Risk Not in VaR: A Perspective with Some Practical Examples

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The Value at Risk (VaR) framework is now an industry standard to measure the risk associated with a given portfolio of financial instruments. VaR finds favor because it is easy to understand. It is simply one number which gives you a rough idea about the extent of risk in the portfolio. It is measured in terms of price units (dollars, euro) or as a percent of the portfolio value. Value at Risk is applicable to stocks, bonds, currencies, derivatives, or any other assets with price. This is why banks and financial institutions like it so much – they can compare profitability and risk of different units and allocate risk based on VaR (this approach is called risk budgeting).

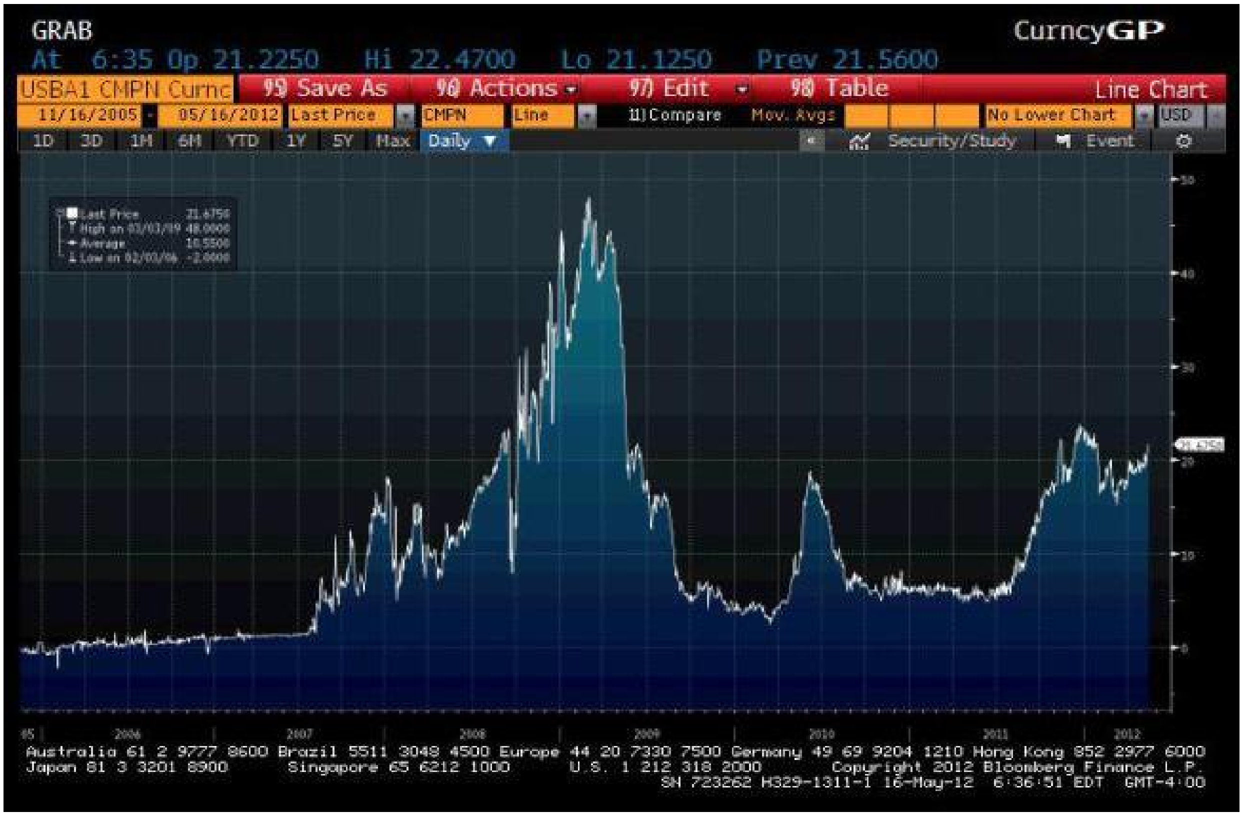
Risk Not in VaR (RNIV)

While VaR has found favor in part because it is easy to understand, it is simplification of real world. The main behavior of the real world is captured but some features are discounted to avoid making the model too complex and also because historically they never played a crucial role.

The financial crisis of 2008 proved that some previously ignored data behaviors – e.g., a tenor adjustment on a basis swap can suddenly and significantly contribute to a catastrophic event. Tenor adjustments were ignored in many VaR models. It is a premium expected by a party which pays coupons at a higher frequency then its counterparty.

When two parties enter into a swap agreement where one party makes a monthly payment and the other pays quarterly, a tenor adjustment occurs. The party that pays monthly and receives quarterly will face credit risk. Hence that party demands a premium in its quarterly received coupons.

Prior to 2008, the risk of a basis swap was quite minimal. Indeed, primarily because of liquidity concerns, spreads in 1 month and 3 month swaps in the US were just .25 basis points (bps). Consequently, basis swap risk was mostly ignored in VaR models.



Courtesy Bloomberg

However, in the wake of the collapses of Bear Stearns and Lehman Brothers (which significantly spiked the counterparty credit risk concerns and fears of financial institutions), spreads for the aforementioned swaps skyrocketed all the way to 41 bps during the peak of the 2008 crisis. VaR models did not capture this spike in risk.

In this article we would like to discuss various examples where we will demonstrate that there are some risks which are not covered in VaR.

