Asset Liability Management in a Large Insurance Company

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Overview

- Background
- Assets
- Liabilities
- Assets and Liabilities
- Summary

About me

- PhD in Mathematical Statistics, Stockholm University 2007.
- Postdoc at the Centre for Theoretical Biology at the dept. of Mathematical Sciences, University of Gothenburg 2007–2008.
- Assistant Professor at dept. of Mathematics, div. of Mathematical Statistics, Stockholm University 2008–2009.
- Financial Mathematician at AFA Insurance from August 2009.
- All views presented here are my own and not necessarily representative of AFA Insurance!

About AFA

- Owners: Svenskt Näringsliv, LO and PTK. (All) municipalities and county councils are customers but not owners.
- AFA Insurance consists of three non-dividend paying companies.
  - AFA Sjuk: Sickness compensation in addition to that of the Social Insurance Office (Försäkringskassan).
  - AFA Trygg: Work injuries.
  - AFA Liv: Life assurance and severance pay.
- More than 3 million people insured, everyone through collective agreements.
- Assets under management: 205 billion SEK.
  Technical provisions: 138 billion SEK.

Definitions

- Strategic Asset Allocation (SAA): Asset allocation with respect to long term (> 1 year) risk preferences and long term views on risk premia and diversification. I include all passive management in this term.
- Tactical Asset Allocation (TAA): Asset Allocation with respect to short term views on the markets, i.e. “bets” on price movements, or identification of mispricing in the market. I include all active management, even within an asset class, in this term.
- Asset Liability Management (ALM): Asset allocation with respect to the liabilities’ cash flow.

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SAA vs. TAA

- SAA is usually done top-down, prescribing, e.g.,
  - allocation to different asset classes (equities, fixed income, property, commodities, private equity, hedge funds, etc.), possibly with geographic specifications for the larger asset classes.
  - duration for the fixed income,
  - credit exposure,
  - currency exposure,
  - rules for when rebalancing should occur,
  - how much the TAA is allowed to deviate from the above.
- The strategic portfolio is often described in terms of passively investable indices.
- The TAA is measured against this strategic benchmark.

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Objectives of AFA's asset management

- Ensure solvency.
- Low premium: asset returns pay for a part of the insurance.
- Stable premium in order not to interfere in the collective wage bargaining. (The premium is a percentage of the wage.)
- Not being overcapitalised since we cannot pay dividends.

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Risk versus return

- Risk and return may be measured in many different ways.
- For most reasonable measures the trade-off between risk and return produces an efficient frontier of portfolios with the least risk for any obtainable level of return.
- The portfolio return is increased by increasing the allocation to higher yielding assets, and risk is decreased by increasing the allocation of less risky assets, *and by diversification*.

Risk versus return, continued

- The Markowitz model is a single period model where risk is measured by volatility (finance jargon for standard deviation), and return by expected return.
- The Markowitz efficient frontier is very sensitive to the values of the parameters of the model: especially to the expected returns of the different assets, but also their volatilities and the correlations between them.
- Risk premium: The risk premium of an asset (class) is the expected return of that asset in excess of the expected return of a risk free asset. An asset with higher risk is often assumed to have a higher risk premium.

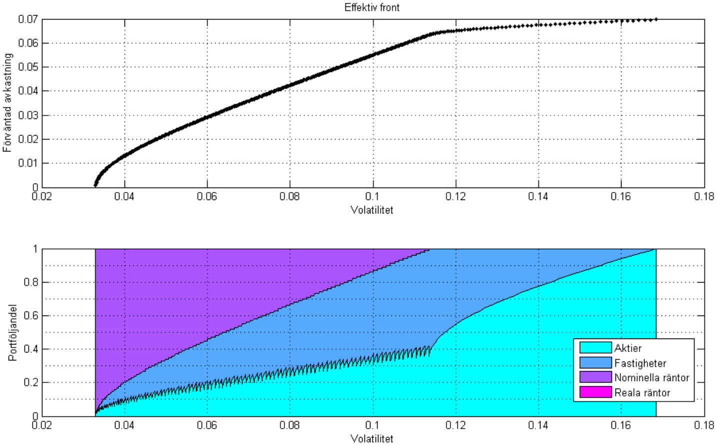

Figure: Fictitious efficient Markowitz frontier.

