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Capital Framework Best Practices.

IAA Life Section Seminar

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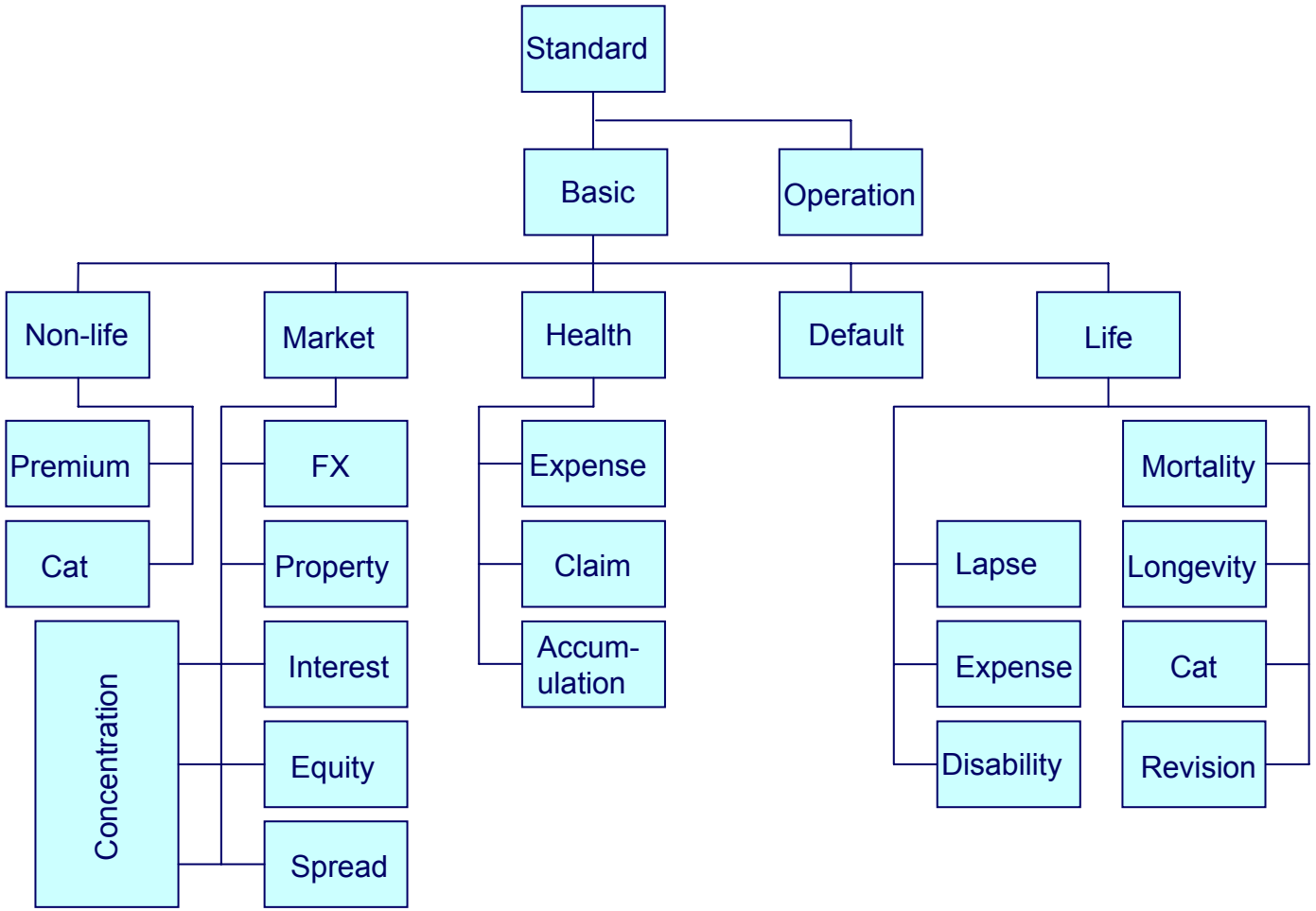
Capital Framework Best Practices Presentation Overview

