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Value at Risk by Northfield

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Workshop Webinar

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Workshop Overview

- Review Value at Risk or VaR
- Describe statistical moments used to define a distribution
- Simple example with return data
- Northfield approach to VaR
  - Based on Variance – Covariance
  - Adjusted for non-normality
- Review traditional Parametric VaR
  - Simplest link between Variance - Covariance matrix and VaR
- How Northfield is adding to the body of knowledge for VaR
  - Non-Normality Distribution Parameters
  - Normal Equivalency
- Hypothetical fund example
  - Illustrates the Northfield methodology
  - Make connection between regulatory reporting and risk management

Value at Risk (VaR)

- Review from December 2021 Northfield Newsletter Article “Northfield Value at Risk (VaR)”
- What is VaR?
  - VaR is a risk measurement for the possible loss of value for a firm, portfolio or position at a given probability over a certain period of time.
  - Important for organizations with solvency concerns
  - Frequently required in regulatory reporting for banks and highly leveraged investments organizations
- There are a variety of acceptable ways to calculate VaR
  - Monte Carlos simulated returns, historical returns, historical simulated returns or a variance-covariance matrix
  - Basic VaR formula assumes that asset returns are IID and the risk of the assets are measurable.

*Note: most analysis is done in returns at risk instead of value

Moments Defining Distribution

Moments [of a statistical distribution]

The shape of any distribution can be described by its various 'moments'. The first four are:

1) The mean, which indicates the central tendency of a distribution.
2) The second moment is the variance, which indicates the width or deviation.
3) The third moment is the skewness, which indicates any asymmetric 'leaning' to either left or right.
4) The fourth moment is the Kurtosis, which indicates the degree of central 'peakedness' or, equivalently, the 'fatness' of the outer tails.

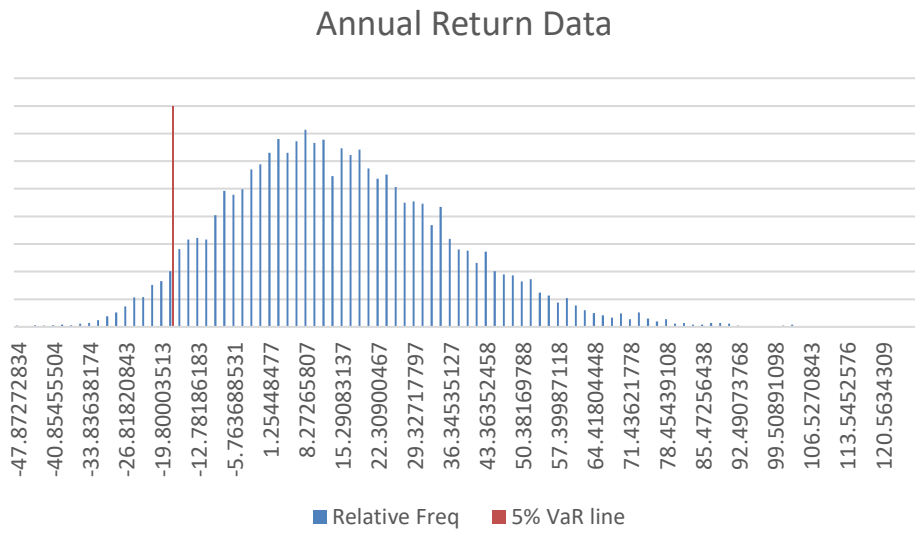
Source: https://www.risk.net/definition/moments-of-a-statistical-distribution

VaR Example (RaR)

1.) Return Data

- Rank returns from highest to lowest
- 95% VaR
- Locate the value at -1.65, which is -17.05
- 95% confident return will not be below -17.05

Summary of Returns	
Number of Obs	10,000
Min	-48.74
Max	126.71
Mean	14.97
Confidence Interval	95%
5% VaR	-17.05
Standard Deviation	21.67



2.) Graph Return Data

- 95% denoted in red

3.) Check for normality of return distribution

	Return Data	Normal
Skew	0.5116	0
Kurtosis	0.4079	3

Northfield Approach to VaR

In the 1997 Jorion-Taleb Debate Derivatives Strategy, Philippe Jorion wrote:

