The Actuarial Profession
making financial sense of the future

Update from Investment and Hedging practice area of VA Members Interest Group

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Part 1 - VA Market & Hedging Update

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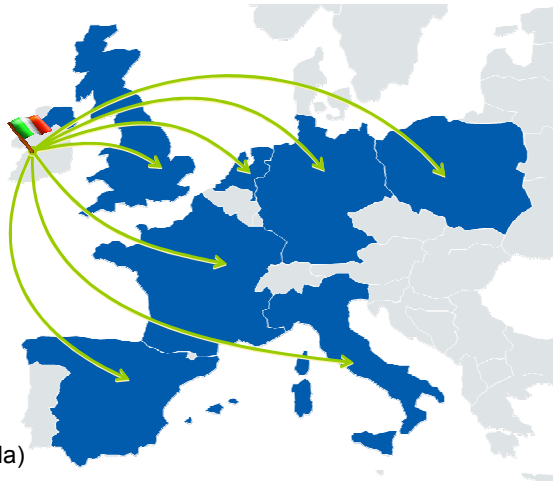
Variable annuities – the life actuary's view

- VA in Europe is still developing – no large inforce blocks in direct writers
- Focus on pricing (product design)
- Focus on obtaining Regulatory authorisation
- Current position – guarantees in the money, but life company does not have to post "collateral" to policyholders.

Choices to date for VA business

- Ireland
  - AEGON
  - Allianz
  - AXA
  - AXA MPS
  - Hartford
  - Met Life
- Luxembourg
  - Ergo
  - Swiss Life
- Netherlands
  - ING
- UK
  - Lincoln (Sun Life of Canada)

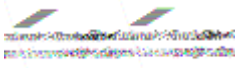


Spread of VA business (Ireland base)

AEGON	UK, Spain, France
Allianz	Germany, Italy, France
AXA	Germany, Spain, Italy, Portugal, France, Belgium, UK
THE HARTFORD	UK, Germany planned but recent withdrawal
MetLife	UK, Poland, Greece, Spain

European sales experience – Ireland

- Five cross-border companies are now writing new business variable annuity products from Ireland.
- One variable annuity company closed to new business this year (The Hartford).
- We estimate total sales over 2008 were in excess of €1.2bn, which was up strongly on a low base in 2007.
- Stock market volatility and falling interest rates have required product repricing
- European sales showed an upward trend over the last 6 months of 2008, and the first quarter of 2009.



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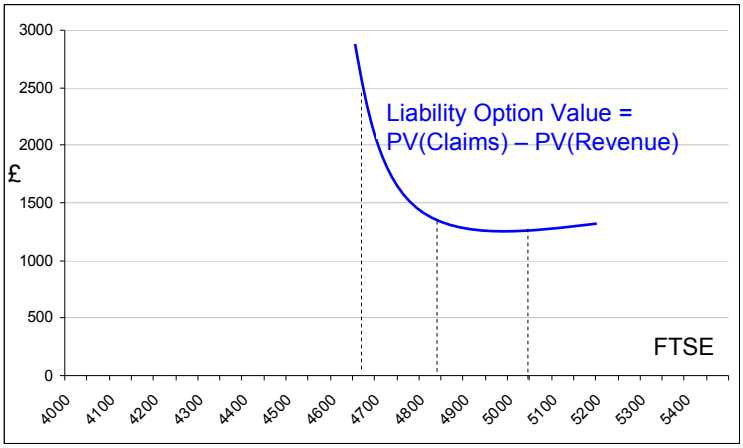
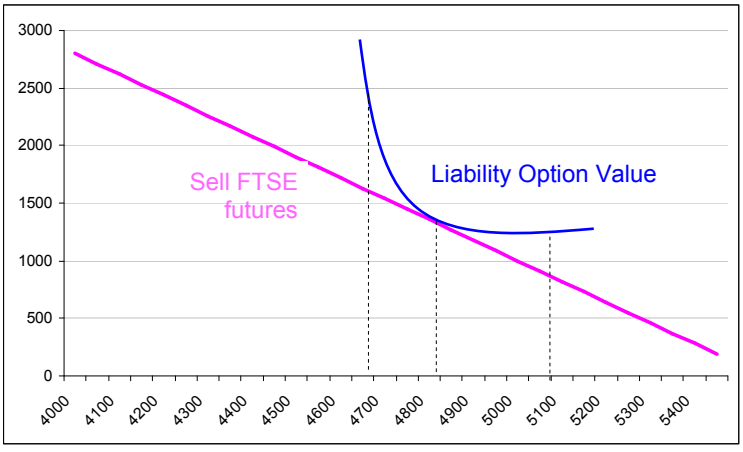
Hedging – variable annuities