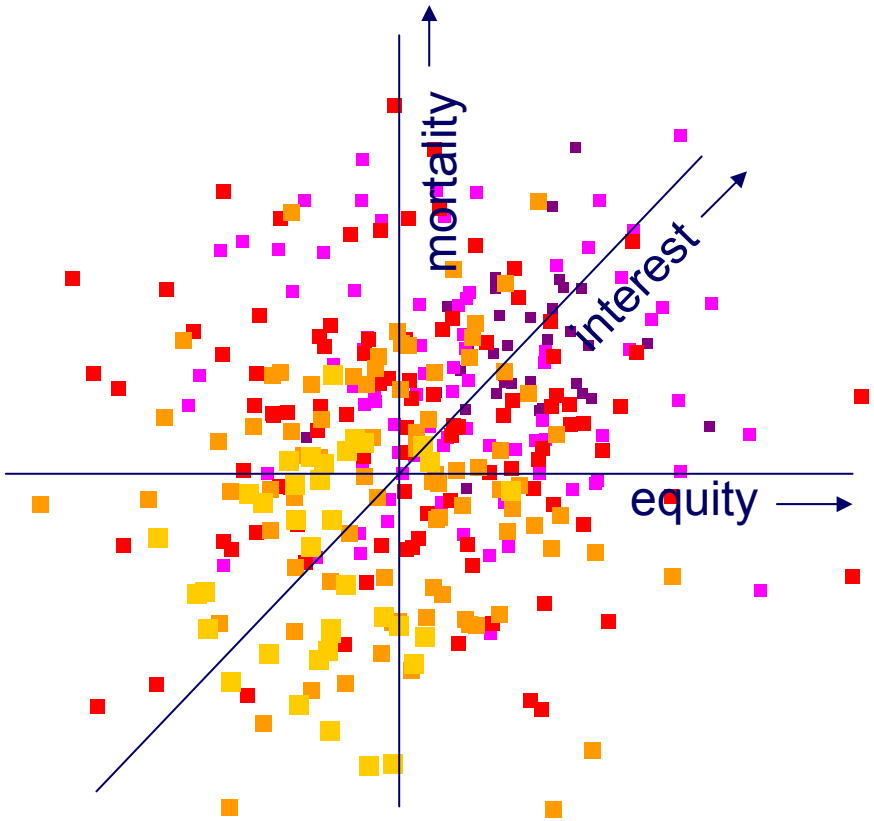
- Presenting capital and risk information
- Communication examples based on simple ALM
  - Duration and convexity
  - Capital allocation
  - Stress test likelihood
  - Big bang and medium bang
  - Least solvent likely event
- Better decisions from capital understanding
- Conclusions

Capital and risk reporting structures may be complex



Solvency II QIS 3 Structure

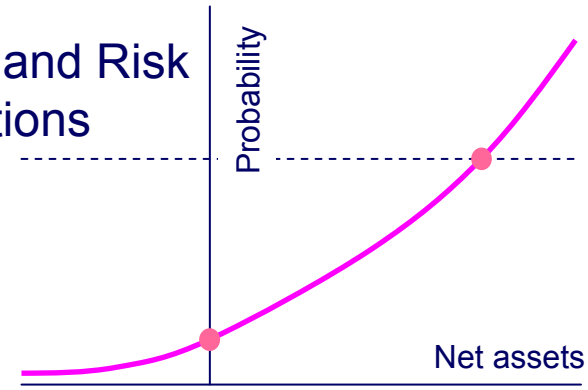
Calculations may be onerous, so computational efficiency is important.



Stochastically generated
drivers

Stochastic
Model Office
response function

Capital and Risk calculations



Results may be challenging to communicate Graphical techniques address these challenges.

Fitness for purpose

Capital based on 99.5% policyholder confidence

Is this right the right measure to drive product price loading?

Or for shareholder value analysis?