> *[T]he greatest benefit of VAR lies in the imposition of a structured methodology for critically thinking about risk. Institutions that go through the process of computing their VAR are forced to confront their exposure to financial risks and to set up a proper risk management function. Thus the process of getting to VAR may be as important as the number itself.*

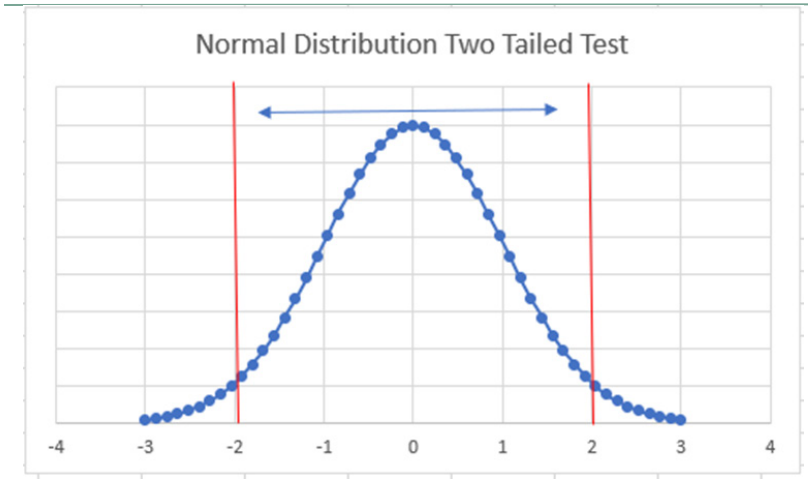
Northfield VaR calculation uses the Variance-Covariance method

- Links the VaR number to Northfield models
- Providing a better understanding of the exposure driving financial risk
  - Adheres to regulatory requirements
  - Bridges the gap between risk assessment and risk management
- Type of rigorous structured methodology and understanding of risk suggested

“Traditional” Parametric VaR

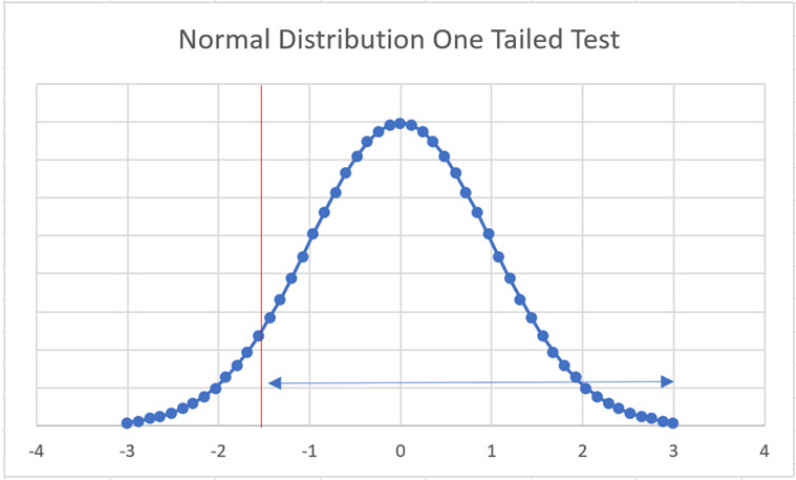
- Simplest connection between a variance-covariance matrix and VaR is parametric VaR
- Northfield multiple factor models define variance-covariance matrix
- Factor models describe the sources of risk
  - Risk forecast of the future rather than what it has been in the past
  - Easy to understand and intuitive
- Parametric VaR is calculated using the parameters from a variance-covariance
  - Mean and variance
  - Assumption of normality implying no skew or kurtosis
- Since risk models assume the distribution is normal so the Parametric VaR will also have the assumption of a normal distribution

From Variance-Covariance to Parametric VaR



The curve on the left illustrates a normally distributed two-tailed test with a mean of 0 and standard deviation of 1. Mean and standard deviation are referred to as the first and second moments of a distribution. Under the assumption of normality in a two-tailed test, 95% of the observations fall within 2 standard deviations. This is denoted by the area between the red lines at -2 and 2 standard deviations.

A simple conversion from a two-tailed test to a one-tailed test demonstrates how the parameters from a risk model can be used to measure parametric VaR. The figure on the right is the same distribution and parameters, but now 95% of the observations are right of the red line between -1.65 and 3 standard deviations.



