# Model validation task.

## Introduction.

Assume that you work for a company that trades [European Equity Options](http://en.wikipedia.org/wiki/Option_style). Assume that your company’s IT system uses the Black-Scholes formula for pricing these options and the dividends are modeled as a continuous yield.

Let’s denote by *S* the today’s equity spot price, *r* – the interest rate, *q* – dividend yield, *K* – option strike, *T* – time to maturity (in years) and *σ* – the option volatility. In the Black-Scholes model a Call option price is calculated as

, where

,

,

,

*r* = 0.03

*σ* = 0.2

*q* = 0.01

*N*(.) - standard (0,1)-Gaussian cumulative distribution function.

A Put option price is calculated similarly:

You will be asked to do two tasks similar to those performed during validation of a model used for calculating [Value-at-Risk](http://en.wikipedia.org/wiki/Value_at_risk) (VaR) arising from moves in equity spot prices (will be denoted by EQVAR below). EQVAR is defined as the amount of cash such that the change of a portfolio’s price due to equity spot price moves from one date to the next will be above it with probability 99%. In other words, EQVAR is the 1% [percentile](https://en.wikipedia.org/wiki/Percentile) of portfolio price changes arising from equity price changes.

EQVAR calculation requires a model, please use the one described below. The model uses the [historical simulation](http://en.wikipedia.org/wiki/Historical_simulation_%28finance%29) approach. We assume that t=0 corresponds to "today", t=1 corresponds to "tomorrow" and negative values of t correspond to values in the past. Also, by N we denote the number of equity underlyings the portfolio price depends on.

The model proceeds as follows:

|  |
| --- |
| 1. For every equity underlying *i* obtain 3 years of historical prices. Use this data to calculate 3 years (t=-750..-1, i.e. 750 business days) of historical equity returns . 2. For every underlying *i* and for each historical date *t* apply the corresponding return to today’s price to obtain a hypothetical tomorrow's equity price . Thus we obtain 750 sets of hypothetical tomorrow's underlying prices. Calculate the portfolio price with these new, hypothetical equity prices. Thus way we obtain ~750 portfolio price changes   , where P() is the portfolio price.   1. We assume that PnLt are samples of a random variable distribution. The VaR is calculated as the 1% interpolated percentile of those 750 samples. |

## The task

You are provided time-series of 3 equity underlyings for this task: Bank of America, Microsoft, Apple.

1. The Historical Simulation approach relies on the assumption that the distribution of returns is stationary, i.e. does not change very fast. Run [two-sample Kolmogorov-Smirnov test](https://en.wikipedia.org/wiki/Kolmogorov–Smirnov_test) to assess stationary of returns.
2. As a high-level check of the methodology you are required to run backtesting: see how many times the actual PnL would be less than VaR during the last year (i.e. the drop in portfolio price was more significant than VaR, for example VaR = -1250 USD, Actual PnL = -1400 USD). For this task assume that all pricing parameters except the equity spot price are fixed.

The portfolio of the company is made up of the following holdings:

* 100 Call options on Bank of America with maturity = 2 March 2015 and K=16
* 30 Put options on Microsoft with maturity = 2 March 2015 and K=40
* 3 Call options on Apple with maturity = 2 March 2015 and K=600

The company’s portfolio has been without changes during the past year.

As result of this task you should produce an Excel (or LibreOffice) file where you do the analysis and a text document describing your thinking and conclusions (in English). If you choose, you may use another system (not Excel), the only requirement is that you must provide all the files where the testing was performed. In other words we would like to be able to reproduce your test results.

Calculation flow of backtesting is available below:

make:

{

make:

{

}

If Then

}