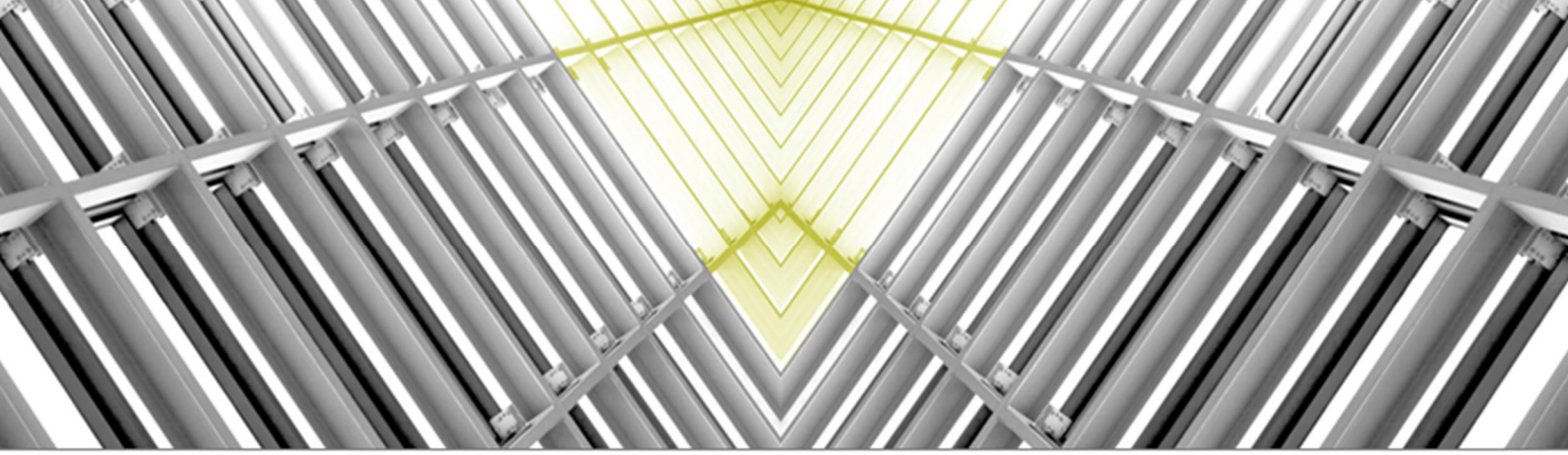


RISKDATA HuLK VALUE-AT-RISK

June 2016

RISKDATA
numbers you can count on

Contents

1. What Is HuLK VaR

VaR is an estimation of the maximum amount that a security, a portfolio of securities, or an index, may lose at a given time horizon for a given level of confidence. For example, the "1 day 99% VaR" of the S&P500 index being equal to 4% means that the estimated probability of the S&P falling more than 4% over the course of a day is less than 1%.

Riskdata proprietary HuLK VaR model has been developed to overcome the possible over- or under-estimation of the risk during a temporary market crisis. As a matter of fact, it provides a more responsive estimate in that it reacts swiftly to a change of market regime. It also attempts to anticipate increases and decreases in VaR numbers by identifying micro-signals which can be often be seen in pre- or post-shock periods. Backtests performed on shorter time periods (one year or even a few months) show that the frequency of exceptions during turmoil periods is more in line with the specified VaR level than when considering traditional Monte Carlo VaR models.

The behavior of HuLK VaR in the various historical crisis and, in particular, through the Credit Crunch in 2008 has shown how effective it is at even anticipating crises, rather than simply reacting to them.

While these may all be good reasons indeed for why our proprietary VaR model bears its name, it is the very nature of the market and the underlying probability laws governing it which are at the root of this choice, as will be revealed when diving into our methodology.

2. Why Use HuLK VaR

The main reasons for using Riskdata HuLK VaR indicator are:

- Unlike more traditional VaR measurement, HuLK VaR is able to avoid over- and understimation of risk in all market regimes.
- HuLK VaR is more reactive than traditional VaR measurement. It can increase by a factor of two or more within a few days following a shock or even anticipating a shock. Similarly, it rapidly falls back to its initial value if the market volatility returns to its long-term levels.
- It is a much better VaR estimate for managers who are involved in daily decisions and who actively use VaR in order to set limits. In such a use case, traditional VaR can be misleading and lead the user to believe that the risk he or she is taking is significantly lower than what it is in reality.

