

Software Programs and Problems at Investing with Options

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Abstract: *Today's financial world is complicated. It is an indisputable fact that derivative securities form part of the essential landscape of managerial financial education. Options are widely used for this purpose in the portfolios of endowment funds, pension funds, and individuals.*

A combination of powerful but inexpensive personal computers, the availability of financial information on the Internet, and online discount brokers has made it very attractive for individuals to do their own analysis and investing. The famous software products for solving the financial problems at investing with options are: MATLAB®, Peter Hoadley's Options Strategy Analysis Tools, SmartPortfolio, The Numerix Toolkit, Opti-Template Analysis & Pricing, Variance-covariance VaR with VaRworks, @RISK .

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I. Introduction and aim of publication

It is an indisputable fact that derivative securities form part of the essential landscape of managerial financial education. An understanding of options is becoming a must for anyone whose career touches financial markets. Indeed, it is difficult to find a business school with a curriculum that does not contain as part of its core requirements some exposure to the theory of derivative securities.

Today's financial world is complicated. We face many sources of risk that were not present in the mid-nineteenth century. Today's communication technology provides us almost instantaneous information about different events. All of these bits of news can affect the value of our investments.

Managers frequently use stock to refine the portfolio's investment characteristics. Options are much more convenient (and less expensive) to use than wholesale purchases or sales of shares of stock each time an adjustment is appropriate. Options

also provide a means for risk to be transferred from one person to the next. I may own a portfolio of stock and face some potential risk that I find unacceptable. Using options, I can transfer that risk to some other market participant who, for a price, is willing to bear it [4].

Some people use options as a means of generating additional income from their investment portfolio. Options are widely used for this purpose in the portfolios of endowment funds, pension funds, and individuals.

In short, options give the marketplace opportunities to adjust risk or alter income streams that would otherwise not be available. An economist would call this phenomenon "enhanced spanning" of the market.

1. Black-Scholes Option Pricing Model (OPM)

One of the most useful and talked-about developments in finance during the last decade is the Black-Scholes Option Pricing Model (OPM). This model is a useful representation of how the option premium is determined in the marketplace. Popular with a growing number of individual investors, options have been analyzed and successfully used by institutional investors for many years. Virtually all options analysts use some form of the Black-Scholes Option Pricing Model to assist them in their decision marketing. A number of computer software programs can generate theoretical OPM values, and some firms provide hourly printouts of computed option prices to floor trades on the option exchanges. The well known model is as follows:

$$C = S[N(d_1)] - K e^{-rt} [N(d_2)],$$

$$d_1 = \frac{\ln(S/K) + [r + \sigma^2/2] t}{\sigma \sqrt{t}},$$

$$d_2 = d_1 - \sigma \sqrt{t},$$

where C is theoretical call premium; S - current stock price; t - time in years until option expiration; K - option striking price; r - risk free interest rate; σ - standard deviation of the stock returns; $N(x)$ - probability that a value less than 'x' will occur in a standard normal distribution.

At every instant of time, the value of the call option depends on a few parameters. Some of these parameters are fixed and inherent in the specified option definition, e. g., the exercise data. Some are assumed to be fixed but may indeed change, e. g., the interest rate. Other parameters depend on time or are changing in a random manner. The effect of a "small change", in a certain parameter on the price of the call option, is captured by its partial derivative with respect to the parameter in question [7].

2. Sensitivity Measure

The measure of the sensitivity of the call price to time is the derivative of the call price with respect to time. This derivative is the precise measure of the instantaneous rate of change of the call option's value that is due to the passage of time. It is customary to assign Greek names to the sensitivity measures of options. The sensitivity with respect to time is called Theta and represented by the Greek letter Θ . It is defined to be the rate of change of the call price as the time to maturity increases. In terms of the notation for the call price it is calculated as

$$\Theta = \frac{\partial \left(PN \left(\frac{\ln \left(\frac{P}{K} \right) + \left(r + \frac{\sigma^2}{2} \right) t}{\sigma \sqrt{t}} \right) - Ke^{-rt} N \left(\frac{\ln \left(\frac{P}{K} \right) + \left(r - \frac{\sigma^2}{2} \right) t}{\sigma \sqrt{t}} \right) \right)}{\partial t}$$

The Delta (Δ) measure is simply the first derivative of the call value with respect to the stock price. The Delta measure therefore represents the instantaneous rate of change in the call price due to an infinitesimal change in the stock price. It is defined below:

$$\Delta = \frac{\partial \left(PN \left(\frac{\ln \left(\frac{P}{K} \right) + \left(r + \frac{\sigma^2}{2} \right) t}{\sigma \sqrt{t}} \right) - Ke^{-rt} N \left(\frac{\ln \left(\frac{P}{K} \right) + \left(r - \frac{\sigma^2}{2} \right) t}{\sigma \sqrt{t}} \right) \right)}{\partial P}$$

To increase the quality of the approximation one can take account of the second derivative of the call option value with respect to the stock price. The Gamma measure is the second derivative of the call price with respect to the stock price. Correspondingly, Gamma is the first derivative of Delta with respect to the stock price. Gamma is represented by the Greek letter Γ and can be stated as

$$\Gamma(K, t, P, \sigma, r) = \frac{\partial}{\partial P} \Delta(K, t, P, \sigma, r) = \frac{\partial N \left(\frac{\ln \left(\frac{P}{K} \right) + \left(r + \frac{\sigma^2}{2} \right) t}{\sigma \sqrt{t}} \right)}{\partial P}$$

Vega, represented by the Greek letter V , measures the sensitivity of the call price with respect to the value of the volatility. Perhaps the best way to appreciate this effect is to look at a graph or an animation of the value of the call option as a function of the time to maturity and as a function of the stock price for different values of volatility. The measure Vega is defined in a similar manner to the other measures. It is the derivative of the value of the call option with respect to a particular parameter, in this case sigma, i.e.,

$$V = \frac{\partial \left(PN \left(\frac{\ln \left(\frac{P}{K} \right) + \left(r + \frac{\sigma^2}{2} \right) t}{\sigma \sqrt{t}} \right) - Ke^{-rt} N \left(\frac{\ln \left(\frac{P}{K} \right) + \left(r - \frac{\sigma^2}{2} \right) t}{\sigma \sqrt{t}} \right) \right)}{\partial \sigma}$$

The measure of sensitivity of the call option value to changes in the interest rate is called rho and is denoted by the Greek letter ρ . The interest rate and exercise price, like the volatility, are also parameters that are assumed to be fixed and constant through-

out the life of the option. The measure rho is defined again as the first partial derivative of the call value with respect to the interest rate r . In other words,

$$\rho = \frac{\partial \left(PN \left(\frac{\ln\left(\frac{P}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}\right) - Ke^{-rt} N \left(\frac{\ln\left(\frac{P}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}\right) \right)}{\partial r}$$

Indexes are portfolios of certain stocks that are traded in a certain market or markets. Usually the indexes are formed so as to represent a certain segment of the market, e. g., blue chips or the performance of the market as a whole. For example, the S&P 500 index includes common stocks of industries, utilities, transportation, and financial institutions [5].

