A CEO's guide to value at risk models

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Value at Risk (VaR) models are being used extensively in the world of risk management. VaR provides an upper bound on the potential loss due to adverse market fluctuations. VaR can be used to estimate risk in the case of various financial instruments including bonds, equities and derivatives.

Since the past decade or so no other tool in financial risk management has been heard about as much as Value at Risk (VaR) modeling. VaR has rapidly become the industry standard for measuring and reporting market risk in trading portfolios of banks and other trading institutions.

VaR provides an upper bound on the potential loss due to adverse market fluctuations. Any VaR number has to specify which portfolio is being considered (e.g., Equity derivatives book), the confidence level (e.g., 97.5%) and the holding period (e.g., 10 days). VaR objectively tries to combine the sensitivity of the portfolio to market changes and the probability of a given market change.

VaR has been adopted by the Basel Committee to set the standard for the minimum amount of capital to be held against the market risks. VaR can be used to estimate risk in the case of various financial instruments including bonds, equities and derivatives. VaR can be used to communicate risk and to control risk by setting limits for frontline traders and operating managers.

Pros and cons of using VaR models

There are many advantages of using VaR models. When calculated at the corporate level, it summarizes the overall risk across all the bank's trading activities into a single number for senior management. Therefore, it is a very effective means of communicating risk exposures to senior management. Since VaR is denominated in currency units and is linked to a confidence-level measure of loss, it provides a consistent and comparable measure of risk across all instruments, products and business lines.

But VaR does have some limitations. VaR rests on modeled volatilities and co-movements of risk factors. It offers little guidance in exploring abnormal events outside the realm of normal statistical probability. This limitation may be overcome by using stress testing as a complimentary tool. A stress test examines the implications when the abnormal, unexpected worst-case scenario does materialize.

Calculating VaR[1]

The three popular methods of calculating VaR are:

- Parametric VaR
- Monte Carlo VaR
- Historical VaR.

Parametric VaR

Parametric VaR assumes a normal probability distribution. The changes in the instrument values are assumed to be linear with respect to the changes in risk factors. The broad approach in case of Parametric VaR is as follows. The primary advantage of Parametric VaR is that it is fast and computationally simple to calculate. This facilitates the calculation of VaR on portfolios with many different assets and risk factors. But Parametric VaR assumes that asset returns are linearly related to risk

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[1] This section draws from the analysis of *The Fundamentals of Risk Measurement* By Chris Morrison, 2002, McGraw Hill.

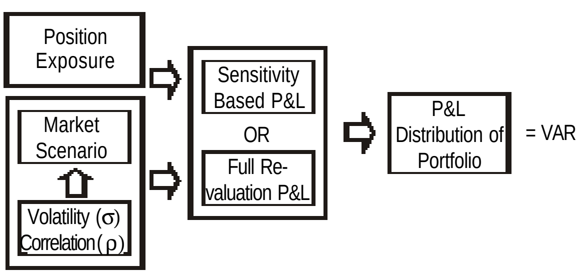
factor returns and that the risk factor returns are assumed to be normally distributed. Thus it ignores non-linear price sensitivities. So this method may misestimate potential future portfolio volatility.

Monte Carlo VaR

Monte Carlo VaR removes the assumption that assets are linearly dependent on price. It simulates normally distributed future scenarios using historical variances in risk factor returns and uses them to reevaluate the portfolio. It estimates VaR by randomly creating many scenarios for future rates, using nonlinear pricing models to estimate the change in value for each scenario and then calculating VaR according to the worst case scenario. The biggest advantage of this method is that it captures non-linearities and can generate an infinite number of scenarios. It is generally the slowest form of VaR to calculate, taking 1000 times longer than parametric VaR. The method also assumes that risk factor returns are normally distributed.

Picture 1

Monte Carlo simulation generates numerous random market scenarios using predetermined parameters for price volatility and correlation and calculates the P&L for each scenario



Source:Capital Market Risk advisors Ltd.

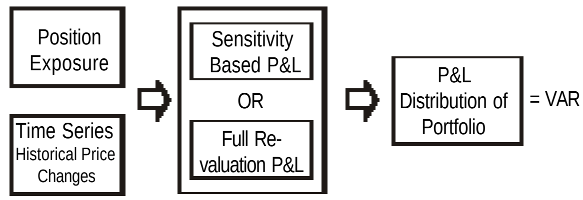
Historical VaR

In Historical VaR, actual daily fluctuations in risk factors are used to simulate their impact on the valuation of a portfolio of assets. So it captures a better estimate of the actual distribution of risk factor returns.

Historical VaR is the most easy to understand, as it is simpler in approach than other methods mentioned above. But it takes more time to run than parametric VaR. Historical VaR is the only method that removes the assumption of normally distributed risk factor returns. This method typically takes the market data for the last 250 days and calculates the percent change for each value to present 250 scenarios for tomorrow's values. For each of the scenarios, the portfolio is valued using full, non-linear pricing models. The third-worst day is then selected as being the 99% VaR. The biggest limitation of this method is that historical trends may not hold in the future.

Picture 2
Calculation of Historic VAR

Historic simulation calculates the P&L for each day based on observed changes in price



Source: Capital Market Risk advisors Ltd.

The advantages and disadvantages of each form of VaR are summarized in Exhibit 1:

Exhibit 1

	Parametric VaR	Monte Carlo VaR	Historical VaR
Captures non-normality of risk factor returns	○	◔	●
Captures non-linearity of price sensitivities	○	●	●
Little time required to compute	●	◔	○
Lack of dependence on historical observations	◑	◑	◔

Source: Risk analytics.

