Morgan Stanley

Value at Risk – Risk Management in Practice

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Overview

- **Value at Risk: the Wake of the Beast**
- **Stop-loss Limits**
- **Value at Risk: What is VaR?**
- **Value at Risk: Advantages**
- **Value at Risk (VaR) calculation: Numerical Methods**
- **Value at Risk (VaR) calculation: VaR Methods**
- **Backtesting: the Proof of the Pudding**
- **Variations on VaR**

Value at Risk

The Wake of the Beast

- Response to the financial crises of 1990s:
  - 1989 Japanese stock price bubble. Nikkei Index went from 39000 to 17000. $2.7 trillion capital was lost.
  - 1997 Asian turmoil. ¾ of capitalization was lost (measured in $) in Indonesia, Korea, Malaysia and Thailand
  - 1998 Russian default. Near failure of Long Term Capital Management (Myron S Scholes, Robert C Merton, 1997 Nobel Prize winners in economics).
  - 6 days financial market freeze after 9/11/2001. US stock market lost $1.7 trillion in value.

Value at Risk

The Wake of the Beast

- Developed for market risk management, now used for credit risk and operational risk too. The ultimate model for understanding any type of firm-wide risk
- Where is risk coming from?
  - Human created (business cycles, inflation, government policy changes, war)
  - Natural (weather, earthquakes)
  - Long term economic growth, technological innovations
- The key to understanding the finance industry: **sharing the risk**
  - Savings
  - Personal loans
  - Insurance
  - Diversification
  - Social security (a.k.a TB)
  - Derivatives – hedging

Stop-loss limits

- If the cumulative loss exceeds the pre-set limit, the position has to be cut
- Loss can be larger than the limit
- In what measure do you define the limit?
  - Some assets are more risky than others when taken the same notional
  - Current value (mark to market): may change significantly in a crisis
    – Sensitivity tests, stress tests, scenario analysis
  - Different positions are sensitive to different risk factors. How do you define a comparable metric?

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What is VaR?

- ***"VaR summarizes the worst loss over a target horizon that will not be exceeded with a given level of confidence"***

$$p(loss > VaR) \leq 1 - conf$$

- What does it mean if my 1-day VaR at 99% confidence is $1MM?
- How often will I breach my VaR limit?
- How much will be my expected loss when I breach my VaR limit?
- What is my largest possible loss?

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Advantages

- Aggregate measure of my portfolio's risk (current positions, correlations, leverage)
- Forward looking measure
- Standard across the industry
- Well understood by regulators
- Easy to understand for management
- 3 uses: managing risk (active), controlling risk (defensive), reporting (passive)
- **Coherent risk measure**:
  - Monotonicity: if portfolio A has systematically lower returns than portfolio B, then portfolio A has higher risk
  - Translation invariance: adding x$ of cash to a portfolio reduces its risk by x$
  - Homogeneity: increasing the size of a portfolio by a factor of b scales its risk by a factor of b
  - Subadditivity: merging two portfolios creates lower or equal risk

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Numerical Methods

- Basic inputs:
  - Portfolio MTM
  - Inventory of risks
  - Distribution of risk factor moves
  - Time horizon, confidence level
- Non-parametric VaR
  - Distribution: Histogram
  - How far do you look back? Data quantity vs relevance

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Numerical Methods – Parametric VaR

- **Extreme Value Theory (EVT):**
  - Distribution of the tails of unknown variables – it may be inaccurate at the center
  - The shape of the cumulative distribution function (cdf) belongs to the **generalized Pareto distribution family**

$$F(y) = 1 - (1 + \vartheta y)^{-1/\vartheta} \qquad \vartheta \neq 0$$

$$F(y) = 1 - e^{-y} \qquad \vartheta = 0$$

  - Exponential distribution for ϑ=0; heavy tail distribution for ϑ>0
  - kth moment is infinite for $k \geq {}^{1}/_{\vartheta}$
  - Stock market data is heavy tailed with estimated $0.2 < \vartheta < 0.4$
  - Percentiles behaviour:
    - EVT VaR is higher than normal VaR; more pronounced at higher confidence levels
  - Time aggregation:
    - EVT distributions are stable under addition
    - Scaling parameter is approximately T^{ϑ}, slower than sqrt(T) for normal distributions -> offsets fat tail effect

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VaR Methods

- Delta-Lognormal:
  - Delta: 1st order partial derivative
  - Assuming normal distribution: VaR = delta * Φ^{-1}(confidence lvl)
- Full Revaluation:
  - Very non-linear payoffs
  - Monte Carlo simulation or historical simulation
- Delta-Gamma (Greeks):
  - Include higher order derivatives, cross derivatives
  - Faster than full revaluation
  - Balance of speed and accuracy: depends on the number of higher order terms

Backtesting

The Proof of the Pudding

- Reality check: is the model well calibrated?
- When do we reject the model?
- Corrections:
  - Portfolio changes
  - Fees, interest income, commissions etc
- Number of observations:
  - Longer horizon makes backtesting increasingly hard
- Basel: 1-day horizon for backtesting vs 10-day horizon for capital adequacy
  - Green 0-4 exceptions per year
  - Yellow 5-9 exceptions per year
  - Red 10+ exceptions per year

Variations on VaR

- Portfolio VaR: positions on a number of assets
  - Diversified VaR: taking into account diversification benefit between components
  - Individual VaR: the VaR of one component in isolation
  - Undiversified VaR: sum of individual VaRs. Corresponds to the worst possible correlation.
- Marginal VaR: the change in portfolio VaR when taking an additional $1 exposure in a given asset (partial derivative)
- Incremental VaR: the change in portfolio VaR when a new position is added to the portfolio. Can be non-linear (large position)
- Component VaR: the part of portfolio VaR that would be nulled if an asset was removed from the portfolio

Suggested Literature

- Philippe Jorion: Value at Risk

Q&A