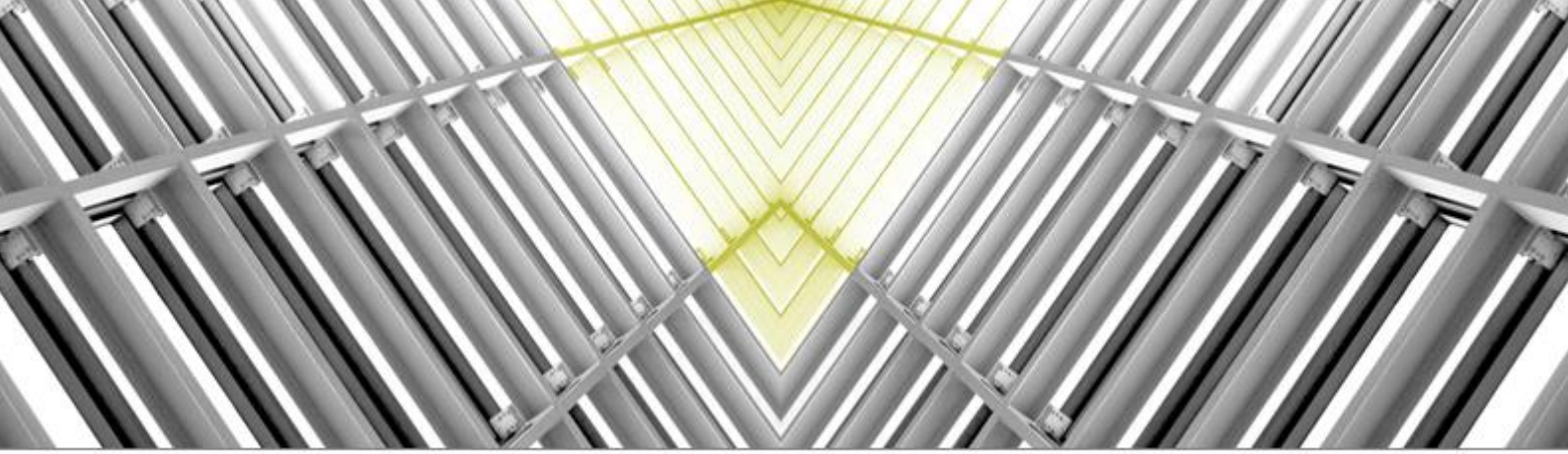


SHOCK VALUE-AT-RISK

August 2015

RISKDATA

numbers you can count on

Contents

1. What is Shock VaR

VaR is the maximum estimated 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 Shock VaR has been developed to overcome the possible over- or under-estimate of the risk during a temporary market crisis. It is a much more responsive estimate that reacts rapidly to changing market regimes. It attempts to anticipate increases and decreases in the VaR by using micro-signals that can be revealed sometimes 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 the Shock VaR through the various crisis and, in particular, through the Credit Crunch in 2008 has shown how effective it is at anticipating crises, rather than simply reacting to them.

2. Why Use Shock VaR

The main reasons for using the Shock VaR indicator are:

- ▷ Unlike more traditional VaR measurement, Shock VaR is able to avoid over and under estimation of risk in all market regimes.
- ▷ Shock 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 anticipating a shock. Similarly, it rapidly falls back to its initial value if the market volatility returns to long-term levels.
- ▷ It is a much better VaR estimate for those players who are involved in daily decisions and who use VaR in order to set limits. For such an operator, the traditional VaR can temporarily mislead the user into thinking that the risk is significantly lower than what is actually happening in reality.

As Shock VaR calculation concentrates on the extreme values of the latest months of performance history, it *anticipates the fat tails* of the risk distribution.

2.1. Comparison of Shock VAR and Traditional VaR

2.1.1. Backtest methodology

The Basel Committee specified a methodology for backtesting VaR. The 1 day VaR 99 results are to be compared against daily P&L's. Backtests are to be 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 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:

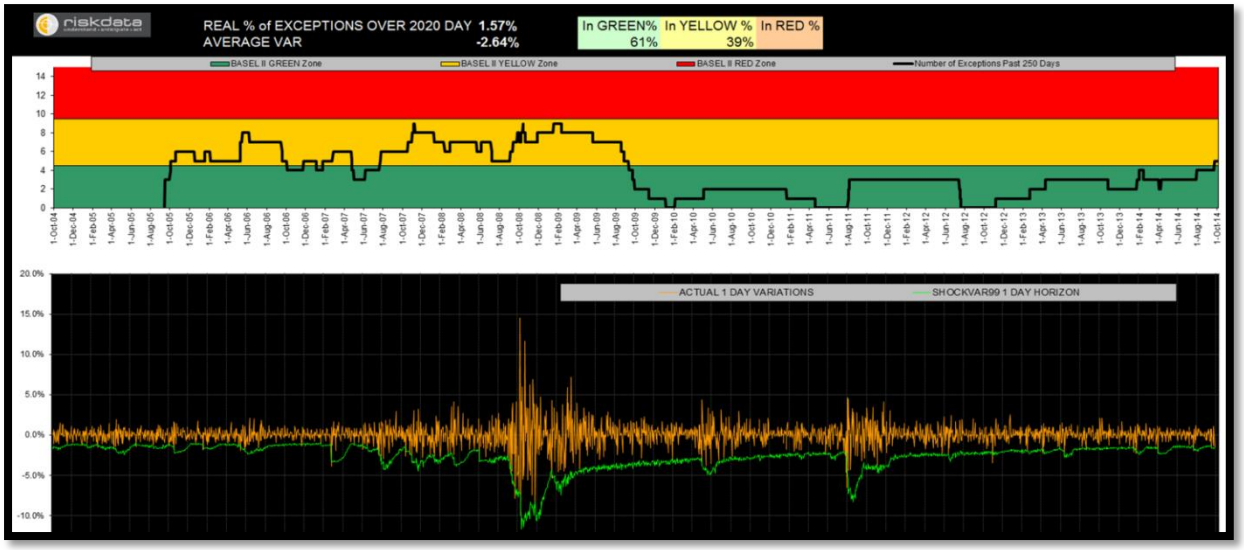
	%EXCEPTIONS	% in GREEN	% in YELLOW	% in RED	in RED > 5%	in RED > 10%	in RED > 25%
SHOCKVAR 99	**1.61%**	**64.13%**	**33.25%**	**2.62%**	22.4%	8.4%	0.4%
STDVAR 99	2.15%	58.04%	24.36%	17.60%	89.9%	79.3%	17.7%