Heavy tailed asset return distributions

- Asset returns over short time horizons, say one day, are known to have heavy-tailed distributions.
- This is in part explained by varying volatility, so-called volatility clustering, but even when compensating for observed volatility, the heavy-tailedness remains.
- A scaled and shifted t-distribution with circa 3 degrees of freedom gives excellent fit for daily S&P500 returns (disregarding the volatility clustering).

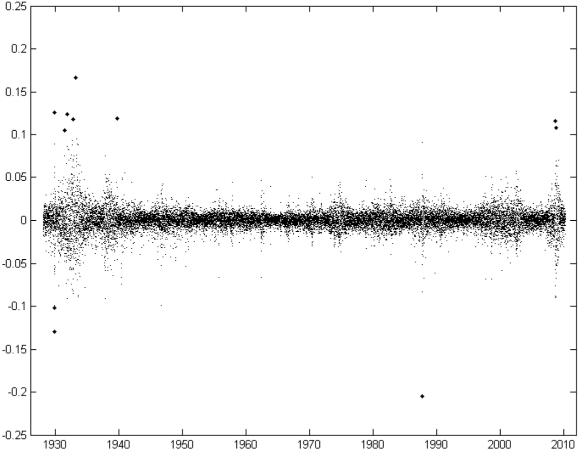

Figure: Daily returns of the S&P 500.

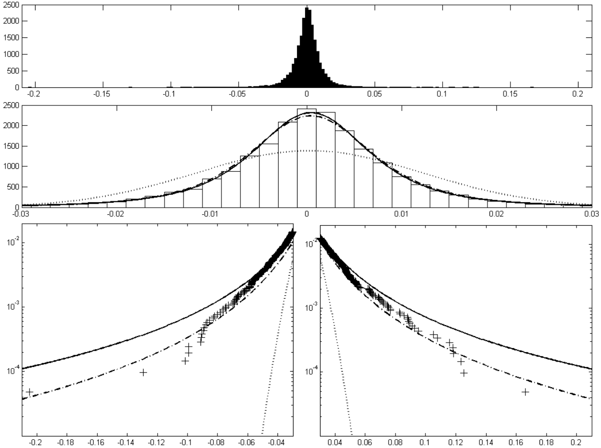

Figure: Daily returns fitted with t-distribution. Full lines $\nu = 2.53$ (ML estimate), dash-dotted $\nu = 3$, and dotted $\nu = \infty$ (Gaussian).

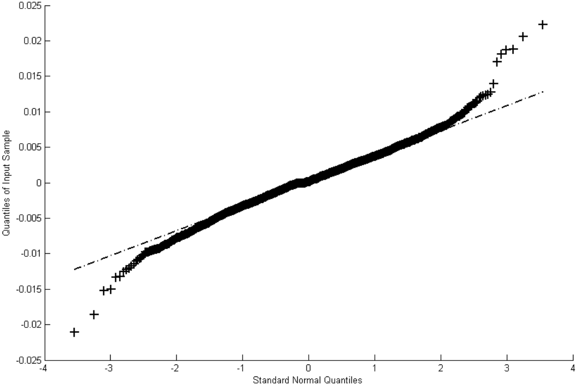

Figure: QQ Plot for daily total return on long Swedish government bonds.

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Heavy tails, continued

- Thus: infinite fourth, and possibly even third, moment which have implications for moment estimators:
  - LLN and CLT work for sample mean.
  - LLN, but not CLT, works for sample standard deviation and correlations. Hence no ordinary asymptotic confidence intervals for such estimates.
  - LLN may, or may not, work for sample skewness. Convergence expected to be slow.
  - Not even LLN works for sample kurtosis!
- Better to use robust, quantile based, estimators, such as the median, the interquartile range, and Kendall's τ.
- However, the CLT seems to save us over longer time horizons: Yearly returns are indistinguishable from a Gaussian distribution!