VaR Units

VaR is normally denoted in terms of currency of the value a portfolio. Risk can easily be converted to illustrate the value of the portfolio that is as risk using the formula:

$$VaR = V * N(P)*\sigma * (T^{0.5})$$

Where:

- V = value of portfolio
- N(P) = number of standard deviations of a normal distribution (one tailed test) to have cumulative density equal to P
- P = Level of confidence that we define our analysis
- σ = Annual volatility of the portfolio in standard deviations
- T = fraction of a year representing the period of time we are concerned about, equal to (N Days to trade)/(Trading days in one year)

Parametric VaR

- Example demonstrates how the parameters defined by a multiple factor model can easily be converted to a VaR number
- Since the parameters are calculated using the factors there is now a direct link between the factors which contribute to market risk and VaR
- Link helps to understand what is driving the riskiness of VaR calculations and we can manage these sources of risk
- For most situations and asset classes with normally distributed returns, this measure is appropriate
- HOWEVER, the weakness with parametric VaR is the normality assumption
- Not all assets exhibit a normal distribution of returns
  - Derivatives and some bonds especially with embedded optionality
- Parametric VaR under the normality assumption is not an appropriate measure for these types of assets

Non-Normal Distribution

- Where Northfield is adding to the body of knowledge in this area is when the assumption of normality no longer holds
  - Introduce non-normality of a distribution to parametric VaR
- Cornish – Fisher type methodology which adjusts a four-moment distribution to an equivalent set of two-moment parameters by adjusting volatility and expected mean.
  - This creates a "normal equivalent“
- Some of these adjustments are made at the portfolio level while others are done at the individual security level
  - Non-Normal Distribution parameters are calculated at the asset level
  - Calculations within applications adjust both factor and specific risk

For more information, please see the May 2017 Northfield research webinar “Use of Factor Models in the Presence of Higher Moments” available at https://www.northinfo.com/documents/766.pdf.

Benefits of Northfield's VaR

Adjustments to normal equivalency provides additional benefits of methodology and functionality:

- Calculations are quicker than other VaR methodology
- News and Sentiment is incorporated into the forecast using Northfield Risk Systems That Read®. For more information, please see https://www.northinfo.com/news-details.php?news-id=6.
- All four moments are considered within a Mean-Variance optimization
- "Portfolio Construction Under Economic Scenarios" as discussed in the September 2019 research seminar available at https://www.northinfo.com/Documents/900.pdf.
  - Construct a portfolio with consideration of various economic scenarios
- Liquidity risk adjustments as discussed in "Technical Support Tip: Liquidity Risk and Active Risk Calculations" which is available at https://www.northinfo.com/documents/554.pdf.

Hypothetical Bond Fund Example

- Hypothetical portfolio is an international bond fund with 20% in derivatives
- Northfield's multi-asset class risk model (everything Everywhere or EE)
  - Adaptive Near Horizon Risk Model – Risk Systems that Read
  - 2 week forecast horizon
- Compare the fund risk:
  - Under the assumption of normality
  - Including the non-normality distribution parameters
    - Non-Normal Distribution Parameters in EE indicate this portfolio has a Skew = -0.13621 and Kurtosis (excess) = 1.46141

	Distribution	
	Normal	Non-Normal
Total Risk	5.74	7.63
20 Day VaR	$ 902,822.01	$ 1,199,642.88

- US based manager subject to the SEC 18f4 regulatory requirement

18f4 - Overview

Funds with 10% or more value in derivatives must provide reporting to the SEC.

Reporting requirements include:

1.) 20-day horizon VaR

- The fund's absolute VaR must be below 20% of the fund's total value.
- The fund's relative VaR must be below 200% of the designated reference portfolio's VaR.
- It must be noted when either VaR exceeds the targets

2.) Daily Performance backtest

- VaR versus PnL
- It must be noted when a loss exceeds the Value at Risk

3.) Stress test

- Stress testing for "extreme, but plausible market changes or changes in market risk factors".
- Open to which factors are used

18f4 – 20 Day Horizon VaR Compliance

20 Day Horizon VaR Compliance

Portfolio	Date	99% Portfolio VaR (20 day) %	99% Benchmark VaR (20 day) %	Absolute Compliance?	Relative Compliance?
Hypothetical Bond Fund	20210731	-4.93	-2.66	✔	✔
Hypothetical Bond Fund	20210802	-4.93	-2.66	✔	✔
Hypothetical Bond Fund	20210803	-4.94	-2.68	✔	✔
Hypothetical Bond Fund	20210804	-4.93	-2.42	✔	✘
Hypothetical Bond Fund	20210805	-4.89	-2.68	✔	✔

Absolute : The portfolio VaR must be below 20% of the fund's total value.
Relative : The portfolio VaR must be below 200% of the designated reference portfolio's VaR.