Variable Annuity Guarantee is a very long exotic “Put Option”



Delta hedge offsets against the “put option”



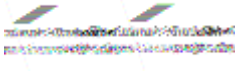
Use of hedging (thanks to Milliman)

Elements of Hedging	Description of Intended Effect	Usage
"Running Naked"	No hedging, leaving surplus fully exposed to market risks	
Dynamic Strategies		
Delta	Protection against small changes in the market value of the underlying funds	
Rho	Protection against small interest rate movements	
Gamma	Protection against changes in Delta, and the consequent need to adjust the delta-hedging position frequently	
Interest-rate Convexity	Protection against changes in Rho, and the consequent need to adjust the rho-hedging position frequently	
Vega	Protection against changes in the hedging costs	
Static hedges	Static hedge using re-insurance or OTC options that match the stochastic behaviour of the VA options and guarantees	

Sources: Oliver Wyman; Milliman survey, May 2008

Valuation models

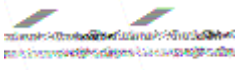
- Pricing guarantees at launch – risk neutral, charge = (say) twice economic cost of guarantees
- Dynamic hedging – risk neutral, good liability data, Monte Carlo calculation, long term volatility assumption
- Reserving (Ireland) – real world, calibrate on current yield curve plus assumption on equity risk premium
- Allowance for hedging in reserves - nested stochastic, "on-the-fly" risk neutral inner loop



Lessons from hedging

- Dynamic hedging is the desired end position
- Trade in liquid and deep markets, frequently rebalance open positions

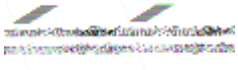
- Delta “works”
- Rho - difficult to match duration buckets when volumes are low
- Other greeks now the main topic of conversation



Current issues – interest rates

- Lower interest rates result in higher costs of guarantees
- Liability model using yield curve as basis, hedge model using swap curve
- OTC swap agreements require collateral postings

- Cash feeder into hedge programme based on (past) fund based charges collected, augmented by share capital
- Ultimately any cash payments to policyholders will be funded from hedge assets. Getting there is not a straight line.