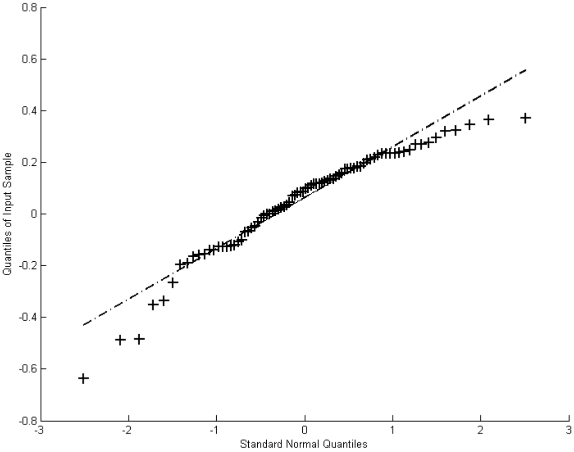


Figure: QQ Plot of yearly log-returns of S&P 500: $\log S_{t+1} - \log S_t$.

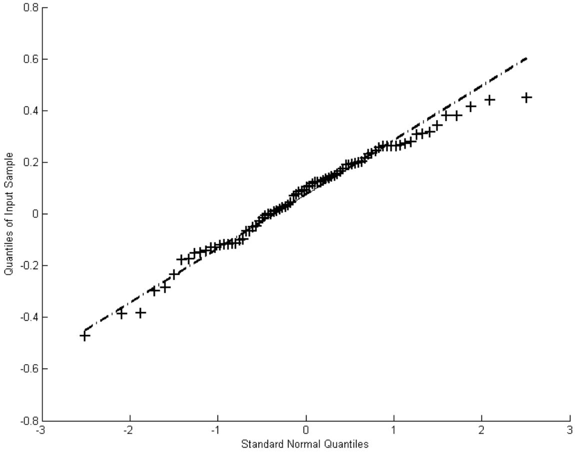


Figure: QQ Plot of yearly returns of S&P 500: $S_{t+1}/S_t - 1$.

Non-stationarity

- Volatility vary quickly, i.e. within a year, but other parameters of interest also vary such as correlations and risk premia.
- These changes can occur continuously over several years, but sometimes the changes are abrupt.
- For a one-period model, this is less of a problem since one “only” has to find the correlations, volatilities and risk premia for all assets at the end of the period.
- For a multi-period model it is much harder since one has to rebalance the portfolio over time and the joint distribution of returns will change from time to time.

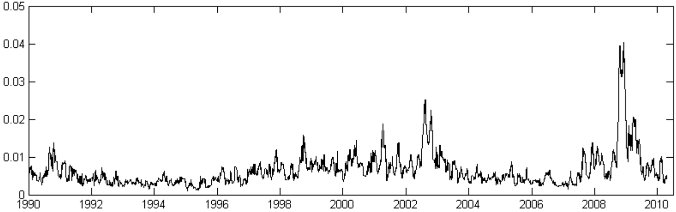


Figure: Median of absolute daily returns over the last month.

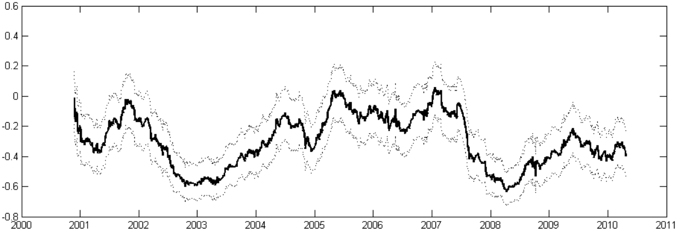


Figure: Correlation (with 95% CI) over the last half year between daily total return on long Swedish government bonds (SHB) and Swedish equities (FTSE Sweden).

