How to code a Cholesky Decomposition in VBA

Introduction

Cholesky decomposition is the process of factoring a positive definite matrix $A$ into $A = LL^H$ where $L$ is a lower triangular matrix having positive values on its diagonal, and $L^H$ is its transpose. $L$ from the equation above is unique.

Cholesky decomposition is used to find the solution to an equation $Ax = b$ by breaking down $A$ to $LL^H$. The solution to $Ax = b$ can then be found by solving $Ly = b$, where $y = L^Hx$, which is quickly done as $L$ is a lower triangular matrix.

Cholesky decomposition also has an important application in multivariate Monte Carlo simulation as used in VaR modelling and in copula models. It enables the generation of correlated random variables from a given correlation matrix.

This enables the correlation properties of a portfolio of assets to be reflected in the Monte Carlo simulation as follows:

$$LL^H = \text{correlation matrix}$$

$$Z(i) = L \ast \text{epsilon}(i)$$

Where $Z(i)$ is the vector of correlated random variables, $L$ is the lower triangular matrix produced by the Cholesky Decomposition of the correlation matrix, and epsilon(i) is the vector of uncorrelated random variables sampled using a random number generator.

The $Z(i)$'s can then be used in an equation such as this for price paths of a portfolio of correlated, lognormally distributed assets: $S(i, t + \Delta t) = S(i, t) \ast \exp \left( (r-0.5\sigma(i)^2) \Delta t + \sigma(i) \sqrt{\Delta t} \ast Z(i) \right)$

This will be applied in the next document, which is a Monte Carlo simulation of VaR.

Cholesky Decomposition Excel VBA Code

```vba
Function cholesky(matrix As Range)
    Dim i As Integer, j As Integer, k As Integer, N As Integer
    Dim a() As Double 'the original matrix
    Dim element As Double
    Dim L_Lower() As Double
    N = matrix.Columns.Count
    ReDim a(1 To N, 1 To N)
    ReDim L_Lower(1 To N, 1 To N)
    For i = 1 To N
        For j = 1 To N
            a(i, j) = matrix(i, j).Value
            L_Lower(i, j) = 0
        Next j
    Next i
    For i = 1 To N
        For j = 1 To N
            element = a(i, j)
            For k = 1 To i - 1
                element = element - L_Lower(i, k) * L_Lower(j, k)
            Next k
            If i = j Then
                L_Lower(i, i) = Sqr(element)
            ElseIf i < j Then
                L_Lower(j, i) = element / L_Lower(i, i)
            End If
        Next j
    Next i
    cholesky_new = L_Lower
End Function
```
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