Selecting the method

The choice of the method to calculate VaR depends on several factors. Dealers and end users with complex portfolios set a goal of implementing a consistent, firmwide VaR that reflects their outlook preferences and the complexity of the portfolio. For portfolios with options the historic VaR and simulation VaR produce superior results compared to the Variance/Covariance VaR. However, the systems,

LTCM: Lack of stress testing creates market mayhem

In 1994, John Meriwether, the famed Salomon Brothers bond trader, founded a hedge fund called long-term capital management. Meriwether assembled an all-star team of traders and academics in an attempt to create a fund that would profit from the combination of the academics' quantitative models and the traders' market judgment and execution capabilities. Sophisticated investors, including many large investment banks, flocked to the fund, investing $1.3 bn at inception. But four years later, at the end of September 1998, the fund had lost substantial amounts of the investors' equity capital and was teetering on the brink of default. To avoid the threat of a systemic crisis in the world financial system, the Federal Reserve orchestrated a $3.5 bn rescue package from leading US investment and commercial banks. In exchange the participants received 90% of LTCM's equity.

LTCM's main strategy was to make convergence trades. These trades involved finding securities that were mispriced relative to one another, taking long positions in the cheap ones and short positions in the rich ones. There were four main types of trade:

- Convergence among US, Japan and European sovereign bonds;
- Convergence among European sovereign bonds;
- Convergence between on-the-run and off-the-run US government bonds; and
- Long positions in emerging markets sovereigns, hedged back to dollars.

According to the complex mathematical models used by LTCM, the positions represented low risk. The key assumption made by LTCM was that high correlation existed between the long and short positions. Certainly, historical trends suggested that correlations between corporate bonds of different credit quality would move together (a correlation of between 90-95% over a 2-year horizon). During LTCM's crisis, however, this correlation dropped to 80%. Stress-testing against this lower correlation might have led LTCM to assume less leverage in taking this bet.

However, if LTCM had used stress testing it would have been much better off. The correlation had dropped to 75% in 1992 (Jorion, 1999). Simply including this stress scenario in the risk management of the fund might have led LTCM to assume less leverage in taking this bet.

The ultimate cause: Flight to liquidity

LTCM also underestimated the importance of liquidity, while being obsessed with market risks. The ultimate cause of the LTCM debacle was the "flight to liquidity" across the global fixed income markets. As Russia's troubles became deeper and deeper, fixed-income portfolio managers began to shift their assets to more liquid assets. In particular, many investors shifted their investments into the US treasury market. In fact, so great was the panic that investors moved money into the most liquid part of the US treasury market—the most recently issued, or "on-the-run" treasuries. While the US treasury market is relatively liquid in normal market conditions, this global flight to liquidity hit the on-the-run treasuries hard. The spread between the yields on on-the-run treasuries and off-the-run treasuries widened dramatically: Even though the off-the-run bonds were theoretically cheap relative to the on-the-run bonds, they got much cheaper still (on a relative basis).

What LTCM had failed to account for is that a substantial portion of its balance sheet was exposed to a general change in the "price" of liquidity. If liquidity became more valuable (as it did following the crisis) its short positions would increase in price relative to its long positions. This was essentially a massive, unhedged exposure to a single risk factor. This situation was aggravated by the fact that the size of the new issuance of US treasury bonds has declined over the past several years. This has effectively reduced the liquidity of the treasury market, making it more likely that a flight to liquidity could dislocate this market.

Source: www.erisk.com.

Table 1 : The advantage and disadvantages of all the models

Method	Advantages	Disadvantages
Variance/ Covariance	• Easy to understand • Least computationally intensive • Widely used in industry • Easiest to implement	• Does not fully capture non-linear risks • Assumes normally distributed returns and constant volatilities • Does not capture "Fat Tails"
Historic Simulation	• Easy to understand • Can capture non-linear risks • Actual distribution • Incorporates "Fat Tails"	• Can be data intensive • Assumes past is a fair representation of the present
Monte Carlo Simulation	• Accommodates a variety of statistical models and assumptions • Can capture non-linear risks, • Can apply multiple time periods.	• Does not capture "Fat Tails" • Computationally intensive • Less transparent/more difficult to understand

Source:Capital Market Risk advisors Ltd.

model, data, personal, educational and time requirements of the historic and simulation VaRs often result in the use of Variance/ Covariance or multiple VaR methodologies on an interim basis. The choice between historic and simulation VaR largely depends on the outlook preferences of users and the desire to perform sensitivity analysis. Historical VaR is based on actual, past market experience whereas simulation VaR is based on the users outlook and expectations.

Key issues in VaR modeling

Issues that should be addressed in VaR modeling are:

- **Robustness**: How accurately the risk is forecasted by the model.
- **Risk volatility**: Risk forecasts fluctuate considerably from one period to the next; this is measured by the volatility of risk forecasts.
- **Measuring horizon**: Regulators require that risk be forecast with at least one year of data and usually no more than one year.
- **Holding period:** Regulations require that risk be forecasted over a 10-day holding period.
- **Non-linear dependence:** Correlations typically underestimate the joint risk of two or more assets.

The important dimensions influencing the method to be selected are:

- The length of the time horizon.
- Correlation assumptions.
- The mathematical model.
- Percentage of outcomes to be considered.
- Other risk-management tools being combined with VaR.

Conclusion

Though in a few cases such as Barings and Orange County, VaR models have been blamed for creating distress situations, they cannot be faulted completely. It should be understood that any model points at possibilities but it is the judgment of the user that is more important in taking a call. VaR models are applied widely to different forms of securities and are used extensively. A better understanding of them will help make better decisions. n

Reference # 15-03-01-04