3. Binomial model

The binomial option model proposed by Cox, Ross, and Rubinstein in 1979, values American options on dividend-paying common stock with explicit recognition of early exercise. The binomial model can be readily modified to work on currency options. In this model, the spot exchange rate at a point in time is constrained to move (or jump) in one of two mutually exclusive paths. One is upwards, and the other is downwards. The expiration value of the call option is a function of the spot binomial tree. Specifically, the value of the option depends on whether the spot moves up or down. The binomial model can also be used to value European currency options. Here the risk-neutrality approach provides a shortcut. The option's value can be derived directly from the final set of nodes and their associated binomial risk-neutral probabilities of occurrence. The value of the call is equal to the expected present value of the payoff at expiration [1].

4. Value at Risk (VaR)

VaR tries to answer the simple question: **How much money (or more) might we lose over time period T with probability X?**

Values at Risk methods, which employ a linear (delta only) approximation to the relation between instrument value and the underlying risk factors are unlikely to be robust when applied to portfolio containing non-linear contracts such as options.

Consider a portfolio consisting of quantities $x = (x_1, x_2, \dots, x_n)^T$ with assets 1, 2, ..., n with time t , values $v = (v_1, v_2, \dots, v_n)^T$. Then the change in the price of portfolio, V , over the next interval Δt is given by:

$$\Delta V = \sum_{i=1}^n x_i \Delta v_i,$$

where Δv_i (ΔV) denotes the change in the value of asset i (the portfolio) over the interval from t to $t+\Delta t$. The value-at-risk of the portfolio x for some defined probability level α , is defined as the level of loss $\Delta V^*(\alpha)$ such a probability that $\Delta V \leq \Delta V^*$ is equal to α . When the joint distribution of the change in asset values can be

taken as multivariate normal with a known mean and variance, the calculation of ΔV^* is straightforward. In many cases, however, and particularly when some of the assets are options, the assumption of multivariate normality will be inappropriate, even when appropriate for the underlying rates and prices [2].

In this case one of two approaches is typically employed. In the first, the so-called "delta-only" method, the non-linear relation between asset values and the underlying rates and prices is replaced by a linear approximation based on each asset's "delta". Assume that the value of each asset i depends on time and K "factors", $f = \{f_1, f_2, \dots, f_k\}$. Then $\Delta^{\delta}V$ —the first order approximation to ΔV , is given by:

$$\Delta^{\delta}V = \sum_{i=1}^n x_i \frac{\partial v_i(f, t)}{\partial t} \Delta t + \sum_{i=1}^n x_i \sum_{k=1}^K \frac{\partial v_i(f, t)}{\partial f_k} \Delta f_k \equiv \mu_{\rho} + \sum_{k=1}^K \delta_k \Delta f_k,$$

where μ_{ρ} is the change in portfolio value resulting from the passage of time:

$$\mu_{\rho} = \sum_{i=1}^n x_i \frac{\partial v_i(f)}{\partial t} \Delta t,$$

and δ_k , the aggregate delta, is given by

$$\delta_k = \sum_{i=1}^n x_i \frac{\partial v_i(f)}{\partial f_k}.$$

Value at Risk is a number that represents an estimate of how much our portfolio may lose due to market movements for a particular horizon (time period) and for a given confidence level (probability).

The definition of that potential loss depends on three main parameters:

a. The **horizon**, over which the potential loss is measured. It is not the same to measure the expected loss over a one-day period as over a one-week period.

b. The **degree of confidence** (probability of occurrence). The degree of confidence is a measure of the degree of certainty of the VaR estimate. The most common degree of confidence is 95%, which means that 95% of the times our losses will be lower than the VaR number, while 5% of the times our portfolio will experience greater losses.

c. The **home currency**, in which we measure the VaR number. VaR is a number, but it is expressed in U.S. dollars, British pounds or Japanese yens. It is not the same to say that our VaR is \$1 million, than £1 million or ¥1 million.

How do we measure the market risk of a portfolio?

A portfolio may have different instruments (stocks, bonds, swaps, floors, option...) in different markets (fixed income, commodities, equities...). To analyze the overall risk of the portfolio, it is necessary to determine the risk of the individual assets, and the interactions (correlations) between those assets. To compute the volatility for every trade in our portfolio, and then estimate the correlation with the remaining trades, could be an impossible task.

The VaR methodology provides a way to deal with the problem of measuring the global risk of a portfolio. It is important to point out, that in the VaR analysis, we assume that portfolio remains constant, and only the market factors will change.

VaR is highly integrative in nature and provides a global picture of the risk of a portfolio. It attempts to bring together into a single framework:

- Multiple types of market risk,
- Multiple types of instruments.

In a nutshell, VaR is an attempt to quantify risk, given the portfolio's current exposure to a certain set of market factors, by asking how much these factors can move (accounting for volatilities and correlations) over a period of time.

As a first step, we must identify a set of common risk factors, for which we can obtain volatilities and correlations, which will represent the "Market Factors". To continue the analysis, we have to find a way to express all the trades of our portfolio in terms of those risk factors ("cash flow mapping"). Once we have the cash flow map in terms of the risk factors, and the volatilities and correlations of those risk factors, we only need to perform basic matrix manipulation to calculate the VaR of our portfolio. [10]

5. Monte Carlo simulation

Monte Carlo simulation is a mathematical technique for numerically solving differential equations. It is used extensively in finance for such tasks as pricing derivatives or estimating the value at risk of a portfolio. The technique tends to be computer intensive, with many problems taking minutes or hours to solve on a high speed computer. For this reason, Monte Carlo simulation is avoided when closed form or other simple solutions exist for a problem. Monte Carlo simulation, however, has the advantage that it is a "brute force" technique that will solve many problems for which no other solutions exist. Because many financial problems are highly complex, this "method of last resort" is used frequently [19].

Monte Carlo simulation is typically used in a financial setting to solve problems which require that one or more statistics of a probability distribution be calculated.

For example:

- The price of an option is the (risk neutral) discounted mean of the probability distribution for the option's value at expiration.
- Value at risk is the upper bound on a confidence interval for the probability distribution of the loss/profit that a portfolio will realize over a specified horizon.

To understand how the process works, let's consider an example of how a complex option might be priced. Suppose the option's value is dependent on two underliers, a stock index and an exchange rate. Monte Carlo simulation might be used to price such an option as follows:

"Randomly" generate 10,000 scenarios for the value, on the option's expiration date, of the two underliers.

Do so in a manner that is consistent with an assumed (risk neutral) joint probability distribution of the two variables.

Determine what the option's expiration value would be under each of the 10,000 scenarios.

Form a histogram of those results. This represents a discrete approximation for the probability distribution of the option's expiration value. The discounted mean of the histogram is the estimated option price.

Note that this solution only yields an approximate price. By using more scenarios - say 20,000 instead of 10,000 - the precision of the result could be improved. Typically, the precision of a Monte Carlo simulation is proportional to the square root of the number of scenarios used. As computers become more powerful, financial professionals are able to perform Monte Carlo simulations with ever more scenarios, or apply the methodology to ever more complex problems. Also, there are various ways to speed up Monte Carlo analyses, including "variance reduction techniques" and "quasi-random" techniques [9].