First example we will discuss is historical simulation. Historical simulation of interest rates scenarios are most widely practiced VaR methodology in measuring interest rate risk. We will explain the historical simulation on 1 day VaR context. In this process, daily changes in historical interest rate curves over a specific period (e.g. 100 or 500 days) are computed and then applied to the current interest rate. This generates a series of scenarios, each of which is given equal probability and valuation of the portfolio is done, then we calculate the worst change in valuation with given confidence interval. The challenge we face is measuring the change in the historical curves which can be computed as an absolute or relative change. While choosing absolute change method can result in negative interest rates, relative changes can lead to unrealistic movements. For example, during low interest rates in historical data, the relative change may be high; but applying the same ratio to current interest rate will generate unrealistic scenarios. Hence, making either of the choices leaves us exposed to some amount of risk because specific interest rate movement on a particular day might not be captured in the VaR model due to the choice of method of change in interest rate curves.

Another market behavior which historical simulation does not capture is the volatility clustering. In the historical simulation every event in the past is given equal probability; but there are times when there is a momentum in the markets i.e.: higher changes follow further higher changes and vice versa.

Modeling of interest rates is also an example where we simplify the real world and hence there are risks which are not covered in VaR. The interest rate curves have many tenors associated with them. All these tenor rates are highly correlated. Hence three major types of movements are captured. These three movements are parallel up or down shift of the yield curve, twist in the yield curve where short end moves up and long end moves down and vice versa, finally curvature in the yield curves meaning short and long end moving in the opposite direction of middle part of the curve. We use the methodology of principal component analysis to capture these movements from historical data. Although the tenor rates are highly correlated but still there is some level of independence among the tenors and hence measuring all the interest rate movements just by three types of movements will expose us to risk not captured by our VaR model.

Another example is stock price movement. Black Scholes theory of option pricing is based on the assumption that stock returns are normally distributed. In real world this assumption is far from being correct. Returns data have fat tails and skew-ness demonstrating trends. Also there is a momentum effect in the data where higher returns follow similar higher returns and vice versa. This behavior is not captured in the VaR models used to measure risks in stock and their options portfolio.

We can observe RNIV at portfolio level as well. Let's imagine a hypothetical situation, where we have two companies GE and Morgan Stanley. In this hypothetical situation both have credit rating "A". We buy a 1 yr GE bond and also to make it risk free we buy a CDS from Morgan Stanley. In this process we pay a premium to Morgan Stanley. Suppose after a month market feels that the credit rating of Morgan Stanley has declined, this will imply that a similar CDS from Morgan Stanley will be substantially cheaper. This will degrade the market value of our portfolio (bond and CDS) and our VaR model may not be able to capture that because the rating agencies might have not updated their ratings. It can also happen that rating agencies believe that market devaluation of Morgan Stanley is not sufficient to degrade its rating.

One more risk which gets generated and not covered in VaR is 'generalization of distribution'. To make model simple and manageable risk managers generalize the distribution of major component of in the portfolio to whole portfolio. Some examples of this:

1. Suppose we have a portfolio of currencies and majority of them are in USD, rest being others. Risk managers generally study the behavior of major currency (in our example USD) and come up with its distribution. For sake of simplicity they force that distribution to rest of the currencies in the portfolio. In interest rate curves, not all tenors in every currency follow mean reversion, but taking the economic theory into account and behavior followed by major tenors this distribution is forced to all currencies.
2. One more classic example is the concept of interest rate parity in foreign exchange. The concept of interest rate parity is generally true among the most liquid currencies. But this concept is not true with illiquid currencies. But in a large portfolio, this concept is forced in all the currencies.

Finally if we see a VaR model, it is basically model within a model. The first model simulates the market scenarios; second model within it prices the underlying asset/portfolio on each simulated scenario. The first set of compromise is made in simulating future behavior of market scenarios. We have discussed this in the examples of interest rates and stock prices in the above. Second model consists of valuation model. This model values the underlying in each scenario. In VaR models, it is said that more the number of simulations better is view about the risk. The valuation has to be performed in each simulation and in order to get the results faster many approximations are done in the valuation model. In case of interest rate risk, change in valuation of bonds is done by using duration convexity approach, in options portfolio case greeks are used for calculation of change in valuation. Mathematical theory clearly says that these approximations can only be used when there is minute change in the risk factors. There is no clear cut definition what this minute measure is. In most of the VaR models this aspect is fully exploited to get results faster. This problem also surfaces when the risk measurement is done using nested stochastic simulation. In nested stochastic simulations simulation is performed at each simulated event. This is again a risk which is not covered by the VaR model.

From the regulator's perspective the concept of Risk Not in VaR has been discussed in Basel 2.5. There is a huge stress to find risks which are not covered by VaR models. There is clearly no fixed recipe to find these risks because every risk factor has a different behavior also this behavior keeps on changing with arrival of new products and market conditions. Further adding to the challenge is the fact that every portfolio may have its own set of risks which may yet to be discovered. Apart from being vigilant about these risks, stress testing is one way where their impact is evaluated. Stress test models are a way to develop alternate model/relationships that portfolio values have with other macroeconomic variables. Their result is a number like VaR and hence gives us an estimate of loss in a given scenario. The comparison of this number with VaR gives us some idea of any un-covered risk.

Concluding thoughts

Data is a natural phenomenon but models are man-made simplifications of that phenomenon. Consequently, there are no models that can completely capture all available information from the data and predict all future behavior. This problem only gets worse when there is limited and unreliable data. Adding to this - VaR models are model within a model. Risks Not in VaR are those risks which get left out in the simplifications of the real world. The points discussed in this article are some of the real world examples where those risks are not captured. These risks play dormant when the times are good because everything goes as per the expectations of the business. But those risks may suddenly become active and influential during un-expected events. Interestingly every portfolio/asset will have their unique set of risks which may not be covered by their respective VaR model. Consequently, modelers and business experts have to analyze business problems from various alternative perspectives also to achieve the best result. They need to compliment the model with alternative scenarios, through other more similar distributions, similar businesses (through expert judgments and independent studies) to support the output delivered by the VaR model.

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