Table description:

- 1st column shows the frequency of "exceptions" (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 Shock 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 Shock 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, the Shock VaR appears to give more accurate results than a traditional Monte Carlo VaR model.

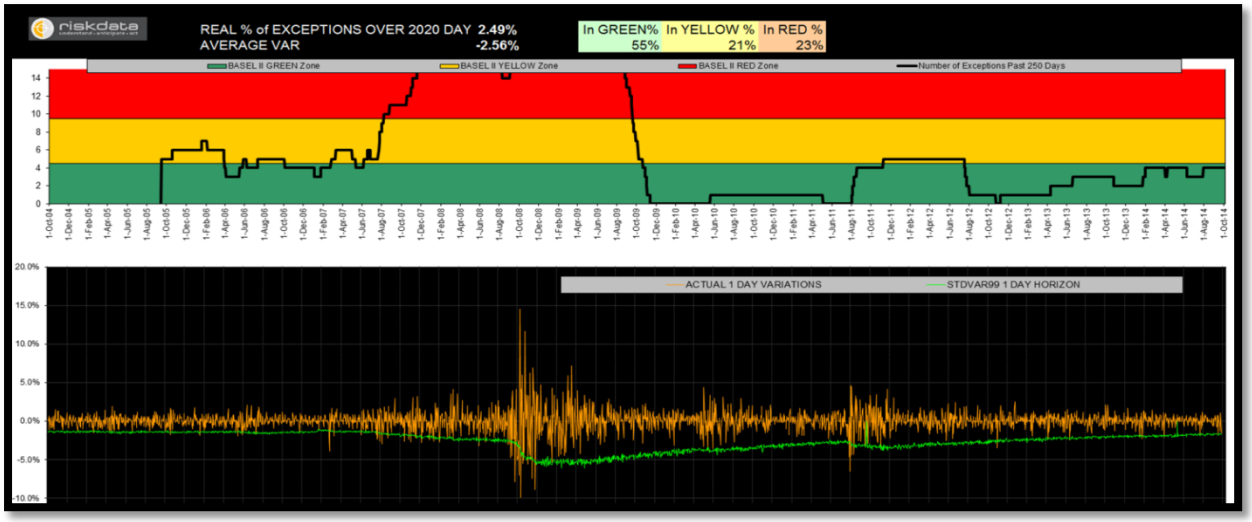
S&P 500 total return Shock VaR backtests results



The figure above contains 3 parts:

- Top: some global statistics – the number of exceptions is of 1.57%, the average of VaR 99 values of 2.64%, the Shock 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 in green.

S&P 500 total return traditional VaR backtest results



Shock VaR reacts rapidly, especially during 2007/2008 period of turmoil. This allows the frequency of "exceptions" to be far lower for the Shock VaR than for the traditional VaR (1.57% vs. 2.49%) while the average VaR is very close (2.64% vs. 2.56%). Besides, one can also see that when Shock VaR is overpassed, it is by far less than the traditional VaR.

3. Methodology

3.1. Mathematical Background

The Shock VaR algorithm starts from a prior distribution, given by the 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 Shock 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 the Monte Carlo series, as well as the recent historical returns, compute percentiles of the prior and the empirical distributions, then the distortion multipliers and finally the Shock VaR. The Shock VaR computation is compatible with "full re-pricing" methods for portfolio and derivative or complex securities as they are fully 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 of inaccuracy, using traditional technique such as Hill's estimator, requires a rather long period of time, hence strongly reduces 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, that which produces figures closest to the Shock VaR. 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 reactive technique, due to its reactive element, is prevented from falling below the long-term volatility, thanks to its long-term element. This measure is reactive, but not anticipatory.

3.3. Heteroleptokurtic Processes

The anticipatory nature of the Shock VaR comes from the "heteroleptokurticity" of financial markets. A 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 Shock VaR is sensitive to the latest variations of α and not only of the volatility, as in GARCH processes or Gaussian mixtures. This feature is most probably the reason for its predictive power. Indeed, one can empirically observe that the ratio Shock VaR/Standard VaR is a good predictor of the probability of market disruptions.

[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

3.4. Affecting Parameters

The following parameters affect the results of Shock VaR calculations:

- ▷ The Shock VaR “Period” is the recent past 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 recent past period. We recommend using this parameter.

The backtests previously presented were produced with the “2 Months” and “Trend” parameters.

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: they better understand their risk with complete drill-down capabilities (risk contribution by sector, by country…), and they can run instantaneous pre-trade simulations to measure the impact on VaR or Volatility.

Riskdata was founded in 2000 and the company operates internationally. Clients are buy-side financial institutions mainly based in New York, London, Paris and Frankfurt, ranging 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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