Non-stationarity, continued

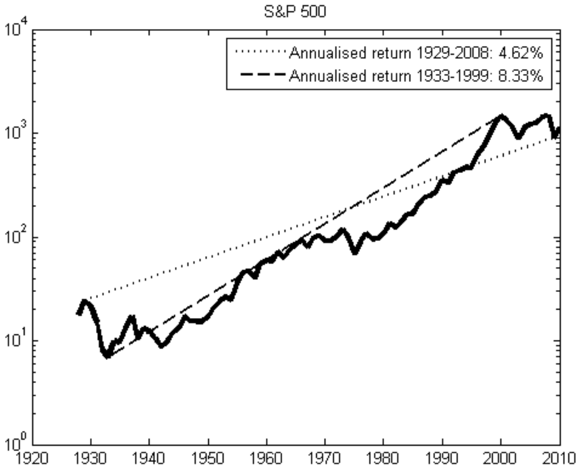
- To model, say, correlations, volatilities and risk premia as time varying processes of their own introduces even more problems.
  - How to estimate the parameters governing these processes accurately when it's hard even to estimate volatility itself for a one-period model?
  - Throwing more parameters at the data will give better fit in sample, but how about out of sample?
- Maybe it's better to have a simple model with known faults rather than a complex one with unknown faults.
  It's important to choose the right level of complexity!

Risk premia

- Q: Why invest?
  A: To take part in the growth of the economy!
  The real, risk free, interest rate should correspond to this.
- Q: Why invest in risky assets?
  A: To earn risk premia!
  Investors should be payed for the risks they take when providing capital to risky ventures.
- To have an accurate view on risk premia of different assets, in effect their expected future values, is essential for asset allocation.

Estimation of risk premia

- A naïve frequentist approach won't do. For example, assume that yearly equity returns are iid Gaussian. A typical value of the volatility might be 20%. This means that a moment estimator of the mean based on a century of data would have a standard deviation of 2% which is comparable to typical values of the risk premium of circa 5%.
- In reality the returns might not be iid, their distribution heavy-tailed and the risk premium may have changed over time, which only makes the problem more difficult.
- Models from Economics might be used, but they typically apply an equilibrium framework which raises questions of its own.


S&P 500
Annualised return 1929-2008: 4.62%
Annualised return 1933-1999: 8.33%
10^4
10^3
10^2
10^1
10^0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

Bayesian methods

- Bayesian methods are reasonable since one necessarily must use both data and judgement as input for a decision about asset allocation.
- Fact 1: If asset returns are multivariate t-distributed, the efficient frontier will consist of the same portfolios as if they were Gaussian, the only difference being that the t-frontier is shifted towards higher risk.
- Fact 2: Using conjugate priors for mean and covariance for a multivariate Gaussian distribution produces a t-distribution as predictive distribution.
- Thus, the frontier will contain the same portfolios whether you use point estimates of means and covariances or you apply conjugate priors. Conjugate priors may therefore not be that useful in this case?

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Discounting

- Different discounting methods for calculating expected present (market) value of liability cash flows.
  - Government bond curve for nominal benefits.
  - Government index-linked bond curve for benefits linked to price inflation, since the price inflation can be hedged with index-linked bonds.
  - No discounting for benefits linked to wage inflation, since we assume that wages and the economy as a whole, or at least the financial returns (incl. dividends), will grow at the same rate in the long run. Note that there are no financial instruments linked to wage inflation.

Non-diversifiable risk

- Since we have a large collective, essentially the whole population, one would think that the LLN and the CLT would ensure that the volatility of the liabilities would be minimal.
- However, AFA Insurance does not decide who eligible for benefits, it is the Social Insurance Office who is the arbiter of that.
- This means that we have had a large historical volatility and still have a future uncertainty about the size of the liabilities due to "political risk"!

Objectives of AFA's asset management, again

- Ensure solvency.
- Low premium: asset returns pay for a part of the insurance.
- Stable premium in order not to interfere in the collective bargaining.
- Not being overcapitalised since we cannot pay dividends.

It's only possible to address these issues in the SAA if one consider assets and liabilities as a whole.

Solvency

- Naïve definition: Having enough assets to cover the present value of all liabilities to the policy holders.
- Better definition: Having enough assets so that some other insurance company would be prepared to take over the liabilities and assets. Therefore one must have extra capital to cover
  1. reasonable (whatever that means...) fluctuations in the liabilities during the run-off, and
  2. decent return on that capital during the run-off.
- True definition: Whatever the regulator says.