Days when Absolute Limit Exceeded	0
Days when Relative Limit Exceeded	1

On August 4th the Fund VaR at -4.93 exceeded 200% of the benchmark VaR which is 2 * (-2.42) = -4.84

18f4 – Exceeded VaR Limit

Daily Performance Backtest – was any loss greater than VaR?

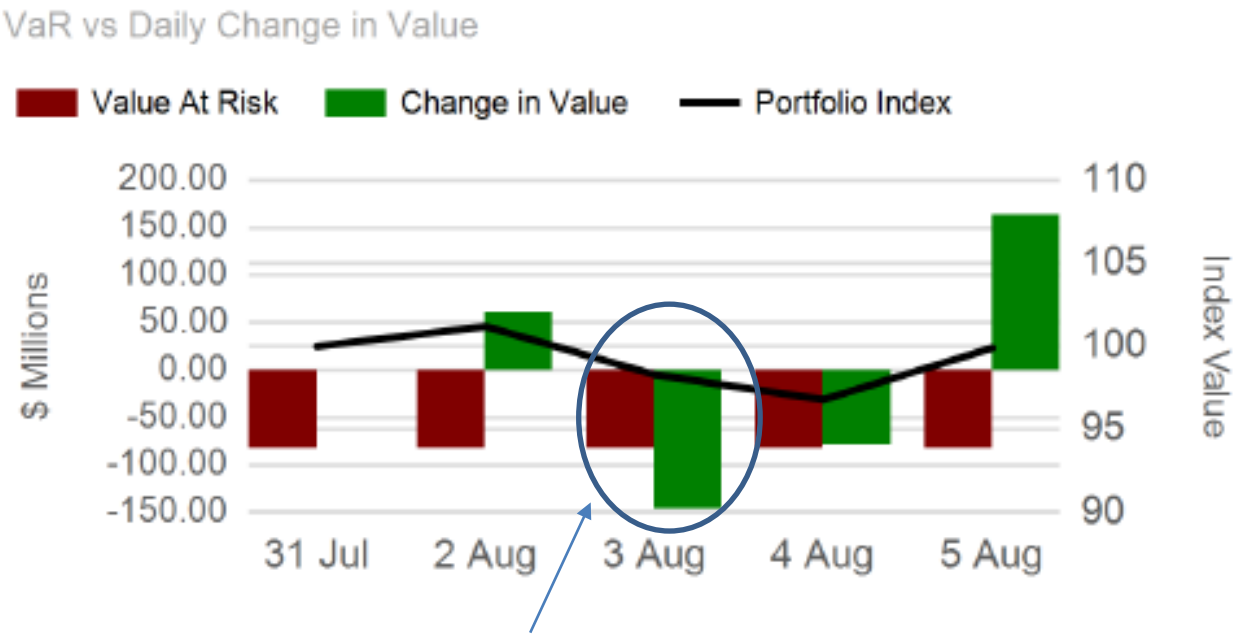
Portfolio	Date	Risk (annual)	Index Value	% Return	99% VaR (daily)	Within Limits?
Hypothetical Bond Fund	20210731	7.63	100.00	0.00	-1.62	✔
Hypothetical Bond Fund	20210802	7.63	101.20	1.20	-1.62	✔
Hypothetical Bond Fund	20210803	7.64	98.30	-2.87	-1.62	✘
Hypothetical Bond Fund	20210804	7.63	96.80	-1.53	-1.62	✔
Hypothetical Bond Fund	20210805	7.57	99.90	3.20	-1.61	✔

