Investment Planning Answer Book by Jay L. Shein, Value at Risk (VaR)

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Advisors attempt to measure potential losses in a portfolio based on adverse movements in the markets. The investment community cannot agree on what the best measure of risk is. Because of this, there are many measures of risk that advisors look to. But how is risk defined? Is it the uncertainty of a certain outcome? Is it the regret that an investor has after their portfolio drops substantially in value? Perhaps, the real risk is not taking any risk at all. Professional investment advisors are looking for the Holy Grail of measurements of risk. They are looking for that one measure that indicates the risk of an investment portfolio. Regrettably, no measure of risk such as this exists. Although Value at Risk (VaR) does not answer all the questions regarding the risk of a portfolio, it is a powerful method to assist in this process.

Investment Planning Answer Book by Jay L. Shein, Q 13:1, What is appealing about Value at Risk (VaR) as a measure of portfolio risk?

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Value at Risk (VaR) attempts to quantify a portfolio's risk by estimating the maximum possible loss that can be expected over a specific period of time. One of the primary benefits of VaR is that it is considered easy to interpret when used to summarize a portfolio's risk. It also treats risk consistently across various asset classes. Since VaR provides a measure of risk describing the possible percentage that can be lost in a portfolio over a period of time, it helps provide a direct comparison between the risks of different portfolios. This methodology provides a single number in dollars that is simple to grasp and can be calculated quickly.

Investment Planning Answer Book by Jay L. Shein, Q 13:2, Can measures of risk such as Value at Risk be used alone to select portfolios or investment managers?

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Value at Risk cannot be used in isolation to make investment decisions. Successful investing relies on quality information, good judgment, and a disciplined process and approach. Statistical measures such as standard deviation and VaR do not tell the investment advisor which portfolio to choose. Each measure of risk provides a different perspective on the inherent uncertainty of investment returns. Like all measures of risk, standard deviation and VaR have their advantages and disadvantages. Along with expected returns, VaR can help provide the necessary information for advisors to make better decisions.

Investment Planning Answer Book by Jay L. Shein, Q 13:3, Why can advisors not just use standard deviation instead of Value at Risk?

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Standard deviation measures the magnitude of the dispersion of realized returns or the dispersion of expected returns relative to an average. Standard deviation and its methods of calculation are discussed in more detail in other parts of this publication. Like all measures of risk, standard deviation has its critics. It is a measure of variability which provides a range of returns that is two-sided. It treats upside and downside risk equally. If most investors were polled, advisors would find that they are most concerned with downside risk. Standard deviation relates risk in percentages rather than in dollar terms. Value at Risk quantifies the maximum amount of dollars that can be expected to be lost in a specific time period. It is also useful to evaluate in dollars the impact of adding or subtracting asset classes or securities from a portfolio.

Standard deviation is not the wrong statistic. It is simply misused and misunderstood by many. Investors willing to tolerate higher standard deviations should expect higher returns. Lower standard deviations tend to lead to more stable investment performance but are not necessarily optimal for an investor. For example, a portfolio could have a negative return of 5 percent with a zero standard deviation. Most investors would want a higher standard deviation to obtain a long-term positive return. Many investors equate risk with losing money. VaR is a way to quantify the risk in dollars. Investments that have high risk on the upside very likely have high risk on the downside. Understanding the financial impact of that risk can be very valuable.

Investment Planning Answer Book by Jay L. Shein, Q 13:4, Can standard deviation be improved upon by using Value at Risk?

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Standard deviation is an excellent measure of risk, but it may not be the best way of always looking at risk. There is a continuous quest for the "Holy Scale." In Modern Portfolio Theory, advisors observe that standard deviation is a major component used to capture the relevant information regarding risk. Standard deviation is used to help develop risk-based rules that help make investment management decisions. Usually, standard deviation is used under the assumption that there is symmetry in the distribution of returns. This is not always the case when options or option-like strategies are part of the investment portfolio. VaR can encapsulate the risk of a portfolio in terms that relate to the potential dollar loss of the portfolio. Investment advisors can use VaR to estimate in dollars the potential that can be lost in a period of time. For example, VaR answers the question regarding how much an investor could potentially lose such as 1 in 20 days (5 percent of the time) or 1 in 100 days (1 percent of the time). This type of analysis has intuitive appeal. Value at Risk has been used for reporting risk, limiting risk exposure, and for certain institutions conforming to regulatory capital requirements.

