



ENTERPRISE RISK
MANAGEMENT SYMPOSIUM

Proxy Models

Applications in Economic Capital and ERM

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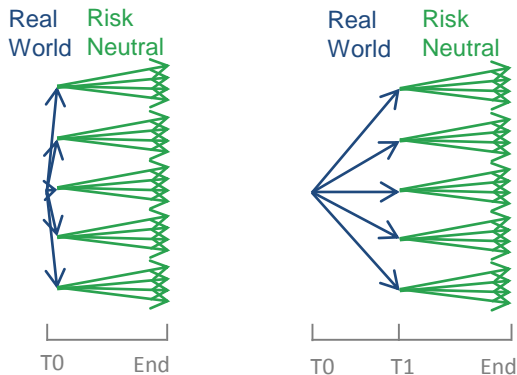
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The need for proxy models

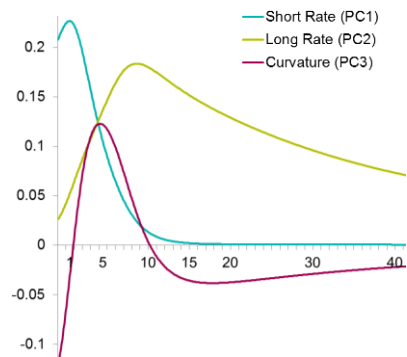
- Proxy models are useful wherever many runs of a model are required for a task
- A small sample of potential uses:
 - Economic capital
 - Daily monitoring
 - Hedging
 - Hedge projection
 - Asset allocation
 - Pricing