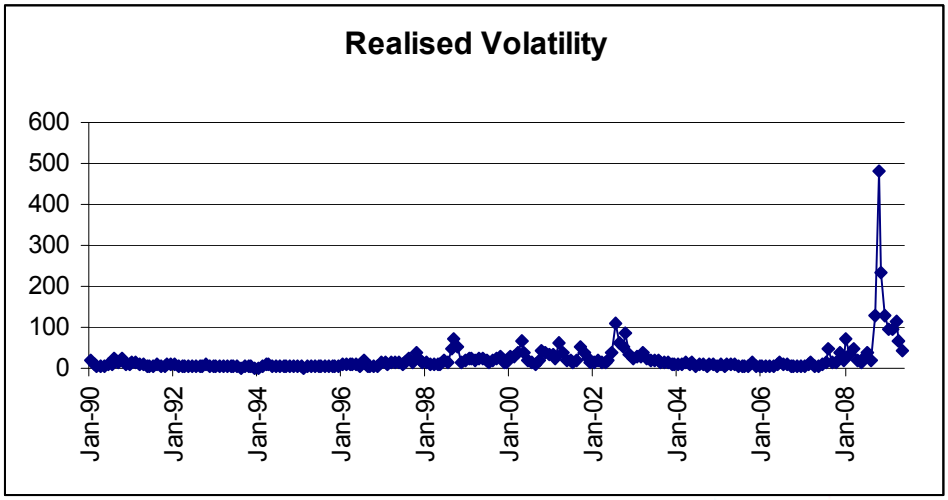
Current issues – volatility

- Liability valuation model uses a long term volatility assumption
- Dynamic hedging model uses implied volatility for short term, moving to long term assumption

- Hedging (i.e. trading) will "book" implied volatility
- No hedging will experience realised volatility (in terms of capital allocated in the early years)

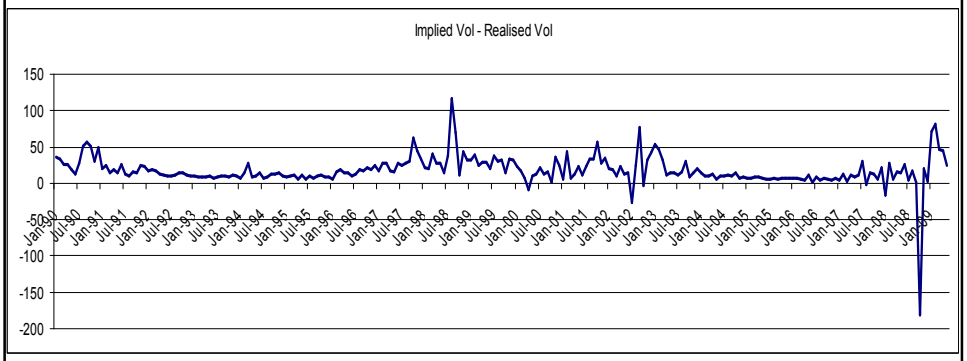
- Life Company fallacy – (long term) liability assumption for volatility not the same as (short term) asset experienced volatility?

S&P historic realised volatility



S&P implied minus realised volatility

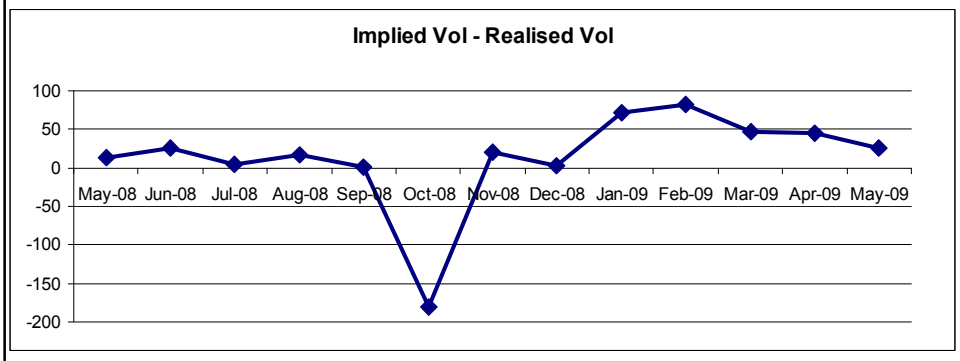
Jan 1990 to May 2009



Source: Hao Zhou Federal Reserve Board, USA

S&P implied minus realised volatility

May 2008 to May 2009



Source: Hao Zhou Federal Reserve Board, USA

What does all this mean (1)?

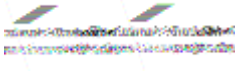
Pricing in current markets has driven product development

- Move back to more hedgeable funds
  - Equity index trackers
  - Limited volatility funds with internal rebalancing
  - Remove property, “active” management, alternative funds (and correlation argument for hedgeability no longer convinces)
- Remove “rich” guarantees, especially any that depend heavily on policyholder behaviours
- Be prepared to reprice and relaunch more frequently (are we moving to tranche products?)

What does all this mean (2)?