Investment Planning Answer Book by Jay L. Shein, Q 13:5, What is the history of Value at Risk?

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Value at Risk has become a popular approach to measure how much risk a portfolio incurs. It looks to the future for a specific period of time. VaR tells the advisor that for a specific confidence level that a portfolio will not lose more than a certain dollar amount in any given day or number of days. VaR was first developed at J.P. Morgan when a former chairman, Dennis Weatherstone, asked for a one page report that could be delivered to him at the end of every business day that would summarize the global exposure and estimate of potential losses over the next 24 hours for J.P. Morgan. This became known as the "4.15 Report" because the objective was to deliver this report to Dennis Weatherstone at 4:15 pm every day which was 15 minutes after the U.S. stock market closed. This was the beginning of the successful risk management tool that has become known as Value at Risk. VaR is widely used by money managers, mutual funds, financial institutions, and corporate treasurers. It is easy to understand because it simply asks the following question: "How bad can things get?"

Investment Planning Answer Book by Jay L. Shein, Q 13:6, What are the methods used to calculate Value at Risk?

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Some of the most common methods used to calculate VaR are delta-normal, historical simulation, and Monte Carlo Simulation. The various methods have their advantages and disadvantages. To some degree, these three methods derive some information from historical data. The delta-gamma method is another way to calculate VaR that uses quadratic math to address the limitations of the other methods when measuring the risk of non-linear portfolios.

Investment Planning Answer Book by Jay L. Shein, Q 13:7, How does the delta-normal method work?

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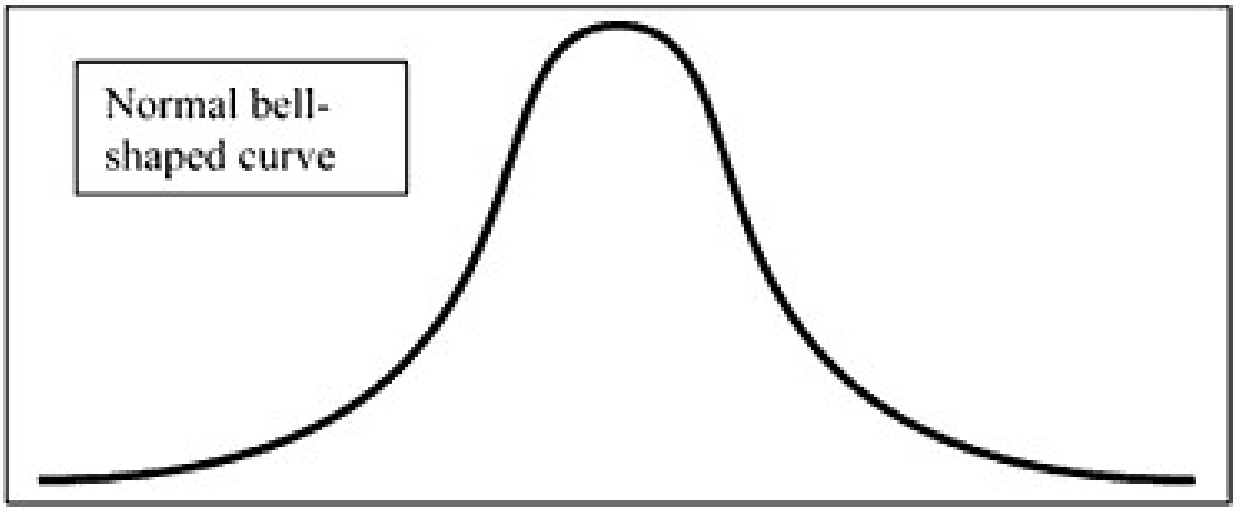
The delta-normal method is sometimes referred to as the parametric or closed form method. This method assumes that investment returns are distributed in a normal bell-shaped curve. In a bell-shaped distribution, the x-axis plots the returns, and the y-axis is the probability or frequency of the returns.