Fitting proxy models

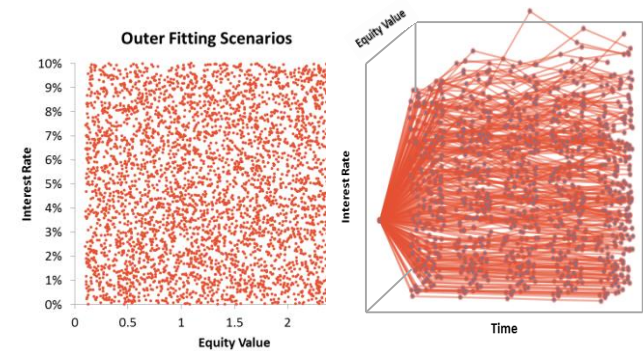
1. Choose timestep



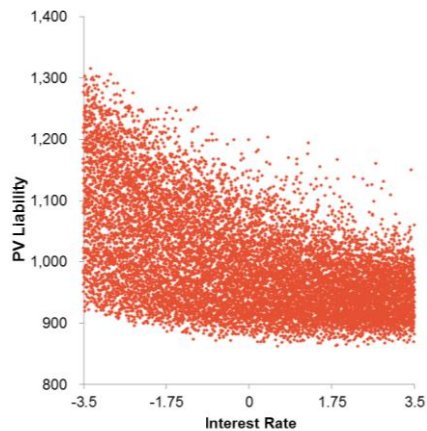
2. Choose risk drivers



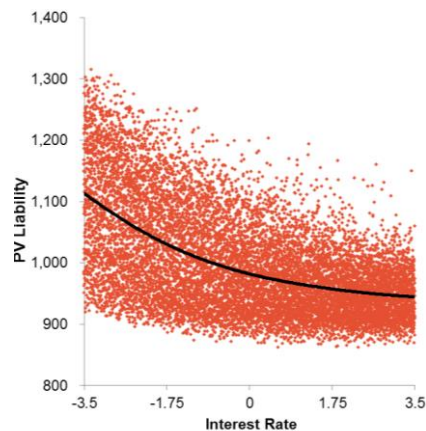
3. Create fitting scenarios



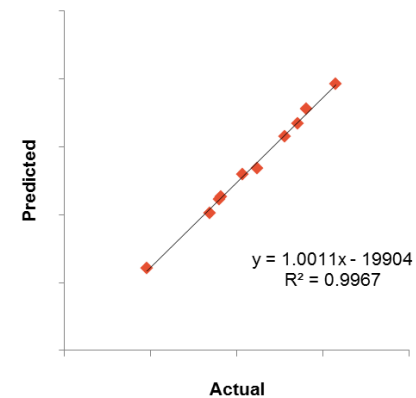
4. Run ALM model



5. Perform regression

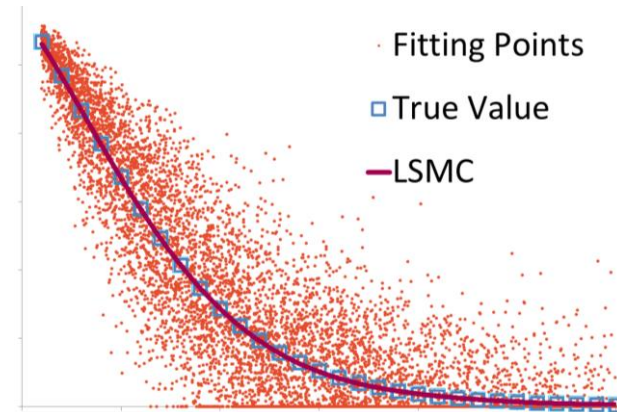
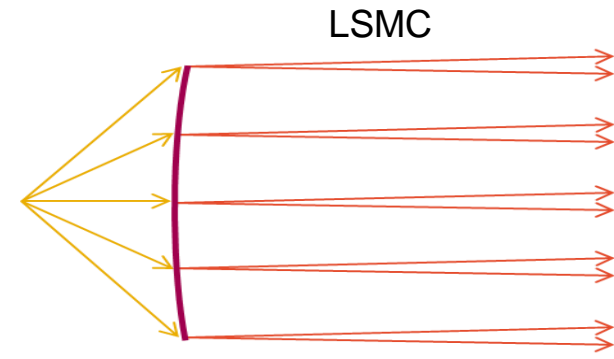
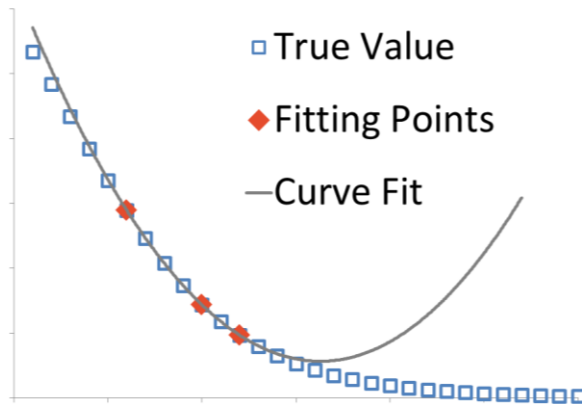
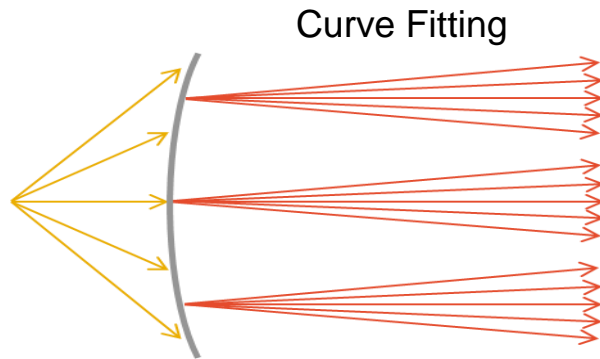