  As HuLK VaR calculation concentrates on the extreme values of the latest months of performance history, it *captures the fat tails* of the risk distribution and adequately *reacts to volatility clustering*.

2.1. Comparison between HuLK VAR and Traditional VaR

2.1.1. Backtest methodology

The Basel Committee specifies a methodology for backtesting VaR. The 1 day VaR 99 results are compared against daily P&L's. Backtests are performed quarterly using the most recent 250 days of data. Based on the number of exceedances experienced during that period, the VaR measure is categorized as falling into one of the three colored zones:

- Green: Up to 4 exceedances => No particular concerns raised.
- Yellow: Up to 9 exceedances => Monitoring required.
- Red: More than 10 exceedances => VaR measure to be improved.

2.1.2. Backtest results

Backtests have been performed for the 1 day VaR 99 over the past 10 years on a universe of 237 securities & market variables (equity, commodity, real estate, hedge funds indices, fixed income, government bonds, corporate bonds, CDS, volatility and currencies).

The table below summarizes the results:

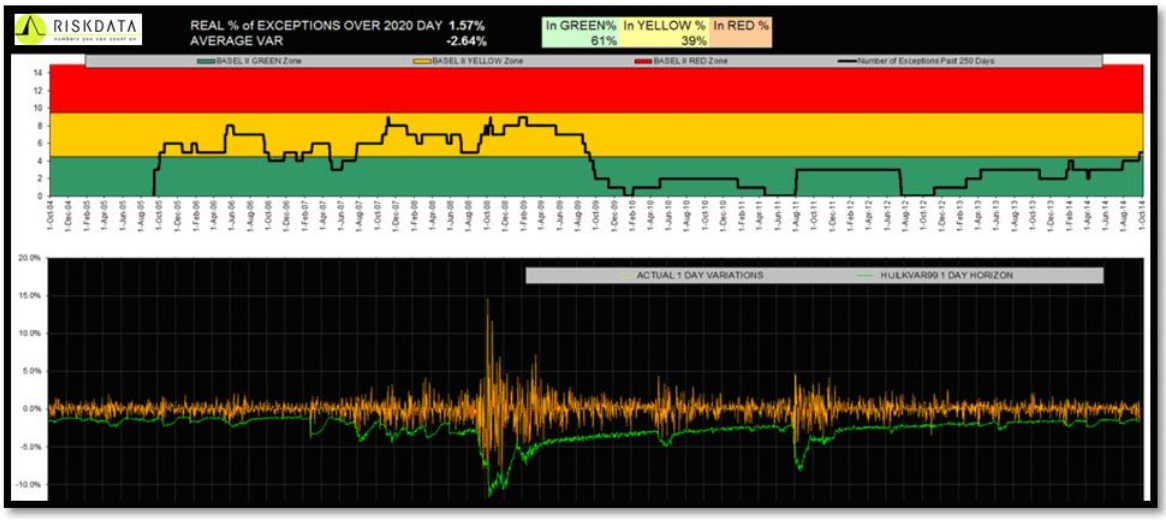
	%EXCEPTIONS	% in GREEN	% in YELLOW	% in RED	in RED > 5%	in RED > 10%	in RED > 25%
HuLKVAR 99	**1.61%**	**64.13%**	**33.25%**	**2.62%**	22.4%	8.4%	0.4%
STDVAR 99	2.15%	58.04%	24.36%	17.60%	89.9%	79.3%	17.7%

Table description:

- 1st column shows the frequency of "exceptions" or exceedances (i.e. the actual loss being larger than the VaR). This figure is more in line with the specified VaR level (i.e. 1% of the time for the VaR 99) for the HuLK VaR than for the traditional VaR, respectively 1.61% vs. 2.15%.
- 2nd, 3rd and 4th columns show the proportion of time during which the VaR is in the green, yellow and red zones. The traditional VaR is in the red zone 17.60% of the time while the HuLK VaR is in the red zone only 2.62% of the time.
- 5th, 6th and 7th columns show the proportion of assets that were in the red zone more than 5%/10%/25% of the time. The proportions are far higher for the traditional VaR (up to 42 times higher).