EXAMPLE 13-1

Assume the portfolio is valued at $12 million and has a standard deviation of 11 percent. The question to be answered with a 95 percent confidence level is as follows: What loss will not be exceeded in a ten day period (two weeks)? The following formula can be used to calculate VaR for this problem.

$$VaR = V_p \sigma_p \sqrt{\frac{V_d}{D_y}} * \alpha$$

Where:

V_p =dollar value of total portfolio

σ_p =standard deviation of total portfolio

V_d =number of days for VaR time horizon

D_y =number of days market is open during year

α =confidence level factor

$$\text{VaR} = (\$12{,}000{,}000)(.11)\sqrt{\frac{10}{252}} * 1.645 = \$432{,}553.23$$

The 95 percent confidence level factor is 1.645. This can be found in a one-tailed standard normal random variable table (found in many statistics books) which shows the probability that a standard normal random variable will be less than a specified value. The VaR for the two week period is $432,553.23. This method of calculating VaR is defined as the absolute VaR: it is the loss in dollars relative to zero. This method assumes that the portfolio value change is zero and is acceptable for short periods of time.

In this calculation, we can see that 95 percent of the time, the portfolio value in a 10 day period will not lose more than $432,553.23. Conversely, this means that 5 percent of the time, the portfolio could lose more than this amount.

Investment Planning Answer Book by Jay L. Shein, Q 13:8, How can one time period be converted to another time period?

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The standard deviation of investment returns tends to increase by an amount that is equal to the square root of time. Users of VaR can convert one time period to another using this methodology. For instance, if the daily standard deviation of an investment was 3 percent and there were 21 trading days in a month, it could be converted to monthly standard deviation in the following manner:

$$\sigma_M \cong \sigma_D * \sqrt{T}$$

Where:

σ_M =monthly standard deviation

σ_D =daily standard deviation

T =time in days

By substituting in the previously mentioned numbers into this formula, we find the following:

$$\sigma_M \cong 3\% * \sqrt{21} \cong 13.75\%$$

If an advisor wants to convert monthly standard deviation to annual standard deviation, they would multiply the monthly standard deviation by the square root of 12.

Investment Planning Answer Book by Jay L. Shein, Q 13:9, How is delta-normal calculated when there is an expected change in portfolio value?

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Portfolio returns may not always be normally distributed. The delta-normal assumes a linear exposure to underlying prices. This is a common method of calculating Value at Risk. Linear relationships have identifiable factors that have some consistency that exist between the variables. As a result of this, measurements of risk with linear relationships are generally more clear-cut than calculations with nonlinear relationships. From the standpoint of risk, nonlinear relationships can be more intricate to quantify as it is not easy to define to what degree each of the causative variables participates in the total output. One example of nonlinear relationships in an investment is bond duration and convexity. The relationship between interest rates and bonds is not constant. Convexity is a measure of the bond's sensitivity to interest rate changes. Duration measures the change in a bond's value based on changes in interest rates.

EXAMPLE 13-2

Consider a $10 million portfolio that has a standard deviation of 12 percent, a 99 percent confidence level, with an expected change in the value of the portfolio of $800,000 or 8 percent. The risk calculation that accommodates this expected change in portfolio value to determine the investor's maximum exposure to loss in any one year is as follows:

$$VaR = \frac{PV(E_{RP} - \alpha * \sigma_p)}{\sqrt{\frac{D_y}{V_d}}}$$

Where:

PV = present value of the portfolio

E_{RP} = expected return of the portfolio

α = confidence level factor

σ_p = standard deviation of portfolio

V_d = number of days for VaR time horizon

D_y = number of days market is open during year

$$\text{VaR} = \frac{(\$10{,}000{,}000)(.08 - 2.33 * .12)}{\sqrt{\frac{252}{252}}} = -\$1{,}996{,}000$$

In this example, 1% of the time, the investor could lose $1,996,000 or more in any one-year period. Stated another way, 99 percent of the time the investor will lose less than $1,996,000 in any one-year period. The confidence level factor for a 99 percent confidence level is 2.33.

Investment Planning Answer Book by Jay L. Shein, Q 13:10, Is the delta-normal method of calculating of Value at Risk accurate?

