BUBBLE VALUE-AT-RISK: A NEW TOOL FOR RISK MANAGEMENT

Max Wong, Author
Review of VaR-- VaR as a quantile

- VaR of confidence level $c$ is the $(1-c)$ quantile of the distribution of PL estimated over the next 1 day horizon.
- Example. Historical simulation VaR; a 97.5% HS VaR is the 2.5% quantile of the sample histogram.
- The expected tail loss at coverage $c$ is beyond VaR—hence, VaR sometimes blamed for “illusion of safety”.

![Graph showing frequency distribution with VaR level and expected tail loss](image)
Review of VaR-- VaR as ranked PL

- VaR as a ranked P&L
- Using a 250-day window, VaR at $c=97.5\%$ is approx. the 7$^{th}$ ranked loss.
VaR assumes daily returns are *independent & identically distributed* (IID).

The IID assumption “allows” the estimation for the next day i.e. past observation is a good indication of the future!

(mathematical quest for *invariants*)

In above, HS VaR uses a rolling window (of 250 days or larger).
Review of VaR—residual of time series decomposition

- VaR is the quantile of the IID “noise” component in the classical decomposition of time series.
  
  \[ \text{Price series} = \text{trend} + \text{cycle} + \text{noise}(\sim\text{IID}) \]

- Noise component derived by differencing (taking returns). Most financial time series are I(1) integrable.

- The basic model is challenged by clustering, fat-tailness observed in the residuals.
Weaknesses of VaR—evidence from the crisis

- Forewarned by Danielsson et al. (2001) in paper “An academic response to Basel II”.
- Here we focus on 4 practical weaknesses highlighted by the credit crisis. BuVaR attempts to fix these.
  - Underestimation of tail risk
  - Late in crises warning & Procyclical
  - Risk symmetric—does not capture direction risks
  - Positional symmetry—does not distinguish between long & short positions
- These make VaR a useless warning system for crises and a poor tool for economic/regulatory capital.
Extreme events are not so rare.

- Most (basic) VaR models implicitly assume a normal distribution.
- Real crises happen more often than suggested by Normal dist– they are fat tailed, atypical events which cannot be forecasted using statistics i.e. *Black Swans*, Taleb (2007).
- Phenomena of clustering also increases event frequency.

**Table: Top 10 largest losses in Dow Jones index (1988-2008)**

<table>
<thead>
<tr>
<th>Event Date</th>
<th>Daily log return</th>
<th>Mean number of years between occurrences (if normally distributed) assuming volatility of 25% p.a.</th>
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<tr>
<td>19-Oct-87</td>
<td>-25.6%</td>
<td>1.86E+56</td>
</tr>
<tr>
<td>26-Oct-87</td>
<td>-8.4%</td>
<td>69,074</td>
</tr>
<tr>
<td>15-Oct-08</td>
<td>-8.2%</td>
<td>37,326</td>
</tr>
<tr>
<td>1-Dec-08</td>
<td>-8.0%</td>
<td>19,952</td>
</tr>
<tr>
<td>9-Oct-08</td>
<td>-7.6%</td>
<td>5,482</td>
</tr>
<tr>
<td>27-Oct-97</td>
<td>-7.5%</td>
<td>3,258</td>
</tr>
<tr>
<td>17-Sep-01</td>
<td>-7.4%</td>
<td>2,791</td>
</tr>
<tr>
<td>29-Sep-08</td>
<td>-7.23%</td>
<td>1,684</td>
</tr>
<tr>
<td>13-Oct-89</td>
<td>-7.16%</td>
<td>1,346</td>
</tr>
<tr>
<td>8-Jan-88</td>
<td>-7.10%</td>
<td>1,120</td>
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</table>
- VaR is surprised by the crisis – late warning.
- VaR is low during boom phase and high during bust.
- If used for capital, amplifies the boom/bust cycle -- *Procyclicality* risk (see Turner Review, which calls for *countercyclical* capital).
Asymmetric – VaR does not capture directional risks (only volatility).

Even though crash risks is clearly highest at the peak (Oct 2007) – where are all the credit risk hiding? Logically, a bubble is more prone to bursting at the top!
- Positional asymmetry-- Longs & shorts have same VaR even though a crash can only happen downwards (never up)!
- At the peak (trough), longs (shorts) are more at risk to crash (bounce)– extreme risks has a directional behaviour!
VaR is surprised by the crisis – late warning.
- Asymmetric – VaR does not capture directional risks (only volatility).
- Peak & base show about same VaR, even though the risk was highest just before the internet bubble burst.
Positional asymmetry-- Longs & shorts have same VaR even though a crash can only happen downwards (never up)!
- VaR is surprised by the crisis – late warning.
Asymmetric – VaR does not capture directional risks (only volatility).

Peak & base show about same VaR, even though the risk was highest just before the oil bubble burst.
Positional asymmetry—Longs & shorts have same VaR even though a crash can only happen downwards (never up)!