6. Validate function



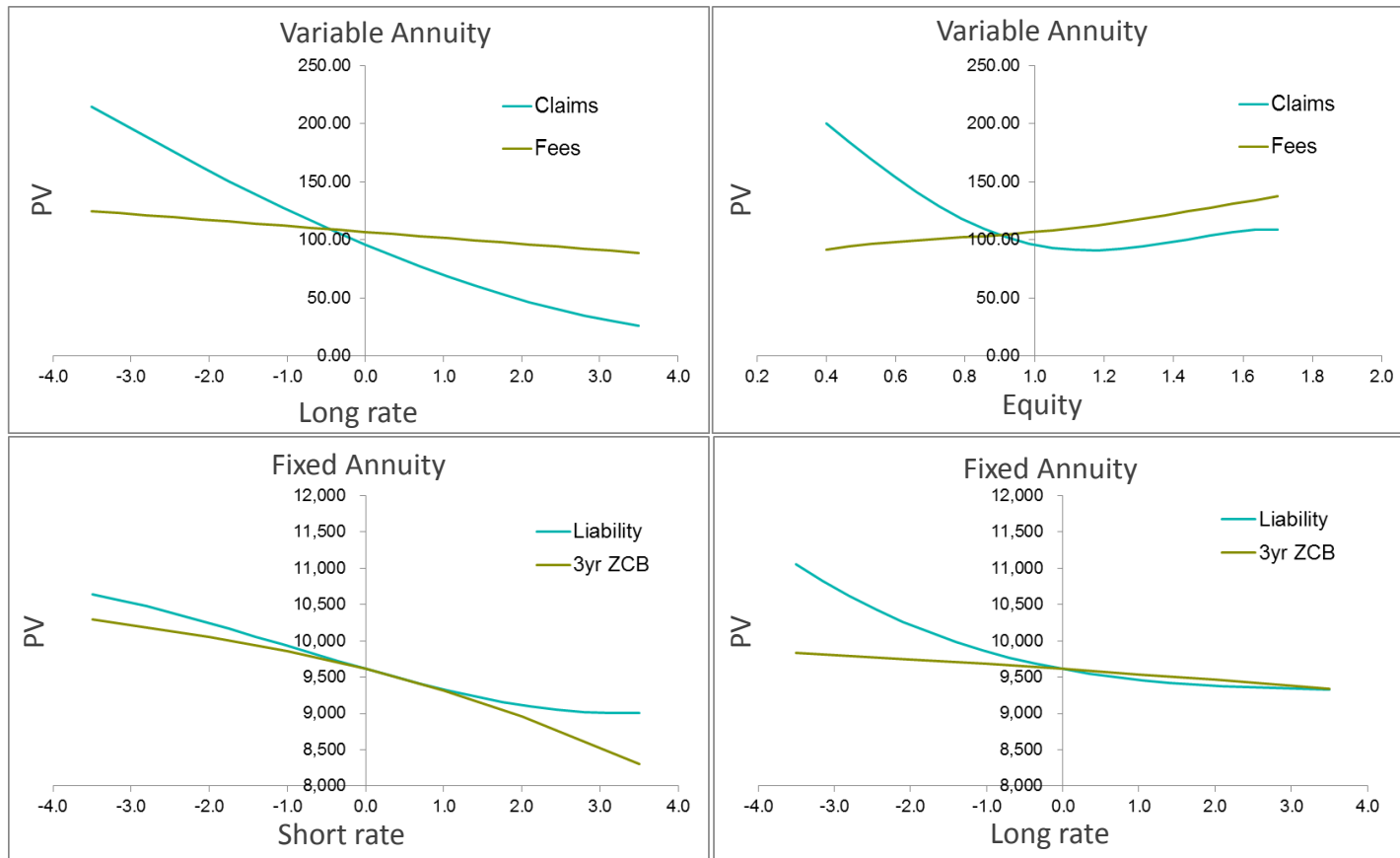
Curve fitting and LSMC

- LSMC method uses more fitting points
- Each fitting point uses fewer scenarios, so is less accurate on its own
- But errors cancel out so overall function is more accurate



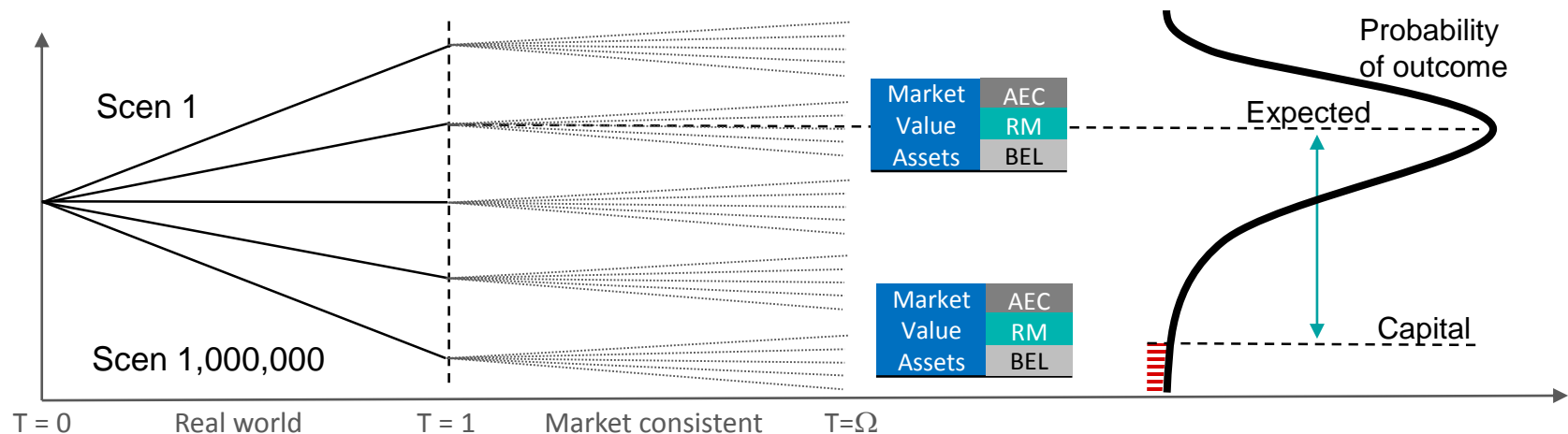
Proxy functions

- Example proxy functions for variable annuity and fixed annuity portfolios



Economic capital calculation

- The largest driver of proxy model adoption has been Solvency II economic capital calculation
- SII internal models mandate a calculation based on the 1 year VaR of market consistent embedded value, read from a full distribution of net assets
- This creates the need for a nested stochastic calculation