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The delta-normal method of calculating VaR produces an accurate result for linear portfolios which typically includes equities, commodities, futures, and many bonds. Some investments that are not appropriate for the delta-normal method include non-linear investments such as mortgage-backed securities, callable bonds, many structured notes, or other investments that have imbedded options. Riskgrades™, the owner of RiskMetrics, who is a major provider of VaR calculations and risk data, has a better methodology for non-linear portfolios. They calculate volatility using an exponentially weighted moving average where the most recent volatility carries the highest weight in their volatility estimates. Using this method, volatilities can react more quickly to the current market environment. Therefore, when there have been recent market extremes, estimates of volatility decreased exponentially as the most recent extreme observations elapse.

Investment Planning Answer Book by Jay L. Shein, Q 13:11, What are some of the pros and cons of the delta-normal method for computing Value at Risk (VaR)?

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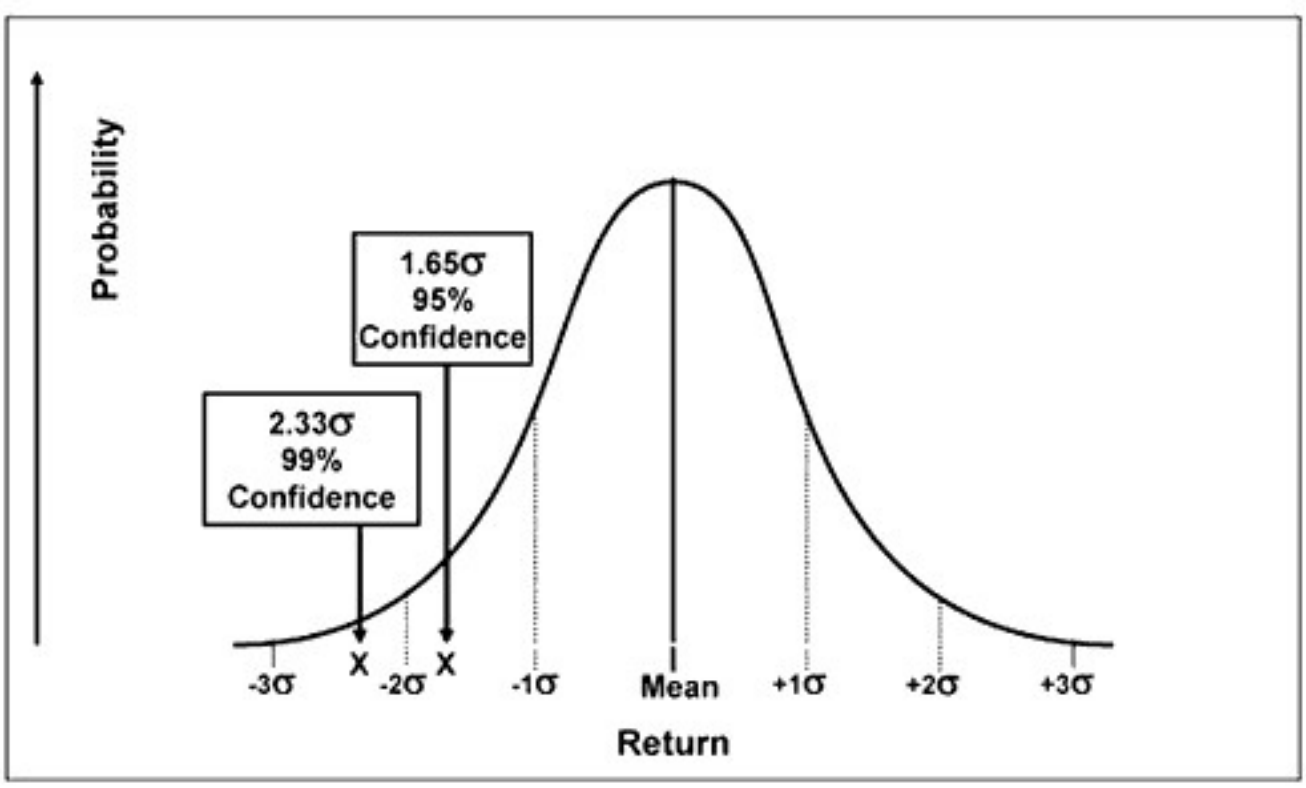
The delta-normal method makes the assumption that the returns are normally distributed. It is easy to understand and is not too difficult to compute. It does not address the fact that the returns may not be normal and can have fat tails (kurtosis). Because correlations do not typically remain constant, it also may be problematic for the delta-normal method. The 99 percent (2.33 confidence level factor) and 95 percent (1.65 confidence level factor) confidence levels with a normal distribution are depicted in the following illustration.