Volatility has driven hedge programmes

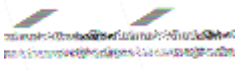
- Traded futures work, but have friction costs
- OTC interest rate swaps market is working, but counterparty risks exist
- Inforce products have convexity – but are they big enough (yet) to require fixing?



What does all this mean (3)?

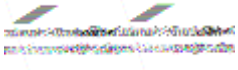
GAAP becoming less important than Capital

- Movement in valuation of reserves hitting GAAP anyway
- Collateral postings on swaps consume life company cash / liquid assets
- Differences in bases and assumption setting magnified (e.g. swaps versus gilts, realised versus implied vol)



Summary

- Life Companies have a long term view
- (Capital) reserves set in the tail – ultimate fatness not an exact science
- Falling interest rates and increased volatility are two separate issues
- More research on volatility within VA's is required



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Part 2 - Insurance approach to Implied Volatility

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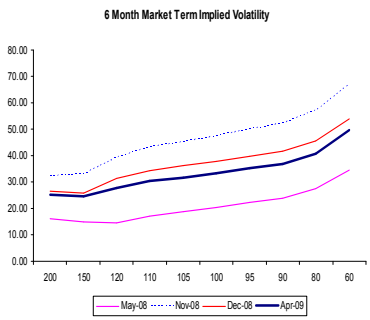
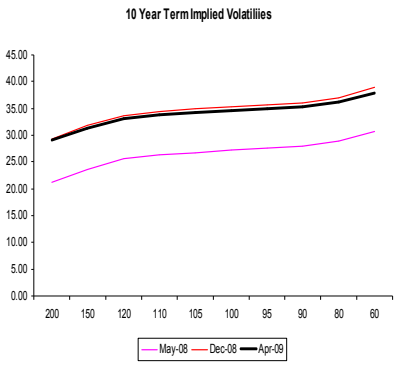
Implied Volatility – US 6 Month

- Short Term Volatility - S&P 500
- Crisis Impacts Level & Skew
- Pre Crisis
  - ATM Vol 20%
  - Skew/Slope (-18%)
- Crisis (Dec 2008)
  - ATM Vol 38% (Pre Crisis*1.8)
  - Skew/Slope (-27%)
- Now
  - ATM Vol 33% (Pre Crisis*1.6)
  - Skew/Slope (-23%)



Implied Volatility – US 10 Year

- Long Term Volatility – S&P 500
- Crisis Impacts Level Only
- Pre Crisis
  - ATM Vol 27%
  - Skew/Slope (-7%)
- Crisis (Dec 2008)
  - ATM Vol 35% (Pre Crisis*1.3)
  - Skew/Slope (-7.5%)
- Now
  - ATM Vol 33% (Pre Crisis*1.27)
  - Skew/Slope (-7%)



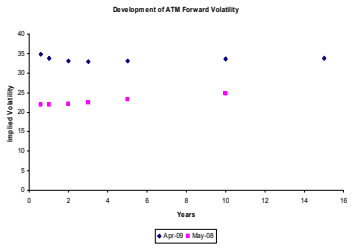
US Surface Structure – 2008/2009

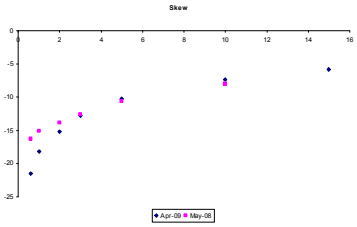
- ATM Forward Volatility
  - Change in Shape
  - Change in Level