Current solvency regulations

- Liabilities (L) are not valued as a true expected value since parameters throughout the reserving calculations are stressed.
- Small "solvency margin" (SM).
- Essentially linear constraints on the asset allocation that do not take diversification effects into account. For example
    1. 50% of L + SM must be covered by fixed income,
    2. 75% of L + SM must be covered by fixed income and equity,
    3. 75% of L + SM must be covered by fixed income and property,
    4. 80% of L + SM must be covered by currency hedged assets,
    5. 100% of L + SM must be covered by the assets.

  In items 3–5 above, only 70% of the property value may be used.

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Solvency 2

- EU wide rule in effect from 2013.
- Risk based, in that benefits from diversification and hedging are acknowledged. This is appreciated by the industry.
- Insurance companies must hold capital to be expected to fail (in the naïve sense) in only one year out of 200. (99.5% VaR at a one year horizon.) The industry find this an excessively high level of capital.
- The 99.5% one-year VaR is well-nigh impossible to estimate!

Solvency 2, continued

- There will be the possibility of using either a standard model, prescribed by the EU, or an approved (partial) internal model for describing financial and actuarial risks.
- Let's call the standard model's implied probability measure $\mathbb{Q}$.
- $\mathbb{Q}$ can (almost) be interpreted as if risk factors have a joint elliptical distribution.
- This (almost) gives a quadratic constraint:

$$\text{overall VaR} = \sqrt{\sum_{ij} \text{VaR}_i \cdot \text{VaR}_j \cdot \rho_{ij}},$$

where VaR_i is the VaR for the ith risk factor, and ρ_{ij} is the (pseudo)correlation between factors i and j.

The solvency constraint

- If Π_t is a portfolio of assets and liabilities and $v(\Pi_t)$ its value, then π is a solvent portfolio under Solvency 2 if

$$\mathbb{Q}\Big(v(\Pi_{t+1}) > 0 \Big| \Pi_t = \pi\Big) > 0.995.$$

- Even though 99.5% is a high level of confidence, we may want to avoid being labelled insolvent with high, say 95%, probability in the future. π is therefore an acceptable portfolio for us on a one year time horizon if

$$\mathbb{P}(\Pi_{t+1} \text{ solvent } | \Pi_t = \pi) > 0.95$$
$$\iff$$
$$\mathbb{P}\Big(\mathbb{Q}\Big(v(\Pi_{t+2}) > 0 \Big| \Pi_{t+1}\Big) > 0.995 \Big| \Pi_t = \pi\Big) > 0.95,$$

where $\mathbb{P}$ represents our view of the future.

Risk vs. return, again

- In reality we are interested in allocations that work over several years.
- Asset allocation and the setting of the premium is done in a comprehensive framework: We must also take into account the objective of a stable premium over time, at the same time as we mustn't accumulate too much capital.
- It's hard to visualise these trade-offs in a two-dimensional graph, but it's natural to consider "premium rebate after tax" against "risk of insolvency".

Modelling

Knowing/choosing $\mathbb{P}$.

- $\mathbb{P}$ may be based on subjective judgement, but it is still a “real world” measure.
- The plethora of risk neutral models for interest rate movements and equity returns is surprising compared to the dearth and relative simplicity of the corresponding real world models, which are mostly found in the field of Econometrics rather than that of Financial Mathematics.
- That not more sophisticated models have been published on interest rates surprises me since fixed income is such an essential asset class.

Hedging

- The difference between $\mathbb{P}$ and $\mathbb{Q}$ may become problematic. For example, currency exposure is costly under $\mathbb{Q}$ (and under $\mathbb{P}$) but under $\mathbb{P}$ we know that Swedish equities are more volatile than global equities in general, and $\mathbb{Q}$ does not differentiate equity markets w.r.t. volatility.
  This may lead to the choice: do you want to increase the risk under $\mathbb{P}$ or under $\mathbb{Q}$?
- Hedging/replication, i.e. matching the cash flow from the liabilities with that of the assets, reduces the risk under both $\mathbb{P}$ and $\mathbb{Q}$ and is therefore beneficial in general.
- With a perfect hedge you don't have to mind your $\mathbb{P}$'s and $\mathbb{Q}$'s at all!