Investment Planning Answer Book by Jay L. Shein, Q 13:12, Can historical data be used to simulate Value at Risk calculations?

Historical simulations use data samples from more recent history and make the assumption that the future may closely mirror the past. An advisor who desires to create a distribution of possible outcomes using the historical simulation method could look at the actual returns for the preceding 200 days and identify the resulting portfolio values. They would then rank the outcomes by their gains or losses.

EXAMPLE 13-3

Assume there are 200 trading days in a simulation where it was desirable to estimate VaR at the 95 percent confidence level. The advisor would select the tenth worst portfolio value in the distribution. In this scenario, 95 percent of the time, the portfolio will lose less than the tenth worst portfolio during this period of time. If the historical period was 500 days, the advisor could select the twenty-fifth worst portfolio value to determine the 95 percent confidence level.

Two advantages of historical simulations are that they have no statistical bias and are easy to understand. Historical simulation is not subject to the constraints that exist when the advisor must project volatility, returns, and correlations into the future. This is because historical simulation is based on the actual occurrences in the past. When historical simulation is used, non-linearity is not an issue. Disadvantages of this method are that it requires sufficient data and can respond slowly to changes in volatility.

Investment Planning Answer Book by Jay L. Shein, Q 13:13, Can Monte Carlo Simulation be used to estimate Value at Risk?

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Monte Carlo Simulation (MCS) is a popular method that is used to estimate VaR. This method involves sampling many changes in the market variables, revaluing the portfolio, and then using each of the results to build a probability distribution to model the estimated change in the portfolio value. With this method, the change in portfolio value would be calculated. This process is continuously repeated to build a probability distribution for the change in portfolio value. The resulting VaR calculation is the appropriate fraction of the distribution times the square root of the number of trials. For instance, with the Monte Carlo VaR method, if 200 trial calculations were made, the one percentile would be the twentieth worst case. This Monte Carlo approach to calculating VaR is very effective and can take into account a variety of risk factors such as but not limited to volatility, credit risk, liquidity risk, operational risk, market risk, price risk, and non-linear risk such as those contained in options. With today's computing power, it has become much easier to calculate VaR using a Monte Carlo Simulation method. Other VaR calculation methods require much less computing power. With the Monte Carlo method, a portfolio exposed to just one risk factor requiring 10,000 trials with a portfolio containing 600 assets would require 6 million portfolio valuations. The Monte Carlo VaR calculation method gives consistent fairly reliable results when significant convexity or gamma exists. When portfolios contain option-like qualities, they will exhibit gamma. These portfolios may be difficult to value with changing volatility or prices.

Monte Carlo simulations are beneficial when compared to linear ones as they do compute a variety of possible outcomes. However, the outcomes of any Monte Carlo Simulation are not assured and should not be relied upon solely to make an investment decision. They are another statistical tool used to help an advisor make investment decisions.

Investment Planning Answer Book by Jay L. Shein, Q 13:14, What is the delta-gamma Value at Risk method?

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Many portfolios have non-linear curvature such as those that contain callable bonds or structured notes. When the association between profit and loss and the underlying investment can be characterized by a curved line, a non-linear curvature relationship exists. The problem with linear models is that they do not capture the skewness in the probability distribution for portfolio values. The delta-gamma method uses a lot of calculations. It calculates the variance of both sides of a quadratic approximation. One of the variables gamma, like convexity which measures the curvature between bond price and interest rates, does the same thing with non-linear assets such as options. The delta-gamma method requires a very large amount of data. Therefore, it is not always viable with many sources of risk. The delta-gamma method gives no guarantee of accuracy. When there are substantial changes in the price of an underlying asset such as a stock, an option on that asset can behave very unpredictably.

Investment Planning Answer Book by Jay L. Shein, Q 13:15, Which method of Value at Risk is the best?