Model complexity

Thousands of assumptions

Prevents interactive analysis

Can't do the sums in your head

Effect of assumptions unclear

Capital results change unexpectedly

Need to control all inputs

Sub-additivity

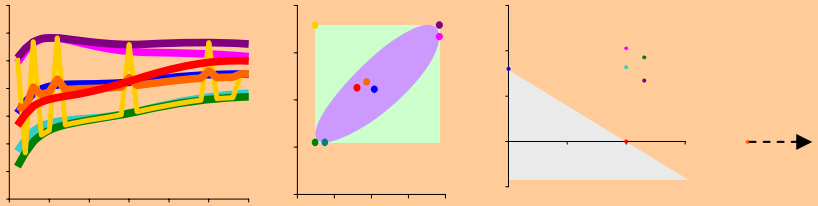
Financial reporting consolidation requires capital to add up

Diversification effects are balancing items

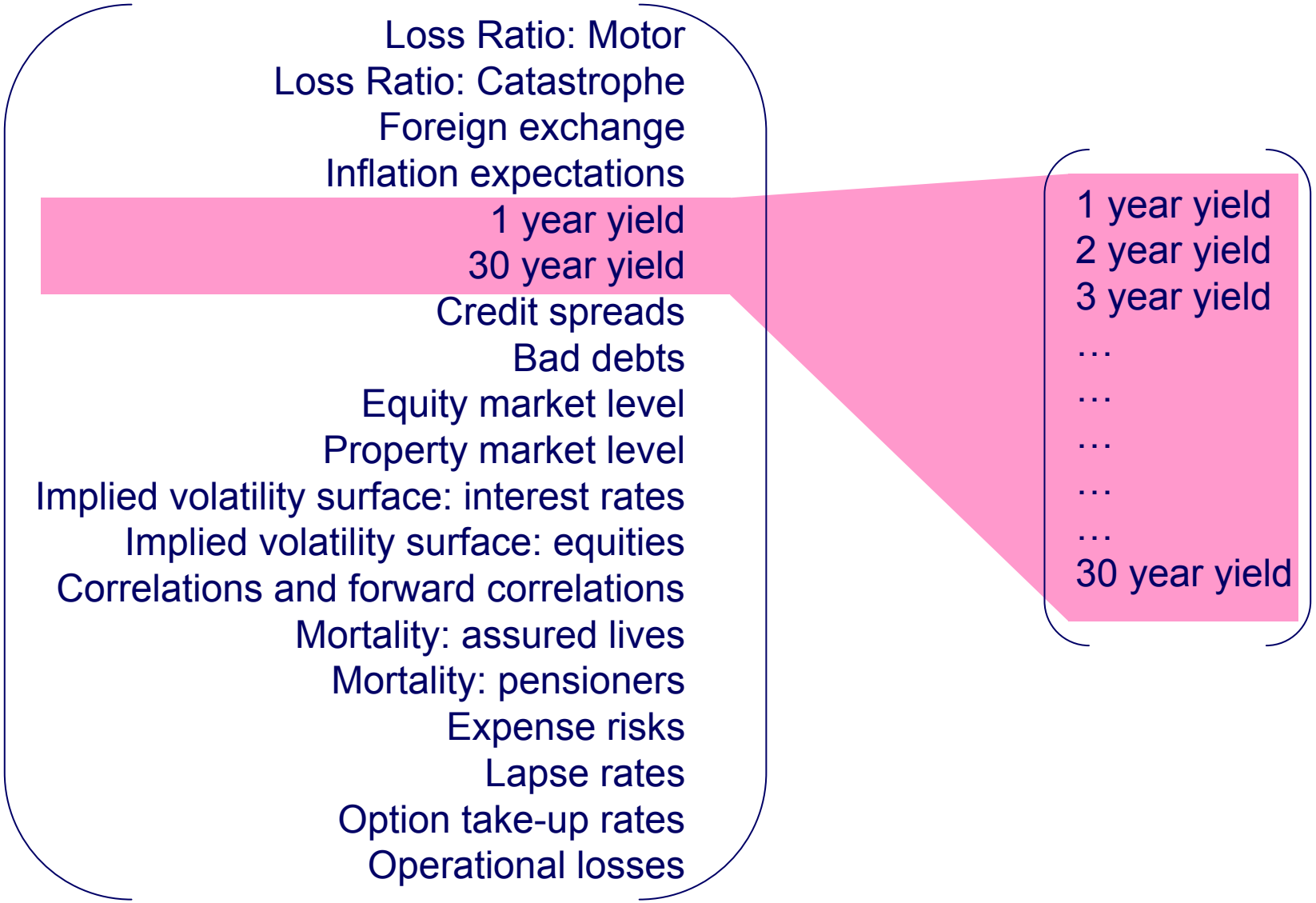
Remote actions: change in interest rate hedge affects capital allocated for natural catastrophe risk