Risk of long/short equal?!
Why models underestimate during crisis

- Crisis contagion
- Feedback loop
- IID violated
- Returns serially correlated
- Vol clustering (stochastic)
- Fat tail dist of risk factor
- By CLT, portfolio dist fat tailed

Sudden regime shift

Assumption in many models

Extremistan (Black Swan)

Very likely (N. Taleb)
Statistical skew is a bad measure of direction risk

- Statistical skew is distorted by microstructure—trading around key levels.
- Example. Speculative attacks on pegged currencies.
- Due to occasional failed ‘attack’ on defended levels, short covering will see Skewness in the opposite direction to the latent risk.
Implied skew is a better measure of direction risk

- The true (latent) risk is downwards as reflected by implied skew from options markets
- Risk neutral density (distribution) is negatively skewed.

![Graph showing the movement of USDHKD 25delta Risk Reversal and HKD Currency from Oct-03 to Oct-10. The graph indicates a trend of latent risk being downwards.]
Why VaR is practically symmetrical

- Stats skew is noisy--explains why long/short VaRs are practically symmetrical (uninformative).


- Evidence that risk aversion at base and peak of bubble are unequal!
VaR is the quantile of the \textit{IID} component. But differencing (using returns) removes useful info about directional risk, leaving only volatility.

\textit{Price series} = \textit{Trend} + \textit{Cycle} + \textit{Residual} (\sim \textit{iid})

Proposal: Cycle breaks/compression (shaded zone) could produce observed phenomena.
Bubble VaR (buVaR) idea..

- Crashes are extremistan (precise measurement is impossible/unnecessary). Need to robustify VaR for capital purposes.
- Better to be approx. correct, than precisely wrong (Keynes dictum)
- Crashes are caused by cycle breaks
- “crashes” can only happen in the countetrend direction
- The larger a “bubble” forms on the upside (downside), the larger the risk of a crash (bounce), the long (short) positions are more risky to a crash (bounce)—risks of longs & shorts are unequal!
- So if bubble forms on upside (downside), risk for long (short) should be increased—we inflate negative (positive) side of distribution.
- The bubble measure $B_t$ is computed using “rank filtering” & must satisfy a few criteria, detailed in Wong (2011a).

The variable $R_n = \ln(X_n/X_{n-1})$ undergoes a transformation:

$$R_n \rightarrow \begin{cases} \Delta_t R_n & \text{if } \text{sign}(R_n) \neq \text{sign}(B_t) \\ R_n & \text{if } \text{sign}(R_n) = \text{sign}(B_t) \end{cases}$$

where $\Delta_t \geq 1$ the inflator is a function of $B_t$ and $n$ is the scenario number in the historical simulation VaR approach. We shall use a 1-year window, so $n=1,\ldots,250$. 
The inflator is then given by:

$$
\Delta_t = \min \left( \frac{\psi}{2\sigma_t}, \exp \left( \left( \frac{\operatorname{Abs}(B_t)}{B_{\max}} \right)^{\omega_2} \ln \left( \frac{\psi}{2\sigma_t} \right) \right) \right)
$$

(2)

where:

- \( \psi \): average of 5 most extreme (absolute) returns in all available history of that asset, capped by a circuit-breaker if applicable.
- \( B_{\max} \): largest absolute \( B_n \) observed in all history of that asset
- \( \sigma_t \): standard deviation of returns of the last 250 days
- \( \omega_2 = 0.5 \)

■ The form of the inflator ensures that buVaR is between VaR (lower limit) and a reasonable upper limit \( \psi \), and grows with the bubble.

P&L, \( y \), can be sampled. The buVaR at confidence level \( q\% \) is the expected shortfall of the distribution \( y \) estimated over a 1-day horizon at \( (1-q) \) coverage:

$$
BuVaR_q = E(y \mid y < \mu) \quad \text{where} \quad \Pr(y < \mu) = 1-q
$$

(3)
buVaR for Nasdaq index

- buVaR versus conventional expected shortfall (ES) for two crises.
buVaR for Nasdaq index

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buVaR for Oil futures

- buVaR versus conventional expected shortfall (ES) for various oil crises.
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![Graph showing VaR (%) loss and Price Level for different periods with ES (Longs), ES (Shorts), buVar (Longs), buVar (Shorts), and Oil future lines with Long/short unequal events noted.]
Summary

The buVaR model has following advantages:

- Its countercyclical – leads crises– countercyclical capital may dampen boom/ bust cycle.
- reflects risk asymmetry – long/ shorts unequal – only penalize positions which chase the bubble.
- Thicker & timelier capital buffer (multiple times of VaR) – protect against fat-tail risks & crashes in the *countertrend* direction.

Interesting points:

- buVaR is more *accurate* (though less precise) than VaR– a best guess of loss b/w VaR (an underestimate) and a credible upper limit.
- *IID* is dropped since conditional on cycle (its violated anyway during crises).
- Extremistan philosophy: focus on risk protection, not measurement.


Max Wong is a risk professional with 15 years of experience in financial services, and book-author of “Bubble value at risk: extremistan and procyclicality” (2011). Max’s current research is in the area of financial regulatory reform and innovative risk management. The views expressed in this presentation are his own and do not represent the views of any organizations that he is affiliated to.

For more information on my research visit: www.bubble-value-at-risk.com

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