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Each method has advantages and disadvantages which have been discussed. In large portfolios where optionality is not a major factor, the delta-normal method is efficient and quick to compute. For portfolios that do not have too many sources of risk but have significant option elements, the delta-gamma method may be more appropriate. The Monte Carlo method is also valuable but in most situations will give the same result as the delta-normal method.

Investment Planning Answer Book by Jay L. Shein, Q 13:16, How does Value at Risk indicate the maximum loss?

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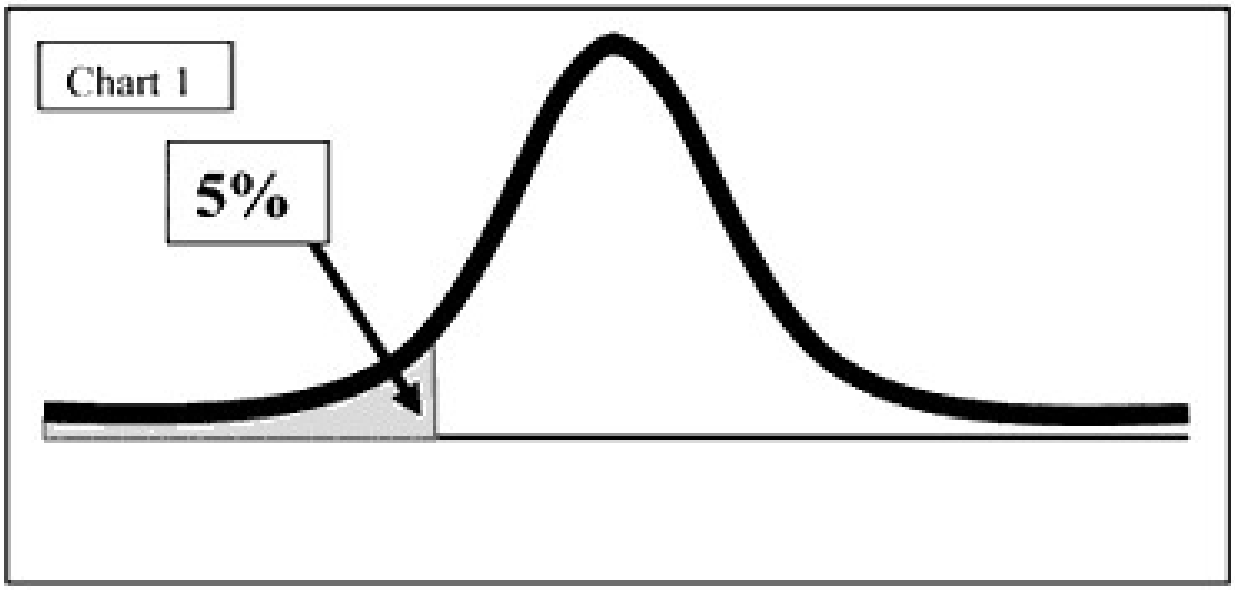
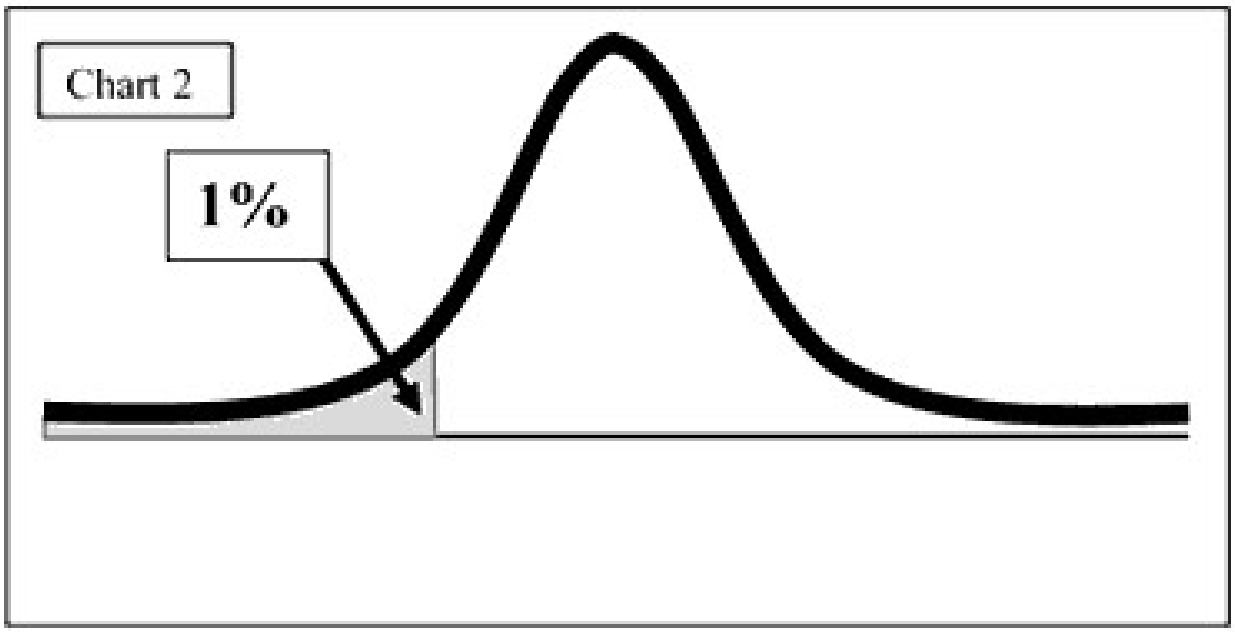
Value at Risk is typically used to estimate the maximal potential loss from an unusual capital market's event in a normal market environment. In Chart 1, Value at Risk makes a statement that a portfolio loses no more than a certain amount of dollars 5 percent of the time (which is a 95 percent confidence level); the confidence level factor corresponding to this confidence level is 1.65. Chart 2 makes a statement that a portfolio will lose no more than x dollars 1 percent of the time (99 percent confidence level); the corresponding confidence level factor is 2.33.