  =>Need to consider model

- Skew
  - Change at short end
  - No change at long end

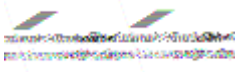
  =>No need to consider model





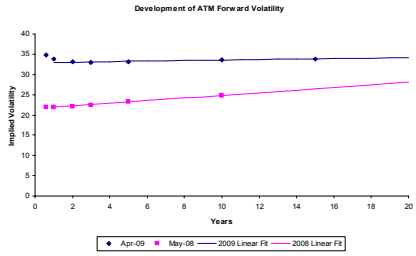
Long Term Volatility

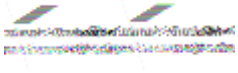
- Implied Volatility is a market price => need to separate out factors to make a call on "value" or use to calibrate real world prices
- Technical Factors=> Convergence of Price as t→ ∞
  - Mean Reversion of volatility
  - Jumps are less relevant
  - Effect of heteroscedasticity as measured by skew more sticky
  - More consistent with Log Normal assumption
  - Uncertainty over parameter error (assume Δ hedge to limit this)
- Market Factors => Divergence of Price as t→ ∞
  - Supply/Demand Balance => opportunity
  - Parameter Observability & Profit Recognition
  - Capital Charges & supply of hedge capacity to banks
  - Not great for "bonus" mindset



Fitting Curves to Term Structure

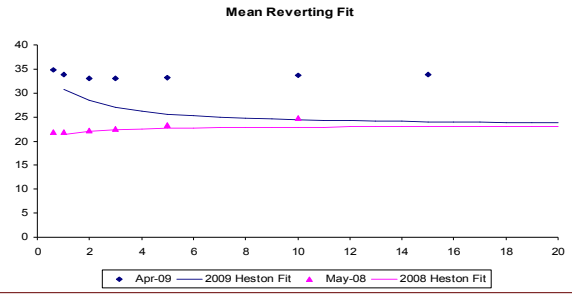
- Observed data Linear in the region of the data (for >1yr)
- Very Good fit R-squared >95%
- Linear Extrap. beyond the data ?
- Observations & Implications ?





Fitting Curves to Term Structure

- Technical Argument supports mean reversion of Volatility
- $V_{t+1}=V_t-\lambda(V_t-V)\Delta t+\eta\sqrt{V_t}\,\Delta t\omega$, where ω is a wiener corr. with index at rate ρ
- Project with $\sqrt{V_{0/2009}}$= 35%, $\sqrt{V_{0/2008}}$=20%, $\sqrt{V}$ = 25%
- Parameterise Correlation -.8, Vol. of Vol. 30%, reversion rate λ = 1
- Assymptote for ATM Implied Vol as $t\to\infty = \sqrt{(V^*\lambda/(\lambda-\eta\rho/2))}$



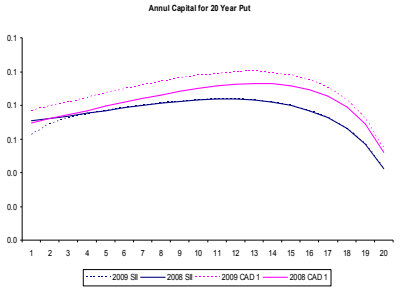
Insurance/Solvency II Approach ?

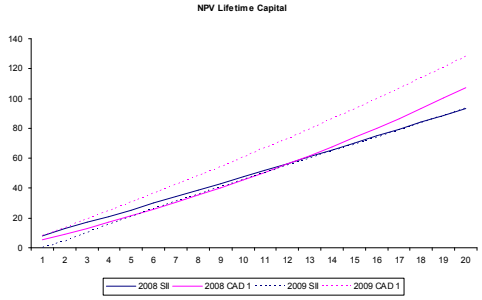
- Market Price of Put = Price on Best Est. Vol + Cost of Capital
- Cost of Capital Vol =Implied Volatility – Best Est. Vol
- Model
  - Maintain current Mean Reverting parameters for Best Estimate
    - long term rate not affected by crisis, thus model allow for convergence to pre crisis level of volatility
  - Maintain linear fits for Implied
  - Set capital requirement to
    a) Vega stress test from CAD 1as a measure of bank capital
    b) High watermark as a SII style insurer capital requirement

=>Thus can establish the market cost of capital for implied volatility under both frameworks