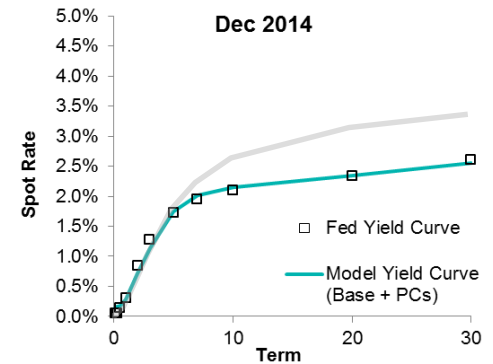
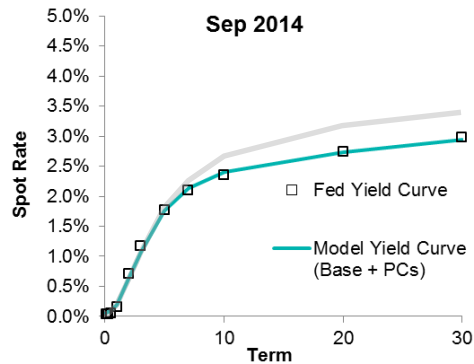
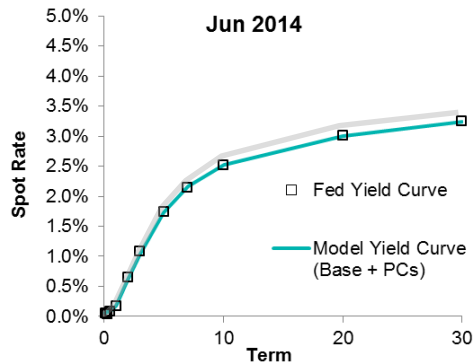
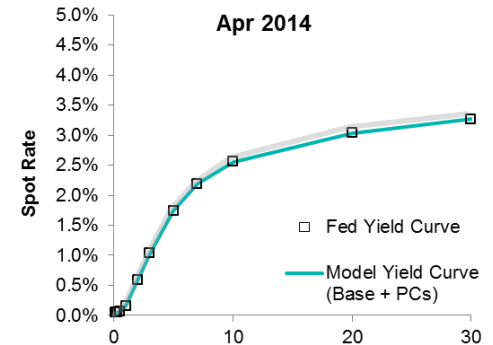
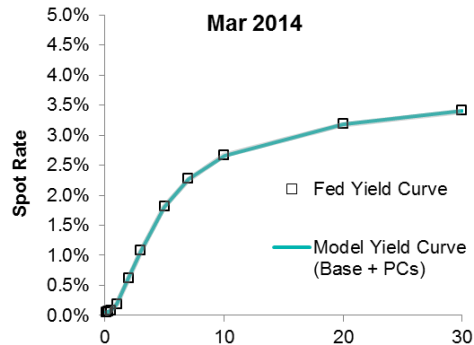
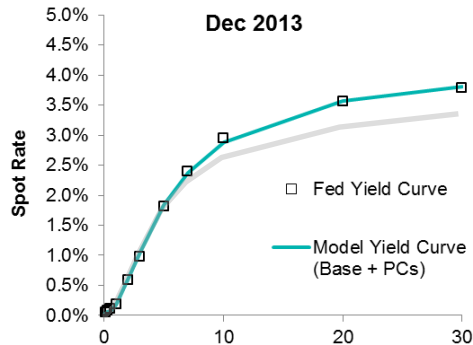
- To make the calculation possible, proxy functions are used to replace the market consistent valuation
- Proxy functions representing other metrics are also possible
 - Statutory reserves and capital, accounting profit, asset values etc

Ongoing monitoring

- Balance sheet and economic capital calculations are currently performed relatively infrequently
- But companies face ever increasing demands for updates, what-ifs, sensitivities etc.
- Ideally, this information should be available and updated in real-time
- Proxy functions are an ideal solution to this problem
 - The required metrics can be tracked continuously without the need for further ALM model runs
- To monitor balance sheet values:
 - Convert market data to proxy risk dimensions
 - Treat market data like a risk scenario realization
 - Rebase the proxy function and use it to calculate economic capital
- Some loss of accuracy is inherent in the process
 - E.g. converting the market yield curve to a risk scenario model yield curve
 - And from stale-ness of policy data
 - But the benefits far outweigh the limitations