Investment Planning Answer Book by Jay L. Shein, Q 13:17, What cannot be explained by Value at Risk (VaR) calculations?

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Value at Risk does not depict the worst possible outcomes. It does provide an estimate of possible losses in a portfolio in dollars subject to the methodology constraints and limitations. VaR does not account for risk that an investment manager may be taking that is not reported. Take for example, the historical bankruptcy of Orange County, California, where Bob Citron, the county treasurer who ran their investments in 1994, made large interest bets that caused the county to go bankrupt. This may have been avoided if all their risks were quantified using Value at Risk. If the trustees had realized through a VaR calculation that there was a 5 percent chance of losing over a billion dollars in one year, they might not have allowed the investments to continue. Minimally, the trustees would not be able to plead ignorance about the potential risk if the potential loss was estimated and disclosed to them. Other major debacles in history such as the fall of Gibson Greeting Cards and Barings Bank may also been avoided with proper VaR mandates.

Investment Planning Answer Book by Jay L. Shein, Q 13:18, How can risk budgeting be used with Value at Risk?

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VaR can be used to budget portfolio risk. For example, an investment portfolio with two managers wants to understand and control the amount of dollars that are at risk. An investment advisor or consultant could use one of the methods such as delta-normal to determine the VaR of the portfolio. To determine the value of the diversification, the advisor could take the sum of each manager's VaR and subtract the VaR of the whole portfolio. This would give the VaR benefit from diversification keeping in mind that a variance/covariance matrix must be used. RiskMetrics developed a VaR methodology looking at exponentially weighted moving averages.

EXAMPLE 13-4

Assume a 95 percent confidence level with the risk budget for the portfolio of 1.5 percent for any one day.

	Value	*1 day Value at Risk*
U.S. Stock Index	$4,600,000	$120,000
U.S. Bond Index	$4,500,000	$52,000
Total	$9,100,000	$172,000

The 1 day VaR for the total portfolio is $101,000. The sum of the individual stock and bond index VaR is $172,000. The difference in the 1 day portfolio VaR and the individual VaRs is equal to the diversification benefit. In this example, $172,000 minus $101,000 equals $71,000 which is the diversification benefit. The 1 day VaR is 1.1 percent ($101,000 divided by $9,100,000) of the total portfolio. This 1.1 percent is within the 1.5 percent risk budget parameters for the portfolio.

This process could be used when adding additional managers or assets to a portfolio to keep the total portfolio within the risk budget. Complex VaR calculations can be accomplished with the use of software programs or spreadsheets programmed to perform these calculations.