II. Software programs for solving financial problems

A wide variety of computational schemes have been proposed for the numerical valuation of various classes of options. Experiences in numerical computation have revealed that the details of the implementation of the auxiliary conditions in the numerical algorithms may have profound effects on numerical accuracy. Difficulties in designing algorithms that deal with the path-dependent payoffs, monitoring features, etc., have been well reported in the literature [18].

The famous software products for solving the financial problems at investing with options are: MATLAB®, Peter Hoadley's Options Strategy Analysis Tools, SmartPortfolio, The Numerix Toolkit, Opti-Template Analysis & Pricing, Variance-covariance VaR with VaRworks, @RISK .

1. MATLAB®

MATLAB® and the Financial Toolbox provide a complete integrated computing environment for financial analysis and engineering. The toolbox has everything you need to perform mathematical and statistical analysis of financial data and display the results with presentation-quality graphics. You can quickly ask, visualize, and answer complicated questions.

In traditional or spreadsheet programming you must deal with all sorts of house-keeping details: declaring, data typing, sizing, etc. MATLAB does all that for you. You just write expressions the way you think of problems. And there's no need to switch tools, convert files, or rewrite applications.

With MATLAB and the Financial Toolbox, you can:

- Compute and analyze prices, yields, and sensitivities for options and other securities, and for portfolios of securities.
- Perform Securities Industry Association (SIA) compatible fixed-income pricing, yield, and sensitivity analysis.
- Analyze or manage portfolios.
- Design and evaluate hedging strategies.
- Identify, measure, and control risk.
- Analyze and compute cash flows, including rates of return and depreciation streams.
- Analyze and predict economic activity.
- Create structured financial instruments, including foreign-exchange instruments.

The Financial Derivatives Toolbox extends the Financial Toolbox in the areas of fixed income derivatives and of securities contingent upon interest rates. The toolbox provides components for analyzing individual financial derivative instruments and portfolios. Specifically, it provides the necessary functions for calculating prices and sensitivities, for hedging, and for visualizing results [16].

Trees

The Heath-Jarrow-Morton model works with a type of interest rate tree called a *bushy tree*. A bushy tree is a tree in which the number of branches increases exponentially relative to observation times; branches never recombine. The opposite of a bushy tree is a *recombining tree*, a tree in which branches recombine over time. From any given node, the node reached by taking the path up-down is the same node reached by taking the path down-up.

2. Peter Hoadley's options strategy analysis tools

On-line Options Pricing Analysis Calculators:

Black-Scholes pricing analysis – Examine graphically how changes in stock price, volatility, time to expiration and interest rate affect the option price, time value,

the derived "Greeks" (delta, gamma, theta, vega, rho) and the probability of the option closing in the money. Uses the Black-Scholes model.

Binomial tree graphical option calculator: Calculate option prices using either the Cox, Ross and Rubinstein binomial option pricing model, or the equal probabilities tree pricing model, and display the tree structure used in the calculation. Designed to calculate accurate prices and to illustrate tree-based pricing principles for both American & European options with discrete or continuous dividends.

Trinomial tree graphical option calculator: Calculate option prices using the trinomial tree pricing model, and display the tree structure used in the calculation. Designed to calculate accurate prices and to illustrate tree-based pricing principles for both American & European options with discrete or continuous dividends [11].

Barrier option calculator using trinomial lattice: Calculate barrier option prices, and hedge parameters, using a trinomial lattice, and display the tree structure used in the calculation. Key features include American & European option pricing, dividends as continuous yield or discrete payment, continuous or discrete monitoring of barrier, and two methods of computation enhancement. Analytic prices, where analytic formulas exist, are displayed for comparison.

Black-Scholes/Binomial convergence analysis: Display graphically the way in which options priced under the binomial model converge with Black-Scholes prices as the number of binomial steps increases. The impact of changes to the other pricing inputs can also be examined.

American & European option pricing comparison, & dividend impact analysis: Examine how dividends paid during the life of the option impact the price, and in particular the sensitivity of the option price to different ex-dividend dates. Also compare pricing for American & European options.

So, use the on-line calculators to look at option and underlying asset pricing sensitivities and pricing variable interrelationships; use the options strategy evaluation model to look at trading profitability.

On-line Stock Price Distribution & Probability Calculators:

Lognormal distribution analysis: Examine graphically the expected distribution of stock prices (assumed by the Black-Scholes pricing model), given a starting price and various assumptions for time, volatility and rate of return.

Stock price probability calculator: Compute the probability of a stock price exceeding, or falling between, upper and lower boundary prices. The results show both closing probabilities (i.e. at the end of a period) and the probabilities of the boundary prices ever being exceeded (i.e. the probability that they will exceed at any time during the period).

Spreadsheet & Development Tools:

Microsoft Excel Add-in: For use in Excel spreadsheets for the calculation of option prices, "Greeks", implied volatility (using the Black-Scholes and binomial models), probabilities and optimal early exercise points. The add-in provides functions which can be used directly in spreadsheet cells and which can be called from VBA modules/Macros.

Open Positions Manager: An Excel-based sample application for the maintenance of a portfolio of open options and underlying asset positions. The application can be used to perform sensitivity analyses (eg what will be my total exposure be if the market drops by 10%), to produce pay-off diagrams and optimal early exercise reports for open positions. Designed to be used as is, the application, which is not password protected, can be enhanced or tailored to meet individual user requirements.

Options Strategy Evaluation Model:

Options types: Equity, currency, index and futures.

Exercise styles: American and European.

Pricing models: Black-Scholes (European options), and the Cox, Ross, and Rubinstein binomial model (European and American options).

Payoff diagrams used to show strategy profitability: Profit at expiration plus profit at "time now" shown for any range of underlying asset prices. The range of asset prices can be shown as absolute \$ values, or as percentage change from underlying asset price at deal date.

Time decay: Time to expiration (i.e. the "time now" line) can be varied a day at a time, or shown for a specific date to show effects of time decay on your strategy. The model will automatically cycle through time to expiration if requested and the pay-off diagrams will show results in "animated" form.

"What if" scenario analysis: Two strategies, for the same or different underlying assets, can be compared on the same pay-off diagram. This enables, for example, the impact on a strategy of changing key variables (e.g. strike prices, volatility) to be easily compared with the unchanged version. The effects of time decay can be viewed simultaneously for both strategies.

Tables and graphs: Profitability for individual trades and net position can be viewed in tabular form as well as graphically.

Dividends on underlying assets can be either a continuous annual yield or up to four discrete payments. If discrete, an amount and ex-dividend date are specified for each dividend payment. Dividends are taken into account in option price calculations and dividends received (or paid) by holding (or shorting) the underlying asset are included in overall deal profitability calculations.

Hedge parameters ("Greeks") delta, gamma, vega, theta, rho, calculated for individual trades and net position. "Greeks" can be viewed graphically and in tabular form for any range of underlying asset prices both for individual trades and for net positions. As for pay-off diagrams, the effects of time decay on the "Greeks" can be viewed graphically and in tabular form.

Sensitivity analysis: Key option parameters, such as volatility, stock price, expiration date and strike prices, can be varied using slider bars, and the impact of these changed assumptions is instantly reflected on all graphs and tables. The changed parameters from the sensitivity analysis can then either be retained or discarded.

