assessing the long-term contribution to the portfolio is more challenging. The QRP includes options in its Monte Carlo simulation, allowing a user to examine the impacts of the stock options on the total portfolio return and risk at various time horizons.

The relative attractiveness of carrying a concentration in stock options is meaningfully impacted by such factors as the Beta and risk of the underlying stock, the Beta and volatility of the overall portfolio allocation, and the risk tolerance of the individual. It is worth noting, for example, that the value of the portfolio of options (including reinvestment) at the 20^{th} percentile is sometimes as little as 1/3 of the median value in this example. This means that you have a 1-in-5 chance that you will end up with the portfolio of options being worth about 37% of the projected median value. In this example, you have a 1-in-5 chance that the value of the portfolio of options (with proceeds re-invested at exercise) will be $82,000 or less, while the median projected value is $217K. The stock portfolio without options shows far less range. The 20^{th} percentile portfolio value at retirement age is 70% of the projected median value. This in no way detracts from the attractiveness of options as part of the overall portfolio, but the probability of having options expire out of the money is often not negligible.

The only way to account for the factors discussed in the previous paragraph (and through much of the rest of this paper) is by using a Monte Carlo portfolio management model that accounts for options. The approach in QRP is a standard application of methods that are routinely applied in a range of risk management applications but which are fairly uncommon in portfolio management applications for individuals.