Hedging inflation risks

- Our liabilities that are linked to the price inflation should in theory be almost perfectly hedgeable with index-linked bonds.
- The trouble is that the value of these liabilities is circa 83 billion SEK, whereas the entire stock of index-linked bonds has a nominal value of 200 billion SEK.
- We hold a substantial share of these, and it's not feasible to increase it to cover all our liabilities (it would raise the price and decrease the liquidity).

Hedging inflation risks, continued

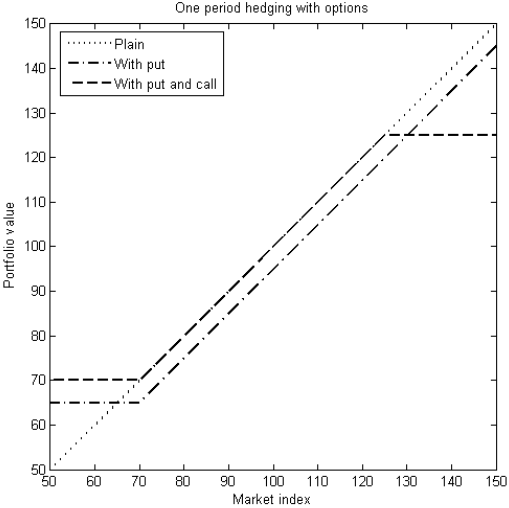
- We therefore have to "hedge" with nominal bonds, equity and property.
- Nominal bonds leave us with an exposure to shocks in both actual inflation and expected future inflation.

$$\begin{aligned}\text{nominal rate} &= \text{real rate} + \text{expected future inflation} \\ &\quad (+\text{inflation risk premium})\end{aligned}$$

- The optimal duration of this nominal "hedge", may differ from the real duration, and may change with the level of the nominal interest rate.
- Currently this is less of a problem due to the Riksbank's inflation targeting which has been effective and is perceived by the market to be credible.

Hedging with derivatives

- Many banks want to provide us with “solutions” using derivatives.
- At first it might seem as a good idea to cap your downside by buying out-of-the-money (OTM) puts on your portfolio, possibly financed by writing OTM calls.


One period hedging with options
Plain
With put
With put and call
Portfolio value
Market index
150
140
130
120
110
100
90
80
70
60
50
50
60
70
80
90
100
110
120
130
140
150

Hedging with derivatives, continued

- Our large size is prohibitive in two ways:
  1. The market (at least the Swedish one) not deep enough to buy so much protection without massively distorting the market price (driving up the implied volatility for puts and lowering it for calls).
  2. If the puts would end up in the money, would the counterparty be around to actually make good on the very large amounts? Financial disaster usually hits everyone at the same time...
- In general one should be wary of any "bespoke" solution with exotic derivatives, since these may become very hard or costly to unwind if the need arises.
- This is not to say that we don't use derivatives: Essentially all foreign fixed income is hedged (circa 40 billion SEK).

Rebalancing

- The size also plays a role in choosing when and how to rebalance the portfolio.
- Rebalancing is necessary to keep the right risk profile.
- Rebalancing is costly simply by the transaction costs so the frequency should not be too high
- Even small fractions of our portfolio is a large number in absolute terms, so in order not to affect the market prices to much, we don't want to make too large transactions, which would be necessary if the rebalancing frequency is too low.

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Positive peculiarities with AFA

- We can theoretically change the premium retrospectively. (Last year we gave back 8 billion SEK by retrospectively lowering the premium.)
- The owners may retrospectively change the conditions of the insurance policies.
- Our size provides significant returns to scale for the asset management: The cost of the asset management is about 0.04% of the value of the assets.

Summary

- SAA/ALM takes a long view on investments: we want to ensure solvency by hedging our liabilities, grow with the economy as a whole and earn risk premia for the risks we take.
- Complex constraints and objectives, due to regulations and the owners' wishes.
- The inputs are hard to estimate: data is heavy-tailed and non-stationary. Expert judgement is needed.
- Size creates issues with liquidity: the hedging instruments are not available in large enough quantities and any change to the portfolio may disturb the market.
- Mathematical and statistical modelling is needed in the "real world", not only in the "risk neutral" one.

Contact information

- I may be reached at

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- All presented views are my own and not necessarily AFA's!

Thanks for your attention!