Implied volatility calculator: Implied volatility can be specified or calculated using the in-situ implied volatility calculator, for each individual option trade thereby taking account of volatility smiles, bid/ask spreads etc. The calculator correctly takes account of dividends.

Deal funding costs/revenues: The cost of carrying the underlying asset, interest earned on option premiums and dividends received etc. can optionally be included in overall deal profitability figures to enable more meaningful comparisons to be made of strategies with similar payoffs but quite different funding requirements.

Optimal early exercise thresholds: The underlying asset prices and dates at which early exercise could be optimal for American options are identified on a special report.

Standard strategies: Approximately 20 "standard" strategies (covered call writing, straddle, bull spread...) provided for illustrative purposes and to provide starting points for building your own strategies.

Build your own strategies: You are not limited to using the standard strategies and any strategy can be constructed, and saved, out of the basic building blocks of buying/selling puts and calls, and buying/selling the underlying asset.

Save strategies: An unlimited (for practical purposes) number of individual strategies each consisting of up to five option trades and two trades in the underlying asset can be saved for future use. Saved strategies can be retrieved by name amended and re-saved.

Re-use of underlying asset details: Same underlying asset details (dividends,

default volatility) can be used for multiple strategies thereby saving on data entry.

Simple to use: All navigation and selection done by clicking buttons, selecting from combo boxes etc.

Industrial strength: A serious tool used by professional traders and financial training organisations.

See Appendix 1 for Binomial Tree Option Calculator and see Appendix 2 for Trinomial Tree Option Calculator.

3. SmartPortfolio

SmartPortfolio is a visual risk management system. It performs interactive graphical analysis of the pricing and hedging of portfolios of derivative securities including interest rate derivatives (equity options, foreign currency options, futures options, bond options, caps, floors and swaptions). In order to calculate prices and hedge ratios the product employs a wide range of the computational methods and instruments, such as lattice methods, finite difference methods and Monte-Carlo simulation under a variety of assumptions about the stochastic dynamics of the underlying asset [12].

SmartPortfolio has been written in C++. The internal structure of the program relies on specially constructed financial C++ classes which provide great flexibility and simplify further development of the system.

Predefined Portfolios. SmartPortfolio contains a set of predefined portfolios of derivative securities and in addition users may define and save their own portfolios (see Appendix 3).

Advanced Plots. You can view the portfolio prices and hedge ratios as functions of any variable (e.g. asset price, volatility, risk free rate of interest, time to maturity etc.). You can also build up to five plots for different values of another parameter and display them in the same area. There is also an animation facility which allows you to view how the price or hedge ratio changes while you are approaching the maturity date (see Appendix 4).

Analytical Methods. SmartPortfolio provides such analytical solutions for portfolio pricing as:

Black-Scholes and all its variants for European style derivatives whose underlying (i.e. foreign exchange, futures, commodities and indices) pays constant dividend yield in a deterministic interest rate environment; Vasicek and Cox-Ingersoll-Ross models for interest rate term structure in a stochastic interest rate environment (see Appendix 5).

Numerical Methods. A range of lattice based numerical methods is presented to calculate American style derivatives and some European style derivatives for which exact solutions are not available. These methods include binomial trees as well as explicit, implicit and Crank-Nicholson finite difference schemes (see Appendix 6).

Simulation Tool. A Monte-Carlo simulation tool is provided for a variety of stochastic processes for the underlying asset value (Brownian motion, jump diffusion processes, stochastic volatility processes, coloured noise, binomial processes). Simulations can be performed any number of times and a Monte-Carlo value for the portfolio is obtained. Furthermore the evolution of this value can be viewed graphically as the number of simulations increases (see Appendix 7).

Term Structure. The construction of the term structure of interest rates from a set of observed market instruments using cubic B-splines is implemented. The term

structure can be viewed as market yields, zero-coupon rates or forward rates at different compounding frequencies (see Appendix 8).

Calibration The product also features the calibration of interest rate derivative models to the currently observed term structure of interest rates and derivative prices (see Appendix 9).

4. The NumeriX Toolkit

The NumeriX Toolkit is a suite of innovative development tools that provide accuracy, speed, flexibility and ease of use for all aspects of options pricing and risk management, including building instrument or product code and new models. A collection of object-oriented modules accessed through an elegant interface, it includes all of the core mathematical and computational functions required for complex derivatives pricing and sensitivity analysis [13].

The NumeriX Toolkit allows you to perform the following:

- Build your own in-house pricing or risk management application for any asset class.
- Extend the NumeriX applications to include your proprietary analytics.
- Build new financial models and improve the performance of existing ones.
- Easily integrate all of the above into proprietary and third party systems.
- Provide a common development framework.

Through an elegant API available in C, C++, and Visual Basic, the NumeriX Toolkit provides immediate access to a broad collection of financial, mathematical, and computational functions and objects. Designed intuitively for rapid implementation and ease-of-use, models, new instruments and risk scenarios can be developed in a fraction of the time needed for traditional methods.

The NumeriX Toolkit contains robust implementations of industry standard mathematical and financial algorithms. It includes: single factor trinomial trees; a general-purpose simulation module for performing multi-dimensional integration, pricing path-dependent options, and calculating Value-at-Risk (VaR); and utility functions and classes for all development needs.

The NumeriX Toolkit includes convenient utilities such as:

- Exception and error handling.
- Curve algebra.
- Template based vectors and matrices.
- Correlation matrix conditioning.
- Single and multi-dimensional root-finding and optimization tools.

A modular code design enables separation of instrument and model analytics, resulting in readable, flexible, and easy-to-maintain code. Costs traditionally associated with development and code modification are greatly reduced. Switching between models often requires changing as little as one line of code, permitting pricing comparisons and assessment of model risk. Typically, building new instrument code using reduces development time by up to 80%.

5. Opti-Template Analysis & Pricing

Now you can use the same closed-form pricing equations as the large investment houses and the Chicago Mercantile Exchange (CME). J&E Research, Inc. has built Excel functions that use the Quadratic Approximation of American Options developed by Barone-Adesi and Whaley. This is the most accurate closed-form analytic pricing model developed to date.

The workbook makes extensive use of Excel 97's Analysis ToolPak and built in data modeling features. The formulas are easy to access and nothing has been compiled into a DLL. This allows easy integration with existing Excel systems or future systems you build. To enhance user friendliness standard notation has been used instead of cell addresses whenever possible. (For MS Excel 97 or 2000)

Opti-Template enables the production of pricing matrices, risk\return profiles and implied volatility analysis for either individual or portfolios of options. An example spreadsheet is supplied free which enables the user to price options and manage risk "straight out of the box" without any programming or "spreadsheet" work.

Featured Highlights

- Separate analytic models for stocks, indices, currencies and options.
- Option pricing models used include: Barone-Adesi and Whaley (1987).
- Time decay analysis (as a percent of price) for any user defined period.
- Risk statistics including Delta, Gamma, Rho, Theta and Vega.
- Automatic Treasury Bill Bid/Ask yield conversion.
- All pricing and analysis adjusted for dividends.
- Calculations made for annualized historical volatility.
- All analysis formatted in strike series using user defined price increments.
- Extremely easy to use yet analytically very robust.