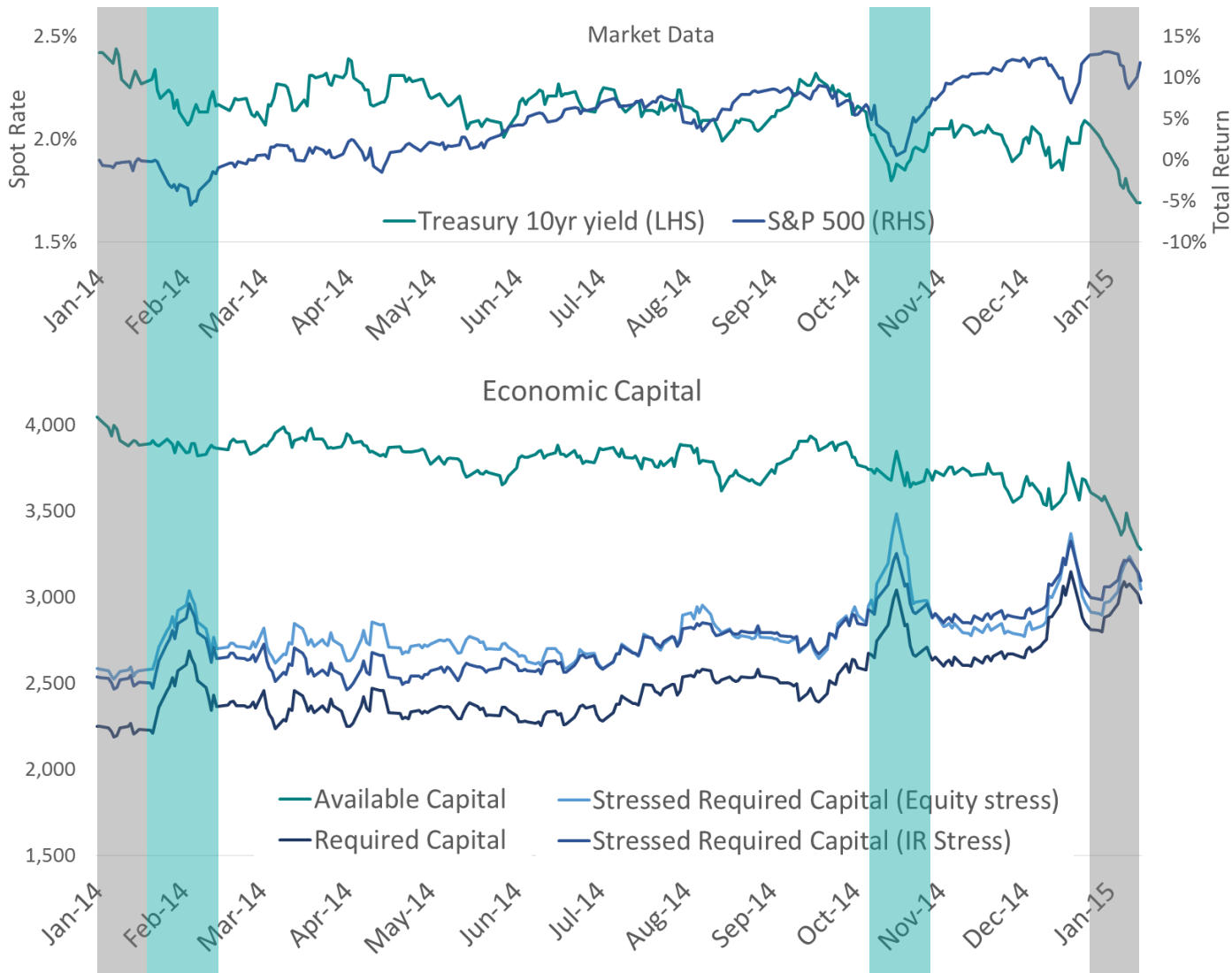
Ongoing monitoring – yield curve roll forward

- Fits to treasury curves are produced over 2014 using the base yield curve (Mar-14) plus 3 PC factor changes



| End Month: | Dec 13 | Mar 14 | Apr 14 | Jun 14 | Sep 14 | Dec 14 |
|------------|--------|--------|--------|--------|--------|--------|
| PC1 | -0.15 | 0.00 | 0.00 | 0.02 | 0.17 | 0.38 |
| PC2 | 0.46 | 0.00 | -0.16 | -0.20 | -0.58 | -1.13 |
| PC3 | -0.12 | 0.00 | 0.02 | -0.02 | 0.15 | 0.18 |
| RMSE (bps) | 3.9 | 0.0 | 0.7 | 2.2 | 4.8 | 8.1 |

Ongoing monitoring – case study



Interest rates fall and equities rise over 2014.

The changes in available and required capital are monitored, as well as the effect on required capital of 1SD interest rate and equity shocks .

Required capital is very sensitive to equity falls.

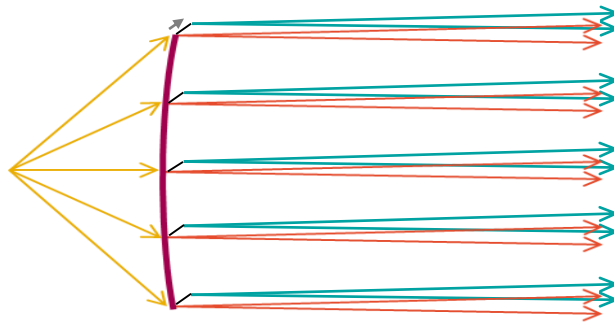
Available capital is very sensitive to interest rate falls.

Hedging

- For many products, VA in particular, companies may calculate liability Greeks daily
- This creates a need to run a number of valuations:
 - Base valuation
 - Equity stress up and down
 - Key rate duration stresses up and down
 - Credit spreads
 - Extra stresses to calculate gamma
 - Equity and interest rate implied volatility
 - A grid of joint stresses for cross-sensitivities
- Total ALM model run requirement can be >100k scenarios per day
- Proxy models give an easy way to reduce the computational burden while increasing the accuracy of hedging calculations

