



# VaR Introduction I: Parametric VaR

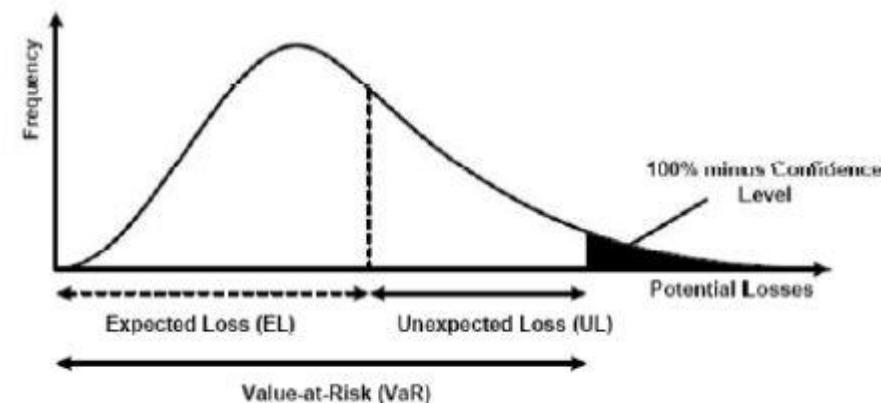
## Summary

- ◆ VaR Definition
- ◆ VaR Roles
- ◆ VaR Pros and Cons
- ◆ VaR Approaches
- ◆ Parametric VaR
- ◆ Parametric VaR Methodology
- ◆ Parametric VaR Implementation
- ◆ VaR Scaling
- ◆ VaR Backtest

## Parametric VaR

### Value at Risk (VaR) Definition

- ◆ The maximum likely loss on a portfolio for a given probability defined as  $x\%$  confidence level over  $N$  days
- ◆  $\Pr(\text{Loss} > \text{VaR}(x\%)) < 1 - x\%$



# Parametric VaR

## VaR Roles

- ◆ Risk measurement
- ◆ Risk management
- ◆ Risk control
- ◆ Financial reporting
- ◆ Regulatory and economic capital

# Parametric VaR

## VaR Pros & Cons

- ◆ Pros
  - ◆ Regulatory measurement for market risk
  - ◆ Objective assessment
  - ◆ Intuition and clear interpretation
  - ◆ Consistent and flexible measurement
- ◆ Cons
  - ◆ Doesn't measure risk beyond the confidence level: tail risk
  - ◆ Non sub-additive

# Parametric VaR

## Three VaR Approaches

- ◆ Parametric VaR
- ◆ Historical VaR
- ◆ Monte Carlo VaR

The presentation focuses on parametric VaR.

# Parametric VaR

## Parametric VaR

- ◆ Assumption

- Asset returns follow normal distribution

- ◆ Pros

- Fast and simple calculation

- Intuitive

- ◆ Cons

- Poor accuracy for non-linear products

- Second order approximation

- Hard to incorporate stress test

## Parametric VaR

### Parametric VaR Methodology

- ◆ Assuming an asset return/valueChange follows normal distribution, the quantile of 99% confidence level is  $2.326\sigma$  where  $\sigma$  is standard derivation
- ◆ If absolute return  $X_1 - X_0$  is normally distributed, the 99% worse change of X is  $X_1 - X_0 = 2.326\sigma$
- ◆ The VaR is given by  $VaR = \frac{\partial F}{\partial X} \Delta X = \frac{\partial F}{\partial X} \times 2.326 \times \sigma$  where  $\frac{\partial F}{\partial X}$  is the delta
- ◆ Similarly for a relative return  $\frac{X_1 - X_0}{X_0}$ , the VaR can be expressed as

$$VaR = \frac{\partial F}{\partial X} \Delta X = \frac{\partial F}{\partial X} (X_1 - X_0) = \frac{\partial F}{\partial X} \times X_0 \times 2.326 \sigma$$

## Parametric VaR

### Parametric VaR Implementation

- ◆ For each asset/instrument/riskFactor, calibrate volatility  $\sigma_i$  based on daily return
- ◆ For each risk factor pair, calibrate correlation  $\rho_{ij}$
- ◆ Calculate the variance of a portfolio value change

$$V_p^2 = [\Delta(P_1)\sigma_1 \quad \dots \quad \Delta(P_n)\sigma_n] \begin{bmatrix} \rho_{11} & \dots & \rho_{1n} \\ \vdots & & \vdots \\ \rho_{n1} & \dots & \rho_{nn} \end{bmatrix} \begin{bmatrix} \Delta(P_1)\sigma_1 \\ \vdots \\ \Delta(P_n)\sigma_n \end{bmatrix}$$

- ◆ The portfolio VaR is  $2.326\sqrt{V_p^2}$

## Parametric VaR

### VaR Scaling

- ◆ Normally firms compute 1-day 99% VaR
- ◆ Regulators require 10-day 99% VaR
- ◆ Under IID assumption,  $10\text{-day VaR} = \sqrt{10} * VaR_{1\text{-day}}$

## VaR Backtest

- ◆ The only way to verify a VaR system is to backtest
- ◆ At a certain day, compute hypothetical P&L. If (hypothetical P&L > VaR) → breach, otherwise, ok
- ◆ Hypothetic P&L is computed by holding valuation date and portfolio unchanged
- ◆ In one year period,
  - ◆ If number of breaches is 0-4, the VaR system is in Green zone
  - ◆ If number of breaches is 5-9, the VaR system is in Yellow zone
  - ◆ If number of breaches is 10 or more, the VaR system is in Red zone

# Thanks!



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<https://finpricing.com/lib/EqVariance.html>