For any user defined strike series the following statistics are generated for options on stocks, indices, currencies and futures. All statistics are adjusted for any level of dividend payment or yield.[14]

Excel Option Analysis Add-in. Opti-Calc is the latest version of our option pricing and analysis system for Excel. It calculates prices, risk parameters and implied volatilities using the Black-Scholes, Garman-Kolhagen and Cox-Rubinstein (binomial) models. We have also incorporated the latest option models, such as, the Barone-Adesi and Whaley quadratic approximation and the Bjerksund-Stensland approximation. Opti-Calc prices European and American style options on bonds, commodities, currencies, futures and stocks. It also calculates sensitivities, such as Delta, Gamma, Kappa (Vega), Rho and Theta.

Opti-Calc enables the production of pricing matrices, risk\return profiles and implied volatility analysis for either individual or portfolios of options. An example spreadsheet is supplied free which enables the user to price options and manage risk "straight out of the box" without any programming or "spreadsheet" work.

Who is the add-in designed for? Anyone involved in the financial markets, risk analysis, valuation or investment strategy. Typical users include Institutional Investors, Traders, Financial Analysts, Treasury Analysts, Quantitative Analysts and Financial Consultants (for MS Excel 97 or 2000).

The version with a template worksheet demonstrates each of the functions, allowing the user to begin working with our add-in immediately. The template provides a starting point for the user to setup his or her own spreadsheet in exactly the manner desired. For example, a user can evaluate several different options on the same screen at once, the same option with different strike prices, or run a portfolio of options aggregating risk measures. The add-in also works well with any Excel compliant live data feed (DDE).

6. Variance-covariance VaR with VaRworks

Cash Flow Mapping

The purpose of cash flow mapping is to find the "best replicate of a financial instrument for the purpose of measuring the instrument's risk within a portfolio."

A cash flow map is the representation of a financial instrument (options) as a stream of one or more zero-coupon instruments marked to market at current market rates and prices. Prior to calculating analytic VaR, financial instruments must be decomposed into their component cash flows (zero coupon instruments) and allocated to a pre-determined set of vertices for which we can obtain volatilities, correlations, and other statistics on a regular basis. See appendix 10 for Cash Flow Map of a Sample Portfolio in VaRworks.

There are three types of inputs to calculate VaR: Market data, Portfolio Data, and User's choices

A. Market data: correlations, volatilities, prices, and interest rates

Volatility data. Volatility files define vertices onto which cash flows are mapped. Each record specifies a vertex series name, price volatility, exchange rate or yield (where applicable), and other statistics. You can create your own volatility files with MakeVC or download publicly available ones. The sample volatility file, `dvmmddy.rm3` (where `mmddy` is some date), is a RiskMetrics file containing daily volatilities. See appendix 11 for example of a Volatility File.

Correlation data. Correlation files contain correlations for the vertices defined in a corresponding volatility file. Each record specifies two vertices and their correlation. You may create your own correlation files with MakeVC or download publicly available ones. The sample correlation file, `dcmmddy.rm3` (where `mmddy` is some date), is a RiskMetrics file containing daily correlations. See appendix 12 for example of a Correlation File.

Portfolio Data. One of the obvious inputs in the VaR calculation is the specification of your portfolio. Portfolio consists of text specifying a portfolio file may include directory and drive. The *portfolio file* describes the financial instruments for which VaR is to be calculated. Each record in a portfolio file specifies either:

- the terms of a single trade, or
- a path "pointing" to another file containing trades.

Horizon (days). In VaRworks, "horizon" is a number specifying the number of business days of the VaR horizon. Express the horizon in number of days (e.g. 1 month is expressed as 30 days) even if you are using monthly (or longer) volatility and correlation datasets VaRs are scaled using the square root of the horizon. The resulting VaR is the expected change in the portfolio's value under adverse circumstances in this time interval. For example, enter 1 (one) for a one-day horizon.

Choice of horizon. The horizon can be a function either of the position or the investor. In the former case, the longer horizon for estimating risk can be the result of the time it takes for the position to be liquidated or neutralized. In less liquid markets, it can take up to a week or longer to significantly modify the market risk profile of a portfolio. In the latter case, it is the investor who defines the horizon. Risk is measured over the period until investment objectives are reviewed and reassessed.

When choosing a horizon, consider:

- Unwind period – how long, on average, does it take to reverse a market position or individual trade?
- Attention period – how often, on average, do you re-examine your portfolio and its mark-to-market or hedging trades?

- Accounting period – how long until the next financial reporting must be done?
- Common choices of horizon.
- One day – recommended by the J. P. Morgan RiskMetrics specification (termed DEaR, for daily earnings at risk). It is thought to be appropriate for banks, clearing houses, traders, etc., because of their rapid turnover, short unwind periods.
- Ten days – recommended by the Basle Committee on Banking Supervision. It is thought to be appropriate to banks for capital charges.
- 25 days – a RiskMetrics alternative. It is thought to be appropriate for funds and triple-A bank derivatives subsidiaries.
- 65 days – a calendar quarter. It is thought to be appropriate for corporations.

Confidence. In VaRworks, “confidence” is a number between 0.5 and 1, exclusive, specifying the size of the one-tailed VaR confidence level.

The probability of incurring losses larger than our VaR will be $(1-X)\%$, being X the confidence level. For example, for a 95% confidence level (5% one-tail level), the probability that the portfolio’s losses will exceed the VaR number will be 5%.

Confidence level selection

Common choices for a confidence level are 95% (RiskMetrics) and 99% (Basle).

- With a 95% level and a one-day horizon, losses in excess of the VaR will occur about once in every twenty days.
- With a 99% level and a one-day horizon, losses in excess of the VaR will occur about once in every one hundred days.

If the probability of loss is normally distributed, the 5% one-tail level is 1.645 standard deviations from the mean; the 1% one-tail level is about 2.33 standard deviations [15].

7. @RISK

@RISK is the Risk Analysis and Simulation add-in for Microsoft Excel® or Lotus® 1–2–3. As an add-in, @RISK becomes seamlessly integrated – via a new toolbar and functions – with your spreadsheet, adding Risk Analysis to your existing models. If you can use a spreadsheet, you can use @RISK!

@RISK uses a technique known as Monte Carlo simulation to allow you to take all possible outcomes into account. Simply replace uncertain values in your spreadsheet with @RISK functions which represent a range of possible values – modeling stock and option prices. Select bottom-line cells, like Total Profits, as outputs, and start a simulation. @RISK recalculates your spreadsheet hundreds or even thousands of times, each time selecting random numbers from the @RISK functions you entered. The result: distributions of possible outcomes and the probabilities of getting those results! This not only tells you what could happen in a given situation, but how likely it is that it will happen. With @RISK, you can answer questions like “What are the chances of getting a negative result?” or “What is the probability of earning profits over \$500,000?” [17].

One of the strengths of Monte Carlo simulation is that it produces enough data to create accurate graphs. Histograms, cumulative curves, area and line graphs are all available in @RISK 4.0.