Hedging

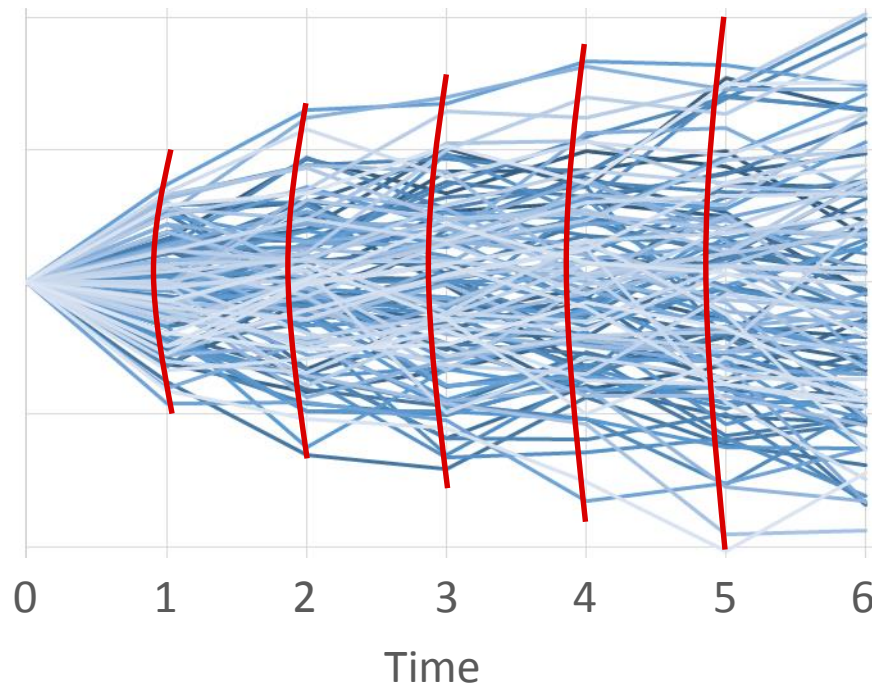
- Proxy functions describe the behavior of the liabilities over a very wide range
 - But just differentiating the functions to find Greeks can lead to a loss of accuracy
 - Even close agreement of the proxy to the true liability value function can lead to significant deviation in the Greeks, particularly in the extremes of the distribution
- Analogous methods are available
 - Simulating the Greeks directly and fitting proxy functions to the results gives an accurate function describing the Greeks under a wide range of market conditions



- This allows companies to update Greeks continuously without the need for further ALM runs
 - Speed, accuracy and stability is vital, especially in times of crisis when markets move fast and hedging is most important
 - Proxy functions that provide accurate Greeks can be generated in a fraction of the time and cost currently used to maintain hedging grids

Hedging

- Extending the functionality used for deriving Greeks, proxy functions can be used to project the Greeks over time
- This requires functions to be fitted at future time nodes within the projection
 - This allows a projection of a clearly defined hedging strategy (“CDHS”) for AG43
 - It also leads to a much better understanding of the nature of the hedging risks undertaken and how they affect performance, pricing and capital