Regulatory Capital

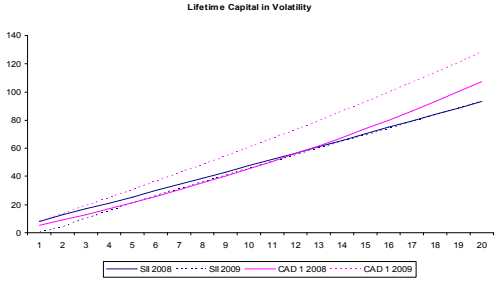
- CAD 1 = Δ in price for a 25% Δ in the level of Implied Volatility
- SII = nth percentile (long periods) adverse value in this case select vol = 30
- Either can be viewed as a reserve/pricing capital charge
- Calculate charge for each future period & NPV for lifetime capital





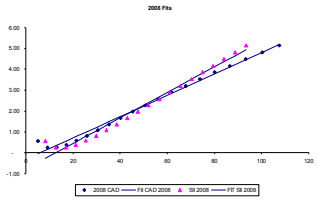
Capital in Volatility Points

- Aim is to translate capital into implied volatility points
- Rebase the capital requirement to Vega at inception
- Capital requirement expressed in volatility is (almost) a linear function of
  - Time & Implied Volatility (at each future t) for CAD 1,
  - Time & Expected Volatility (at each future t) for SII
- Capital charge in implied volatility points then becomes X% * Lifetime Capital

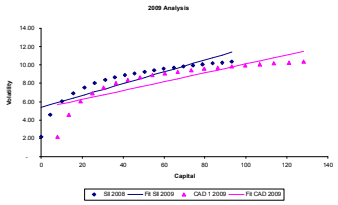


Initial View of Cost of Capital & Vol

- Excess Volatility = Implied - Expected
- 2008 - Excess Vol V Capital
  - CoC explains most of premium
  - 5% Return on CAD 1/6% on SII
  - Poor fit at early durations (as expected)

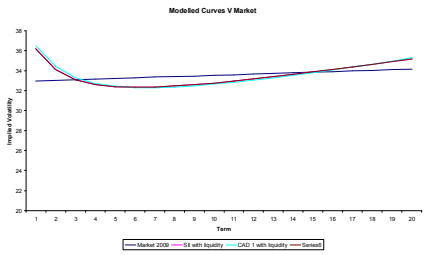


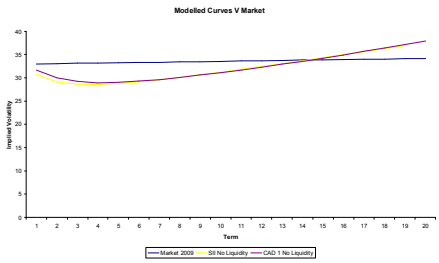
- 2009 - Excess Vol V Capital
  - CoC does not explain premium
  - Circa 5 points of flat margin
  - Residual slope as per 2008
  - Thus return = 5/6% + X
  - ➢ Where X represents Illiquidity ?



Recreating the 2009 Curves

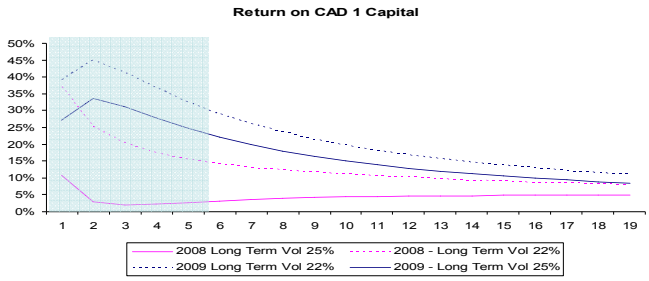
- Observed best fit = Best Est.(t) +CoC (t) +X (Liquidity?)
- Fitting CoC only (Best Est(t) + CoC(t)) => return of 11%+,
- Doesn't matter too much which capital regime (SII or CAD1)
- Cross over at t=15 => the linear fit may not hold beyond the data