@RISK 4.0 lets you write your own custom applications in Excel that can perform virtually any @RISK function. Harness the power of @RISK’s Monte Carlo simulation engine for your company’s specific needs. Utilize @RISK’s extensive reporting options, Sensitivity analysis, Scenario analysis, distribution fitting, and more, all in your own custom Excel program! Example files are included demonstrating how to use these commands. Plus, you can run macros before, during, or after a simulation run. @RISK alone uses Monte Carlo simulation to account for uncertainty in models

and view the probabilities of various outcomes occurring. But Monte Carlo simulation cannot deal with input or decision variables whose values you can control. It views all possible outcomes at a single state of those controllable variables.

III. Problems connected with the use of software programs

A combination of powerful but inexpensive personal computers, the availability of financial information on the Internet, and online discount brokers has made it very attractive for individuals to do their own analysis and investing. Using the computer and the Internet, individuals may buy, sell, and transfer between many mutual funds and buy or sell stocks, bonds, options, etc. on line, through a large number of brokers or funds companies. As a result, there are now a large number of tools to help individual investors make better decisions concerning their investments. These include Internet sites as well as individual programs that can be purchased. Software programs range from those that provide basic financial advice, to portfolio management, to those that provide detailed information and aids in doing analysis of individual securities [3].

Options exchanges, brokers, and many independent sites provide access to quotes, analysis, and other tools for options investors. At the CBOE site, for example, investors can access a wealth of free information at its Trader's Tools section, including delayed quotes, charts, news, market data, and free company research from Zacks Investment Research. CBOE also provides an options calculator that allows investors work out the cost of a particular option. Other calculators are available on many sites, including OptionsSource.com.

Investors trading over the Internet or online, who are used to instant access to their accounts and near instantaneous executions of their trades, especially need to understand how they can protect themselves in fast-moving markets. You can limit your losses in fast-moving markets if you know what you are buying and the risks of your investment; and know how trading changes during fast markets and take additional steps to guard against the typical problems investors face in these markets.

Online trading is quick and easy, online investing takes time. With a click of mouse, you can buy and sell stocks from more than 100 online brokers offering executions as low as \$5 per transaction. Although online trading and many software programs save investors time and money, it does not take the homework out of making investment decisions. You may be able to make a trade in a nanosecond, but making wise investment decisions takes time. Before you trade, know why you are buying or selling, and the risk of your investment.

Set your price limits on fast-moving stocks: market orders vs. limit orders. To avoid buying or selling a stock at a price higher or lower than you wanted, you need to place a limit order rather than a market order. A limit order is an order to buy or sell a security at a specific price. A buy limit order can only be executed at the limit price or lower, and a sell limit order can only be executed at the limit price or higher. When you place a market order, you can't control the price at which your order will be filled. Remember that your limit order may never be executed because the market price may quickly surpass your limit before your order can be filled. But using a limit order you also protect yourself from buying the stock at a too high price.

Online trading and software programs are not always instantaneous. Investors may find that technological "choke points" can slow or prevent their orders from reaching an online firm. For example, problems can occur where:

- an investor's modem, computer, or Internet Service Provider is slow or faulty;
- a broker-dealer has inadequate hardware or its Internet Service Provider is slow or delayed;
- traffic in the Internet is heavy, slowing down overall usage.

A capacity problem or limitation at any of these choke points can cause a delay or failure in an investor's attempt to access an online firm's automated trading system.

Know your options for placing a trade if you are unable to access your account online. Most online trading firms and software programs offer alternatives for placing trades. These alternatives may include touch-tone telephone trades, faxing your order, or doing it the low-tech way talking to a broker over the phone. Make sure you know whether using these different options may increase your costs. And remember, if you experience delays getting online, you may experience similar delays when you turn to one of these alternatives.[8]

Other problems may be the following:

- If you place an order, don't assume it didn't go through.
- If you cancel an order, make sure the cancellation worked before placing another trade.
- If you purchase a security in a cash account, you must pay for it before you can sell it.
- If you trade on margin, your broker can sell your securities without giving you a margin call.
- No regulations require a trade to be executed within a certain time.

IV. Conclusion

The software programs used for solving the financial problems have many advantages. These programs are a highly portable and integrable Internet based portfolio management systems. They help major corporations, government entities, and smaller companies to realize their automation goals. We are recognized nationally for our expertise in web-integrated database systems, client server and relational database technology. We pride ourselves on the value that we have added to information systems at dozens of firms throughout the United States. These clients have come to rely on our expertise and commitment to their organizations to help solve their business automation problems.

The authors of these programs said "Several years ago, we started to research stocks intensely to find out what makes the market tick. We started with popular investment magazines, web sites, books, and financial news programs. We learned a lot of good information from these data sources, but we also felt confused - every book, magazine, and Internet site recommended a different investing style and a different set of stock picks. We were really seeking a more impartial way of picking stocks, outside of the 'hype' of the popular press.

We next started reading academic accounting journals and immersed in learning the latest technology on stock valuation. We were really excited at the potential of these techniques so we joined forces with some fellow scientists and engineers to write a program which would fetch all of the necessary data for a given stock from various Internet sites and crunch out the valuation formulas".

The purpose of the present article does not consist in the representation of all software programs that are used in the process of investing in derivatives but to acquaint the readers with that number only of such programs, that are most frequently applied in practice. In this respect the included bibliographical reference does not encompass all available literature on this issue.