Based on this sample, Riskdata HuLK VaR model appears to give more accurate results than a traditional Monte Carlo VaR model.

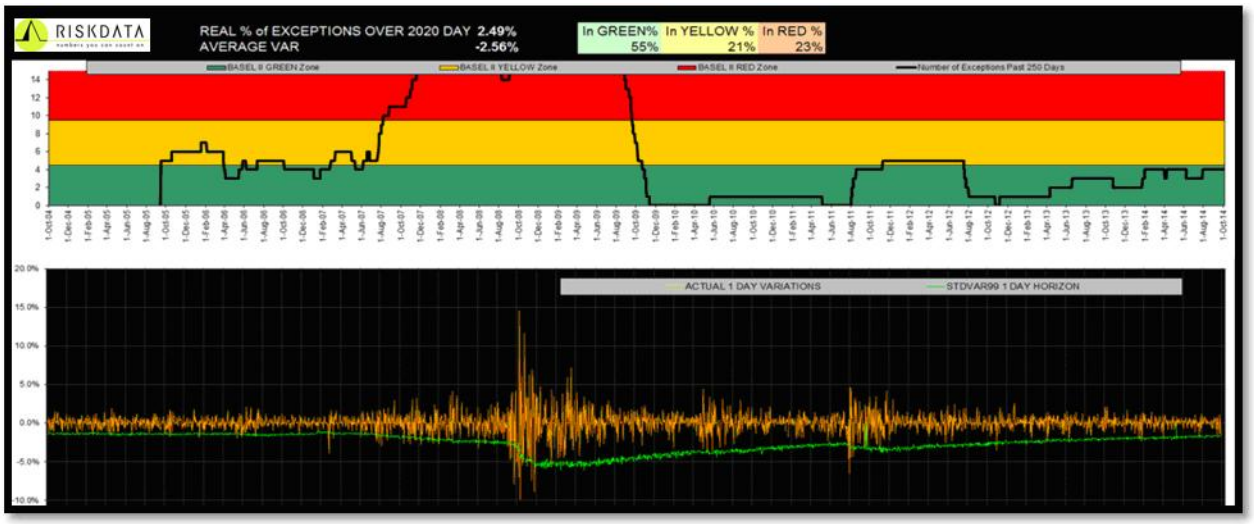
S&P 500 total return HuLK VaR backtests results



The figure above contains 3 parts:

- Top: some global statistics – the number of exceptions is 1.57%, the average of VaR 99 values is 2.64%, and the HuLK VaR is in the green zone 61% of the times, in the yellow zone 39% of the times and never in the red zone.
- Middle: the graph showing the number of exceptions over the last 250 days and the corresponding zone (green, yellow, red).
- Bottom: the index returns are in orange and the VaR 99 is in green.

S&P 500 total return traditional VaR backtest results



Riskdata HuLK VaR reacts rapidly, especially during 2007/2008 period of turmoil. This allows the frequency of exceptions to be far lower for the HuLK VaR than for the traditional VaR (1.57% vs. 2.49%) while the average VaR is very close (2.64% vs. 2.56%). Furthermore one can see that when HuLK VaR is exceeded, it is by a far smaller amount than in the case of the traditional VaR.

3. Methodology

3.1. Mathematical Background

The HuLK VaR algorithm starts from a prior distribution, given by Monte Carlo scenarios of the risk factor. The prior distribution is then "distorted" so as to at least match percentiles which are empirically estimated over the recent past. The length of this recent past period can be specified, from 1 month to 1 year. Percentiles below one standard deviation of the prior distribution are estimated on half of the period, progressively extended to the full period for higher percentiles. The distortion multipliers, which depend on the ratios between the percentiles of the prior distribution and those empirically estimated, are prevented from being smaller for high percentiles than for lower ones, thus making the HuLK VaR reactivity only on the conservative side in turbulent markets, but not on the downside when markets are temporarily less volatile than on the long run.