Investment Planning Answer Book by Jay L. Shein, Q 13:19, What is Conditional Value at Risk (CVaR)?

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Conditional Value at Risk calculates the size of the average loss that a person could expect when it exceeds the Value at Risk amount. It is the amount or percentage of loss that can be expected over a given number of days. CVaR is sometimes referred to as Expected Tail Loss (ETL). It helps answers the following question: when things get really bad such that the VaR level is being exceeded, what then is the loss that can be expected? CVaR conservatively evaluates an investment's risk while it focuses on the less profitable outcomes. CVaR is able to quantify high tail risk that may be beyond Value at Risk.

Investment Planning Answer Book by Jay L. Shein, Q 13:20, What is Cornish-Fisher Value at Risk (CFVaR)?

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Cornish-Fisher (CFVaR) is a modified Value at Risk (VaR) calculation that takes skewness, the directionality or tilt of the returns, and kurtosis, the measurement of the "fat-tailed" nature of the returns of non-normal distributions into account such as those that may be present in some hedge funds. CFVar will give a larger estimate of the potential loss than traditional VaR when returns are negatively skewed or fat-tailed. Parametric methods such as CFVaR try to mathematically predict the future shape of the tail, even when such extreme returns have not been previously observed.

CFVaR,is generally of more use for measuring risk and predicting the potential loss on individual assets. CFVaR and VaR are both estimates of downside risk and can be used interchangeably when there is a normal distribution, but CVaR will give a more accurate prediction of downside risk. CFVaR can alert a manager when a particular asset is riskier than might be evident by just examining the standard deviation of the returns. CFVaR will provide a loss estimate that is larger than traditional VaR when returns are negatively skewed or there are fat tails.

Investment Planning Answer Book by Jay L. Shein, Q 13:21, How can extreme financial events be quantified with VaR?

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Extreme financial circumstances happen more often than can be explained by normal distributions. Advisors may find value in estimating VaR of total portfolios during past events. Sometimes, this is referred to as event risk analysis. Some of the events that portfolios may be stress tested under could include the following:

- October 16-October 19, 1987, frequently referred to as Black Monday
- October 24-October 27, 1997, called the Asian Crisis
- March 24-April 14, 2000, referred to as the Burst of the Technology Bubble
- September 11-September 20, 2001, the Terrorist attack
- September 15-November 20, 2008, sub-prime debacle and collapse of Lehman Brothers and the ensuing calamity it caused around the world

The advisor could assume that all the investments in the portfolios have a correlation of one. They could then take each investment, manager, or strategies' VaR, multiply it by its proportionate weight in the portfolio, and take the sum of those weighted VaRs to come up with a stress test VaR for the total portfolio. Advisors should keep in mind that event risk analysis is not an alternative to other risk analysis methodology. An event could be much worse than the worse case scenario. Stress testing should not be relied upon as the absolute measure of the worse case scenario.

Investment Planning Answer Book by Jay L. Shein, Q 13:22, How can an investment advisor or consultant use Value at Risk to manage risk?

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A Value at Risk maximum for a total portfolio can be established so that when a new manager is added it does not increase the total portfolio VaR. The investment advisor or consultant can use VaR to evaluate the individual dollars that are at risk when using a particular investment strategy. The VaR approach translates risk into dollars which can make it easier for investors, advisors, and investment committees to understand.

Investment Planning Answer Book by Jay L. Shein, Q 13:23, Is Value at Risk an absolute measure of downside risk?

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Value at Risk makes a probabilistic estimate. It makes this estimate with a specific confidence level, and it asks what the maximum expected loss over a specified period of time will be. VaR does have its limitations. The ranges calculated with VaR can be exceeded. Even with a 99 percent confidence level, it is impossible to know the estimate of an absolute outcome. VaR can be used to stress test a portfolio and can calculate VaR for various historical events. Standard deviation is also discussed in this publication and is another valuable statistic that is widely used and should be known by an advisor. Without the knowledge of standard deviation, advisors will not understand the impact of VaR and may be unable to advise investors regarding VaR. Value at Risk focuses on the tail of a distribution but has limitations when fat tails exist. VaR does not give the worse case scenario. It will not project the actual loss under any particular market environment. It does not deal with cumulative losses, and it should not be used in isolation for effective risk management.