Days when VaR Limit Exceeded	1

On August 3rd return of -2.87 is greater loss than Value at Risk of -1.62

18f4 – Backtest Daily Performance

Graphing the daily performance data



On August 3rd return of -2.87 is greater loss than Value at Risk of -1.62

18f4 – Stress Test

- Stress testing using the Northfield Scenario Analysis tool as discussed in "An Optimized Approach to Scenario Driven Risk Simulations", available at https://www.northinfo.com/Documents/687.pdf
  - Simulated history based on observations within the target values
- Stress test macroeconomic and model factors as well as an equity index

Stress Tests

Stress Test	Fund Profit / Loss %	Simulated Return (monthly %)	Target Value
Credit Spread		-2.06	0.61
Oil Price Rise (West Texas)		1.59	17.50
Consumer Sector Factor		-2.59	-5.68
Non-Energy Minerals Factor		-2.28	-7.50
Oil Price Factor		-0.84	-7.50
Tech & Health Factor		-1.90	-7.01
Energy Minerals Factor		-2.11	-7.50
Interest Rate Sensitive Factor		-2.68	-7.50
S&P500 10% Fall		0.02	-11.00

From Regulation to Managing Risk

- Compare the bond fund to S&P 500 to understand the impact

	Hypothetical Bond Fund		S&P 500	
Factor	Variance Contribution	% Contribiton	Variance Contribution	% Contribiton
Region	0.8683	2.33%	25.1647	8.37%
Super Sectors	2.5764	6.92%	270.4637	89.99%
Economic	-0.0409	-0.11%	-1.549	-0.52%
Fundamental	-0.216	-0.58%	-0.8015	-0.27%
Blind Factor	0.4305	1.16%	-0.0157	-0.01%
Currency	27.3799	73.57%	0	0.00%
Curve	6.2081	16.68%	0	0.00%
Total Factor Variance	37.2062	99.98%	293.2622	97.57%
Asset Specific Variance	0.0086	0.02%	7.3019	2.43%
Total Variance	37.2147	100.00%	300.5641	100.00%

- For the macro-economic factor risk in the stress test, the portfolio can be optimized incorporating scenario for the Credit Spread and Rise in Oil Prices (West Texas) using **"Portfolio Construction Under Economic Scenarios" mentioned on slide 13.**
  - Illustrated in the 2020 Workshop "Portfolio Construction Under Economic Scenarios In Action" (workshop recording available upon request)

Factor Risk Stress Test

Analyze factors related to the stress test and make changes as needed

- Expected return for Interest Rate Sensitive Sector worth the risk
- Another Perspective on risk from oil prices
- Curve risk is the opposite side of the credit spread

Factor	Exposure	Factor Variance	Variance Contribution	% Contribiton
Super Sectors			2.5764	6.92%
INDUSTRIAL SECTOR	0.0008	208.359	0.0304	0.08%
CONSUMER SECTOR	0.0007	150.734	0.0209	0.06%
TECHNOLOGY&HEALTH SECTOR	0.015	216.967	0.6315	1.70%
INTEREST RATE SENSITIVE SECTOR	0.0593	208.845	1.8901	5.08%
NON-ENERGY MINERALS	0	322.121	0.0005	0.00%
ENERGY MINERAL SECTOR	0.0002	342.721	0.003	0.01%
Economic			-0.0409	-0.11%
S B WORLD GOVT BOND INDEX	-0.0018	22.2011	-0.0405	-0.11%
OIL PRICES IN USD	-0.0016	3499.68	-0.0716	-0.19%
DEVELOPING MARKET	-0.0151	121.25	0.0711	0.19%
Curve			6.2081	16.68%
TREASURY CURVE FACTOR1	-7.7693	0.1405	6.308	16.95%
TREASURY CURVE FACTOR2	-31.1336	0.001	1.5824	4.25%
TREASURY CURVE FACTOR3	-299.7175	0	-1.6824	-4.52%

Conclusion

Take always:

- VaR is simple measure of possible losses denoted as the n^{th} percentile in a distribution
- Any distribution can be defined using the four moments
- These four moments can be calculated using Northfield models
- A multi-factor risk model provides explanatory power of the distribution using intuitive economically relevant factors
- Cornish – Fisher adjust for non-normality of distribution
- Normal equivalence allows for the functionality and modeling enhancements not normally available using other VaR methods
- **Calculating VaR using Northfield's methodology creates a link between VaR and risk factors that provides "…*the imposition of a structured methodology for critically thinking about risk.*" Further creating an important link between risk management and regulations.**