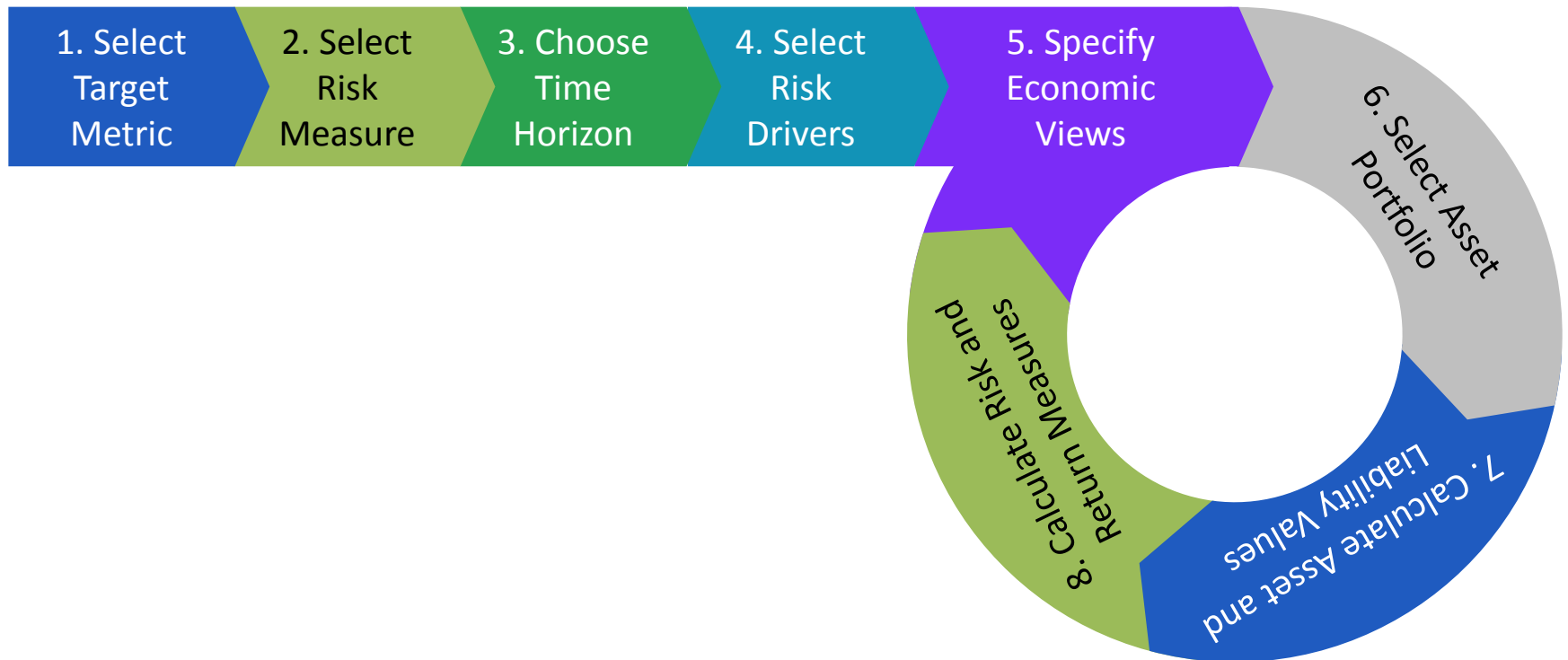
Hedging II

- Proxy models are most formidable under more complex hedging or risk management needs:
- Hedging economic capital on a daily basis
 - To ensure capital ratio does not fall below tolerance
- Hedging regulatory capital / accounting measures
 - To target stability of accounting profits while controlling capital ratios
- Hedging multiple contradictory metrics
 - Companies may focus on different metrics within the business
 - Hedging may be applied based on appetite for deviation and tolerance for changes in multiple metrics – giving a utility maximizing hedge rather than a minimum variance hedge
- In many cases accurate hedging calculations have not been possible until now and this has resulted in a number of significant operational failures

Asset allocation optimization

- Asset allocation for complex life insurance portfolios have not been implemented well in the past
- Typically, an interest rates up and down liability stress are performed and the asset duration set to match the liabilities
 - Some firms go further and include convexity
- But many, more complex questions remain:
 - What happens to the liabilities under bigger stresses?
 - Or joint stresses to multiple risk drivers?
 - What does the full distribution of outcomes look like?
 - How should fat tails and tail correlation affect our decisions?
 - How can house-views of the evolution of economic drivers be taken into account?
 - How does uncertainty in policyholder behaviour or mortality affect asset allocation?
 - What is the interaction between the hedging and asset allocation functions?
 - How should offsetting risk exposures in other lines of business affect decisions?
- The difficulty in approaching these questions stems from the inability to perform a sufficiently high number of model runs

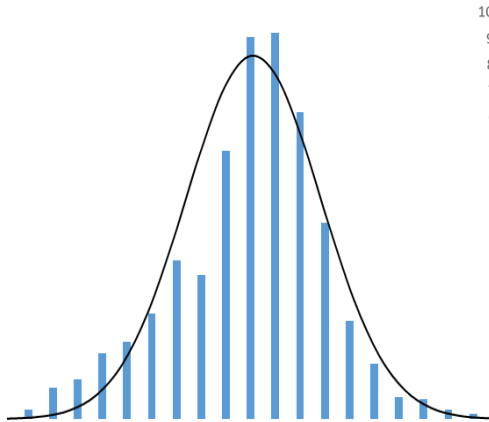
Asset allocation process using proxy models



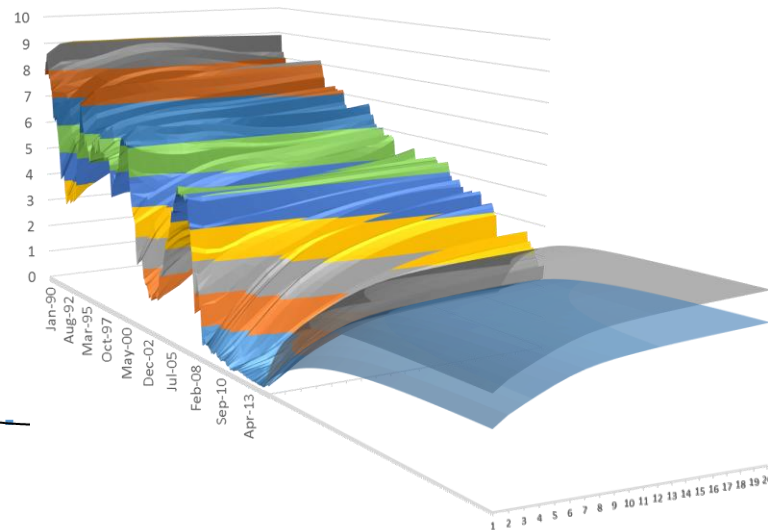
Asset allocation – specify economic views

- Complex views about the evolution and interaction of market risks are modelled in a real world simulation
- Fat tailed distributions, and tail dependence can be modelled as well as views on risk and term premia embedded in financial markets