Looking at Return on Capital

- Shorter dated (<5y) RoC unstable and less reliable inference
- 2008 returns stable and low, 2009 good but deteriorating
- RoC depends on “best est.” => drop long run vol estimate to 22%
  - 2008 now looks good, but doesn’t fit mkt & return still ↓ as t→∞
  - 2009 curve could be argued as an increase in best est. from low base

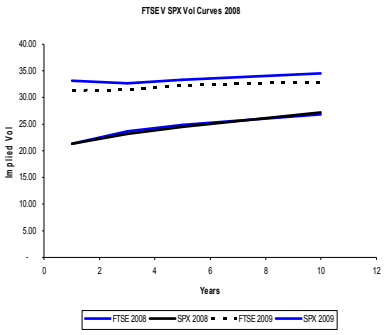


Supply Factors

- Banks
  - Capital Constrained
  - Capital Charge for un-hedged Vega is high
  - RoC for shorter dated options better than long
- Hedge Funds
  - Hedge Funds via sale of Variance Swaps
  - Emerge post LTCM when Implied vol spiked
  - Funding crisis has reduced capacity and availability
- General Factors
  - Vol can’t be created/replicated => transfer => capacity must be finite
  - Industry benefits from unregulated/alternative supply
  - Need to manage risk aggregation (LTCM/AIG/Amaranth etc)
- Other Factors
  - Capital Requirements
  - Collateral
  - Funding

US V UK Comparison

- Comparison of UK & US Curves
- Similar Levels & Shapes
- Without inference on applicability to UK use the S&P Curves for further analysis



Implications for VA/Insurers

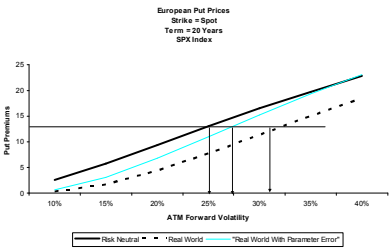
- Variation in implied volatility at the short term driven by expectation and liquidity, but illiquidity/other factors drive variability as $t \rightarrow \infty$
- Volatility lends itself to an insurance analysis over the long term
- Market dynamics suggest insurers should price VA's with Insurance Price + Illiquidity margin
- Insurance sector cannot rely on supply of super long dated options and thus must have a capacity and capability to hold this risk
- Insurance Sector could become a supplier of Variance Swaps through derivatives or asset structures (while being cognisant of the aggregation of limits etc that got AIG into a bind)
- In a way this is what the delta hedged VA rider delivers by way of risk profits

Warren Buffet & All of That

- 2007/2008 Berkshire enter into 20 year put transactions on 4 major indices
- Inferred Details of Cover
  - Aggregate Exposure $37bn
  - Aggregate Premium $4.9bn
  - Strike at 100/Spot at outset
- Approach
  - Insurance Mindset
  - No Hedging
  - No Collateral provided

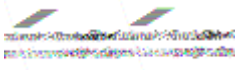
Guessing the Parameters

- Inferred average price = 13%
- Allowing for term and risk neutral return indicative implied volatility circa 25%
- Allowing for Equity Risk Premium of circa 2.5% and the supported vol goes to 30% +
- But going real world has a cost
  - No Delta/Rho Hedge
  - First Order Parameter Error (circa 30% to 50% of σ^2
  - Balance Sheet Volatility (the market can stay irrational longer than you can stay solvent)



The Verdict

- Other Factors
  - Diversification effect will have been of limited use during crisis
  - Change to Int. Rates & (implied) dividends have been significant
- Summary
  - Priced at or above market in 2007/2008
  - Market Levels, Interest Rate and Volatility have all led to massive MTM losses which have had knock on effects on credit rating and funding (you can be wrong even when your right)
  - Reject the thesis that it creates “float” as the premium is an “NPV” of expected claims
  - An easy and unfair criticism but he moved too soon & too cheap
  - Now is the time we need the weight of Berkshire in the market



Summary & Conclusion

- Section One
- Section Two
- Questions