The algorithm takes as input Monte Carlo scenarios, as well as recent historical returns, and computes percentiles of the prior and empirical distributions. Then the distortion multipliers are calculated and finally the HuLK VaR is computed. The HuLK VaR computation is consistent with Riskdata full re-pricing methodology for portfolio and derivative or complex securities: they are re-priced using the underlying risk factors' distorted scenarios.

3.2. Comparison with Other Methods

3.2.1. ARCH, GARCH

This approach considers that fat tails of financial series are explained by their stochastic volatility. It monitors the current volatility as a stochastic process, estimates its evolution through the horizon of simulations, and estimates returns with this time varying volatility. In practice, due to the rather short horizon of simulations (10 to 20 days) the result is close to that of an exponentially weighted moving average of the volatility with a strong decay parameter, only remembering the recent 1-2 months.

3.2.2. Pure Historical

This method, which uses actual historical returns as deviates, is known to be lured by abnormally calm periods ("calm before the storm" effect) if the historical period is short, but lacks reactivity in turbulent markets when the historical period is longer.

3.2.3. Fat-tailed Distributions (e.g. Student t)

The question here lies in the historical length that is used to estimate the exponent α of the distribution tail power decay. Estimating α with too much inaccuracy, using traditional technique such as Hill estimator, requires a rather long period of time, hence strongly reducing the reactivity of the measure, while its over-reactivity to big shocks makes it still subject to sudden uncontrolled jumps.

3.2.4. Gaussian Mixture

This is, among classical techniques, the one which produces figures closest to the ones obtained with Riskdata HuLK VaR model. It is a mixture of Gaussian distributions based on historical periods of different lengths, from that of the prior (one to several years, or exponentially weighted with a nonreactive decay parameter) to that of the short history (one to two months, or exponentially weighted with a reactive decay parameter). This technique has a reactive element and is also prevented from falling below the long-term volatility, thanks to its long-term element. However, while this measure is reactive, it is not anticipatory.

3.2.5. Heteroleptokurtic Processes

The anticipatory nature of the HuLK VaR comes from the "heteroleptokurticity" of financial markets. An heteroleptokurtic process is similar to a Lévy α -stable process in which, just as a GARCH model allows stochastic volatility, the exponent α is allowed to be stochastic. In such processes, usual estimators of α, such as Hill's one, are of little use because only the most recent past is relevant. However, the ratio between empirical extreme percentiles over a short period of time and the standard deviation is representative of the parameter α (although no fast convergent estimator can be extracted from it[1]).

As its methodology is based on recent extreme percentiles, the HuLK VaR is sensitive to the latest variations of α and not only to the volatility ones, as is the case with GARCH processes or Gaussian mixtures. This feature is most likely the main reason for its predictive power. This is further demonstrated as one can observe empirically that the ratio HuLK VaR/Standard VaR is a good predictor of the probability of future market disruptions.

3.3. Parameters

The following parameters may affect the results of HuLK VaR calculations:

- The HuLK VaR "Period" is the historical period taken into account for the computation of extreme percentiles (see Mathematical Background above). The recommended setting is 2 months.
- The "Trend" parameter allows centering the VaR around the asset average trend over that historical period. We recommend using this parameter.

The backtests previously presented were produced using the "2 Months" and "Trend" parameters.

[1] See Falk M., "*On Testing the Extreme Value Index Via the Pot-Method*", The Annals of Statistics, Vol. 23, No. 6 (Dec., 1995), pp. 2013-2035

About RISKDATA:

Riskdata makes asset managers' life easier with an all-in-one solution that computes any risk indicators for all asset classes with state-of-the-art mathematical models. Our data management team collects and cleanses the data necessary for risk calculations and, as a consequence, implementation is smooth and quick.

With its unique "real-time" computation technology, Riskdata also gives asset managers tools to be smarter: better understanding of risk with complete drill-down capabilities (risk contribution by sector, by country…) and instantaneous pre-trade simulations to measure the impact on VaR or volatility.

Riskdata operates internationally with buy-side financial institutions mainly based in New York, London, Paris and Frankfurt and ranging from start-up Hedge Funds to large Asset Managers.

Riskdata was named "Best Risk Management Solution" at the Wealth & Finance Alternative Investment awards in 2015.

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