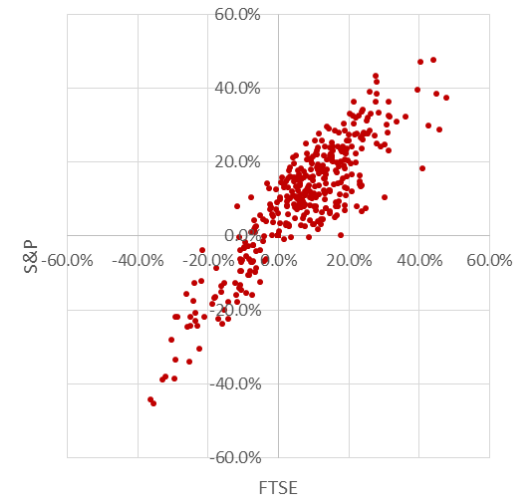
Fat tails



Expected yield curve evolution

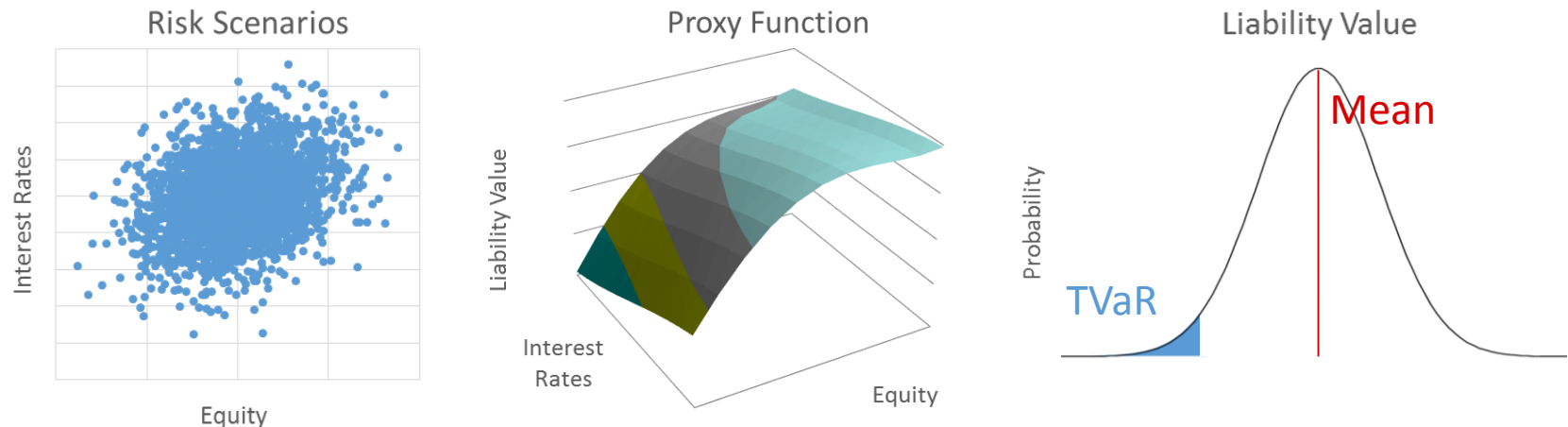


Tail dependence



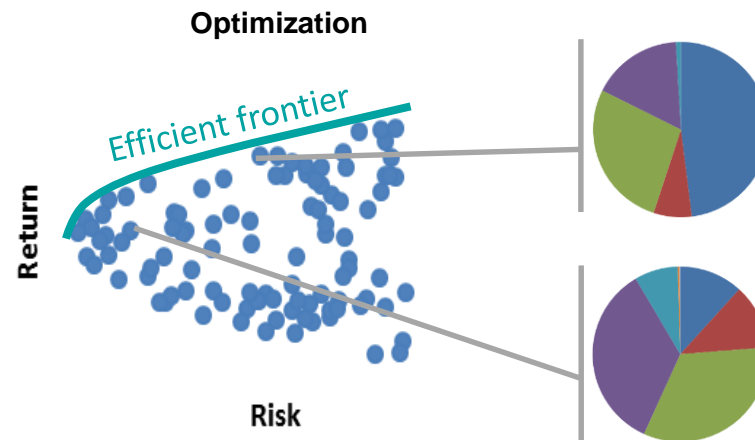
Asset allocation – calculate risk and return

- Real world scenarios are passed through the proxy models to obtain a distribution of the metrics of interest
 - MCEV, statutory returns, accounting profits etc
- Risk and return are measured



Asset allocation – compare candidate portfolios

- The process is repeated for a number of different candidate asset allocations
- Viable / efficient portfolios are found
- When combined with risk appetite, risk limits and utility, an optimal portfolio is produced
- Numerous competing metrics can be weighted by their importance



- Even robust processes do not replace human judgement – substantial professional interpretation is still involved
- The framework allows timely asset allocation decisions to be made using accurate liability metrics

Conclusion

- Proxy functions have proved their worth in economic capital calculations
- And their development has opened up a number of exciting possibilities for life companies analytics capabilities
- They have become one of the most important tools in the risk manager's box
- A significant amount of work will be is required over the coming years to realize the full potential of these tools
- A solid, robust foundation is the key to success