Appendix

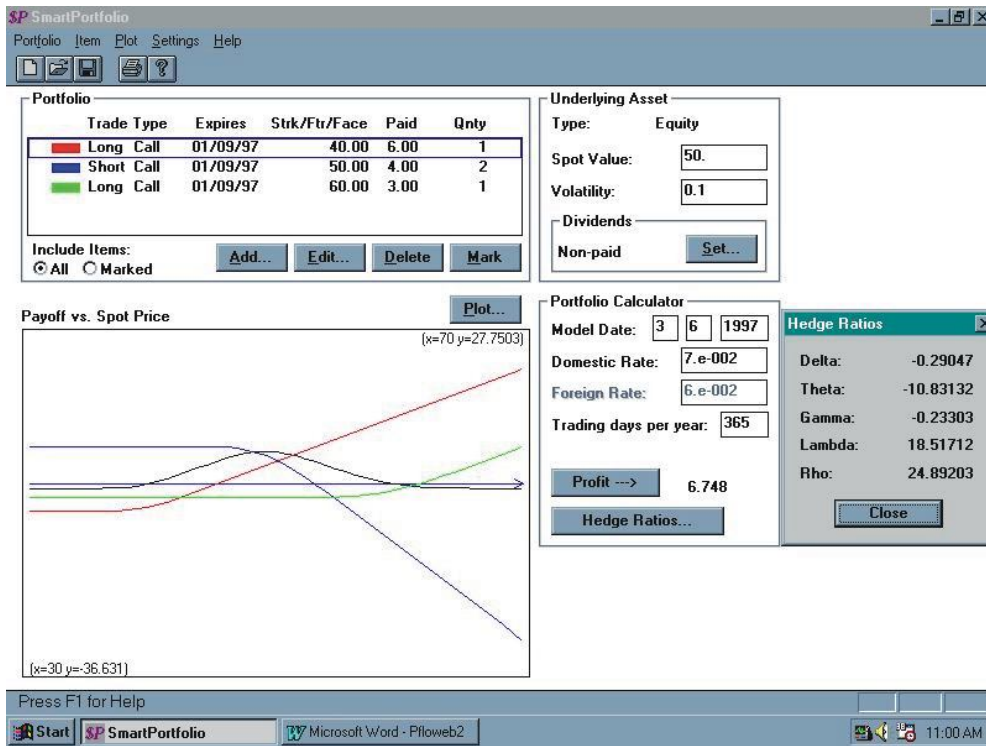
Appendix 1

Values at each node:							
Above line: underlying asset price							
Below line: option price							
Bold: Amended price from early exercise							
						33.706	35.104
						4.732	6.104
				32.364			32.370
				3.417			3.370
			33.573		31.081		
			4.573		2.107		
		32.334		29.843			29.848
		3.360		1.264			0.040
	31.143		31.153		28.660		
	2.242		2.153		0.424		
30.000		30.010		27.519			27.524
1.4148		1.128		0.212			0.000
	28.912		28.921		26.428		
	0.590		0.106		0.000		
		27.867		25.375			25.380
		0.053		0.000			0.000
			26.863		24.369		
			0.000		0.000		
				23.399			23.403
				0.000			0.000
					22.471		
					0.000		
							21.580
							0.000
Days from time now:							
	0.00	6.67	13.33	20.00	26.67	33.33	40.00

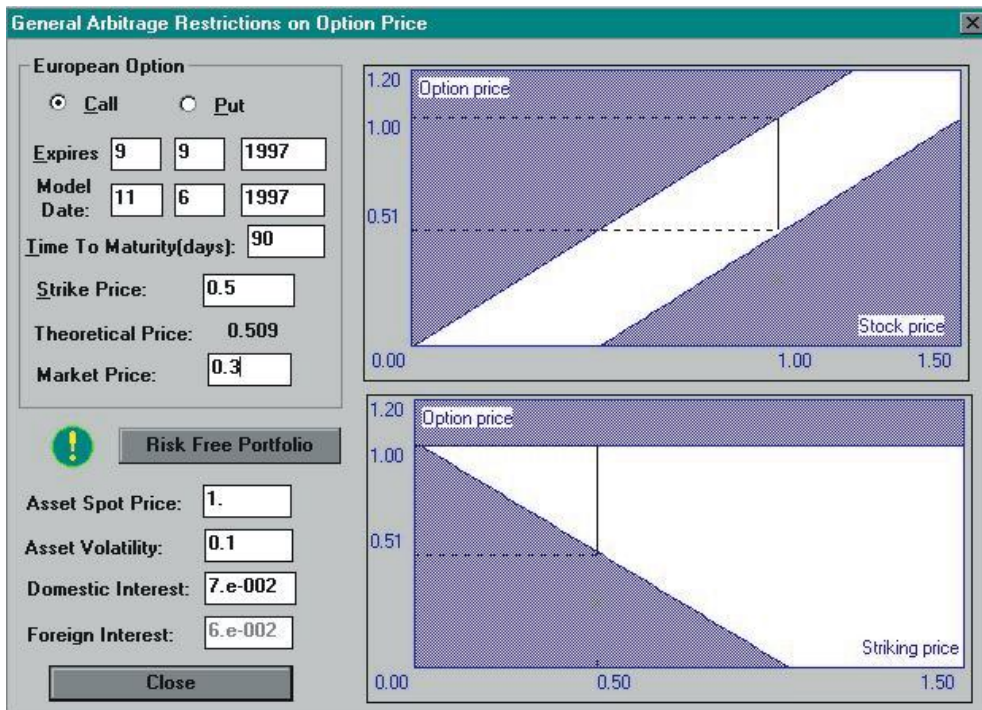
Appendix 2

Values at each node:							
Above line: underlying asset price							
Below line: option price							
Bold: Amended price from Early Exercise							
							38.804
							8.804
						36.542	36.542
						7.568	7.642
				34.600		34.600	34.600
				5.653		5.628	5.600
			35.170		32.872	32.872	32.872
			6.170		3.725	3.598	3.672
		33.347		33.349		30.851	30.851
		4.374		4.349		1.996	1.878
			31.626		31.628		29.132
			2.714		2.654		2.630
				31.630		29.132	29.132
				0.743		0.530	0.132
30.00		30.002		30.005		30.007	
1.4467		1.319		1.172		1.007	
	29.469		29.472		29.474		27.509
	0.433		0.274		0.042		0.149
				25.876		25.876	25.876
				0.008		0.000	0.000
			27.024		27.026		24.528
			0.011		0.002		0.000
				24.528		24.528	24.528
				0.000		0.000	0.000
				25.660		23.161	23.161
				0.000		0.000	0.000
					21.871	21.871	21.871
					0.000	0.000	0.000
						20.652	20.652
						0.000	0.000
							19.501
							0.000
Days from time now:							
	0.00	6.67	13.33	20.00	26.67	33.33	40.00

Appendix 3



Appendix 4



Appendix 5

Bond

Comments:

Position: Long Short

Face Value: Paid Price:

Maturity: Quantity:

Dividend Payments:

29/12/94	5.000
29/06/95	5.000
29/12/95	5.000

Add Delete

Coupon Rate: 10.000 % p.a.
\$5.00 are paid every 6 months

Color:

Model: Vasicek

<<Calculator

Underlying Process

Interest Rate

Initial Spot Rate:

Initial Term Structure

Process Volatility:

Implied Volatility -->

Model Date:

Days to Maturity:

Years to maturity:

Trading days per year:

Model Details...

Model Price -->

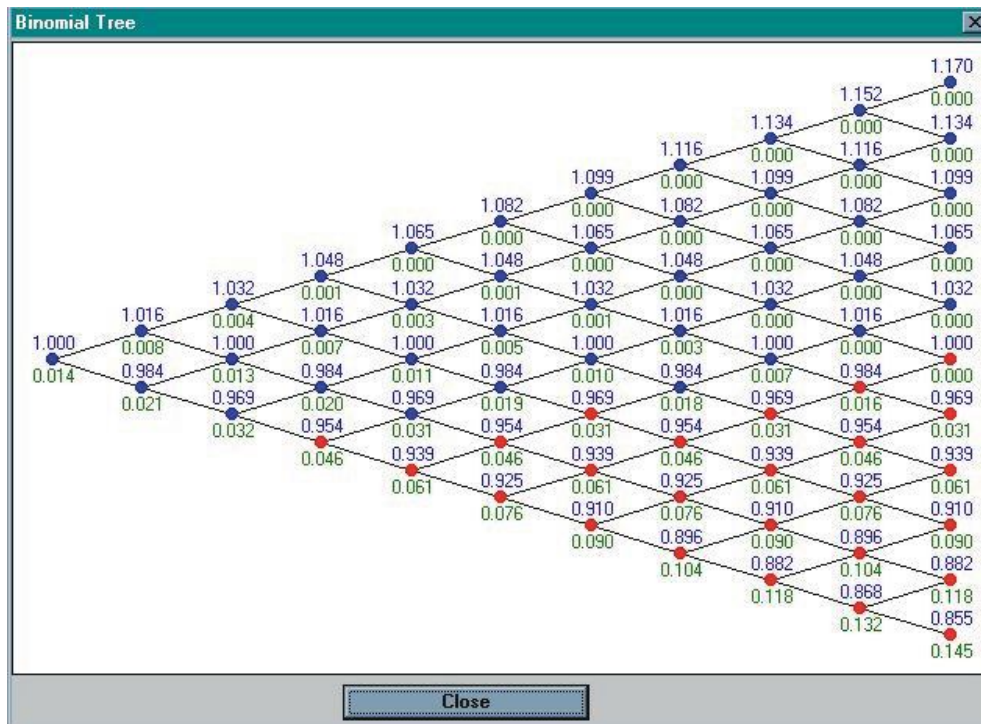
Quotes:

Exchange Price from Quotation:
 Quotation from Exchange Price:

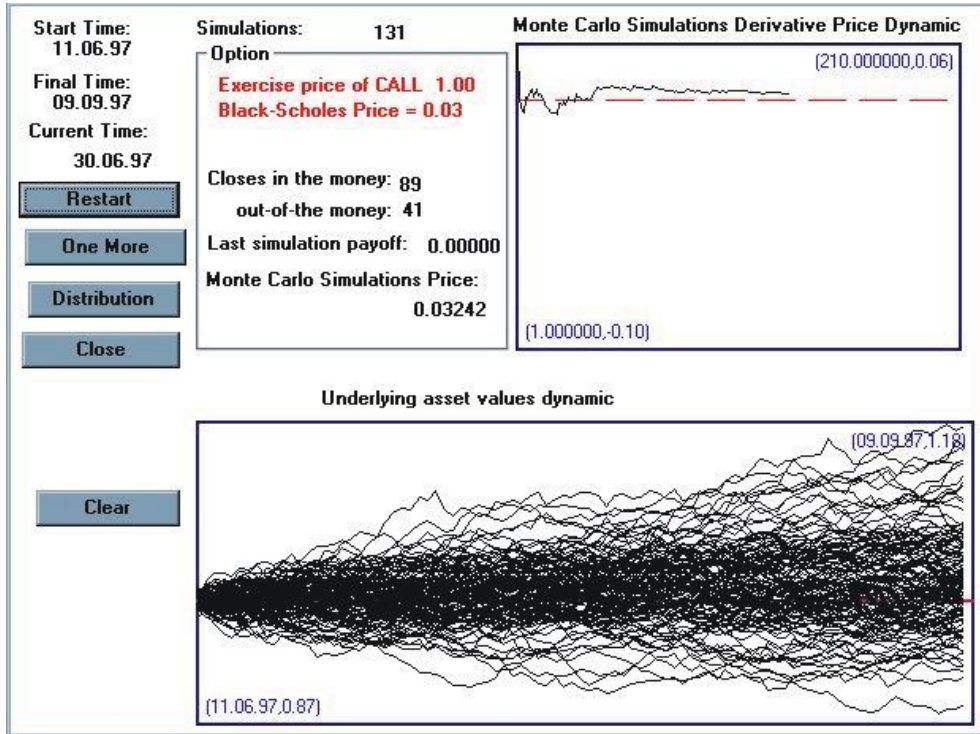
Exchange price:

Quotation -->

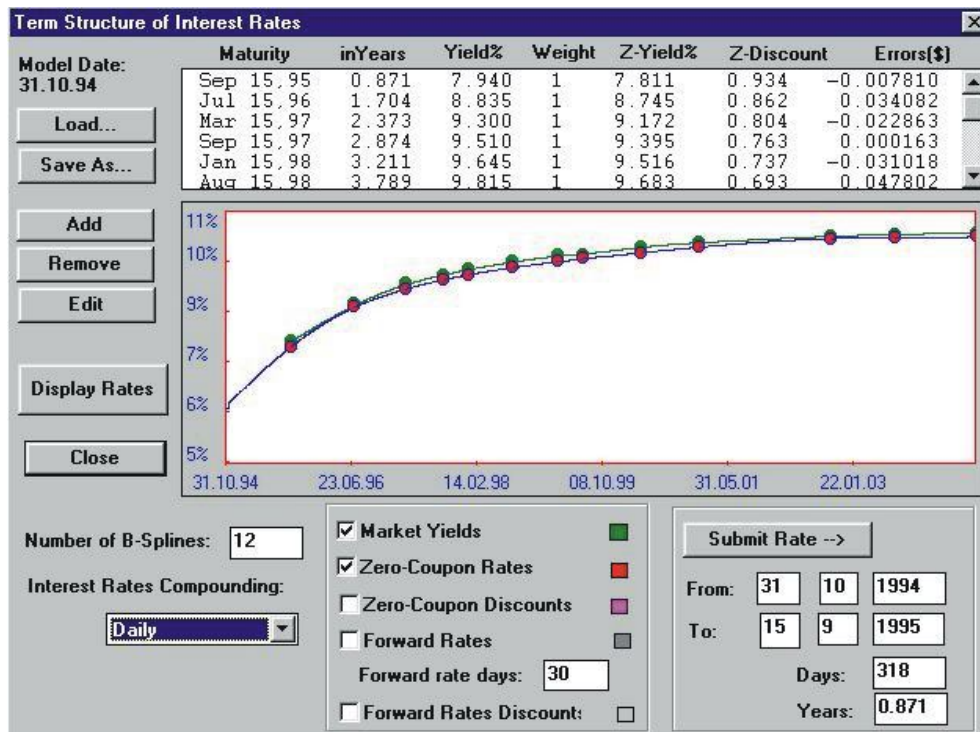
Appendix 6



Appendix 7



Appendix 8



Vasicek Model

$$dr = k(\theta - r) dt + \sigma dz$$

Speed of Reversion (k):

Mean of Reversion (Theta):

Short Rate Volatility (Sigma) :

Maturities	Errors (\$)
Sep 15.95	0.000615
Jul 15.96	-0.000599
Mar 15.97	-0.000756
Sep 15.97	-0.000443
Jan 15.98	-0.000136
Aug 15.98	0.000533
Mar 15.99	0.001115
Jul 15.99	0.001263
Apr 15.00	0.000765

Model fitting to term structure

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- www.jereseach.com
- www.fea.com
- www.mathworks.com
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- www.monis.com
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Програми и проблеми при инвестиране с опции

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(Резюме)

Финансовият свят днес е много сложен. Безспорен факт е, че дериватните ценни книжа са съществена и неразделна част от програмите за обучение по управление на финансите. Това е и основната причина, поради която опциите се използват като основни инструменти за инвестиране от инвестиционни и пенсионни фондове, дарителски фондове, от други институционални и индивидуални инвеститори.

Комбинацията от мощни и евтини персонални компютри, възможността за получаване и обмен на финансова информация по Интернет, както и инвестирането и даването на инвестиционни съвети от брокери **on-line** правят използването на различни софтуерни програми и продукти за инвестиране много атрактивни за инвеститорите и те все по-често ги използват, за да анализират и вземат различни инвестиционни решения. По-известните софтуерни програми и продукти, разработени с цел решаването на различни финансови и инвестиционни решения, които са разгледани в настоящата статия са: **MATLAB®**, **Peter Hoadley's Options Strategy Analysis Tools**, **SmartPortfolio**, **The NumeriX Toolkit**, **Opti-Template Analysis & Pricing**, **Variance-covariance VaR with VaRworks™**, **@RISK**.