Graphical Communication

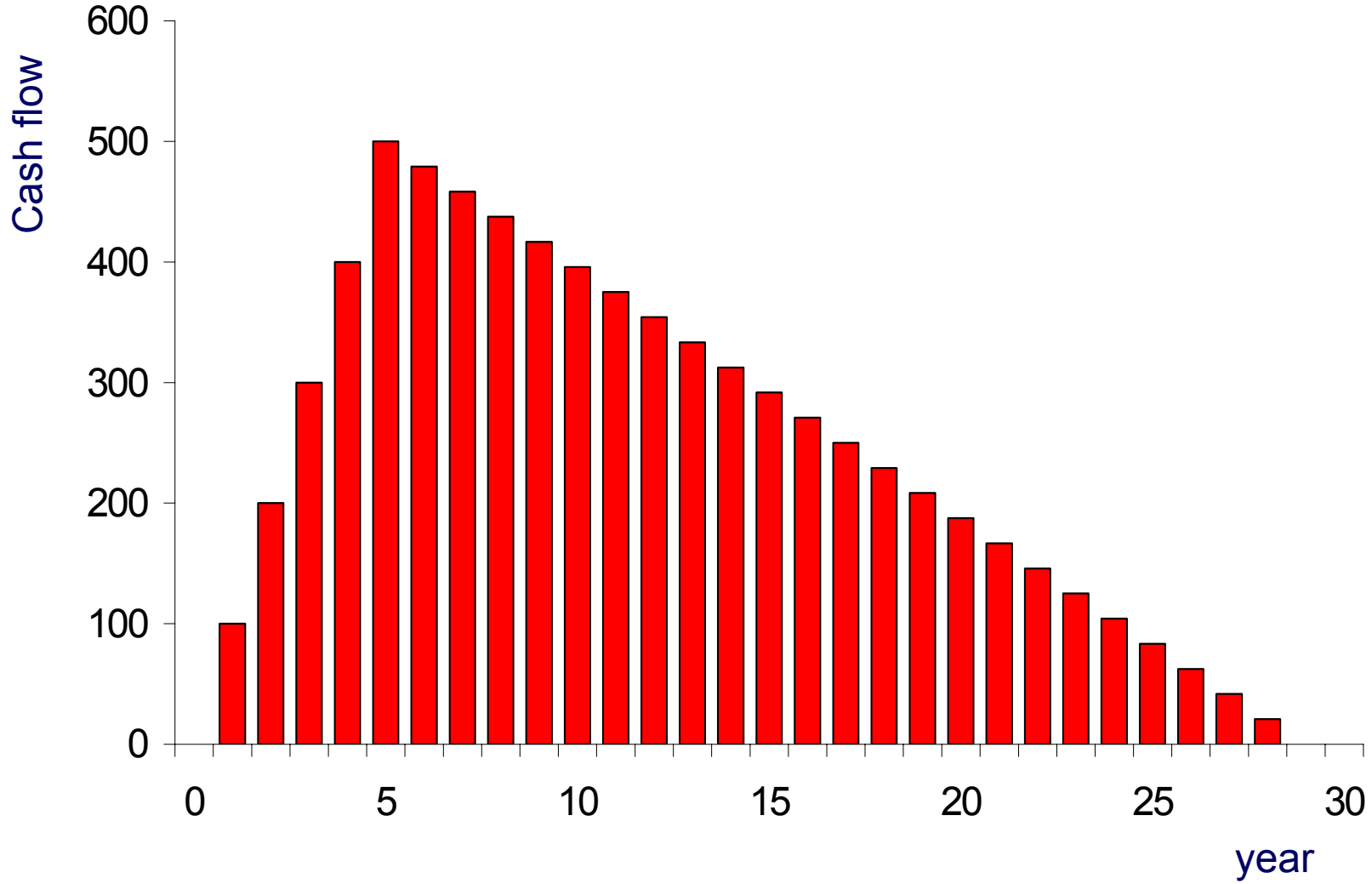
Best practice adopts stress scenarios to communicate risk exposures



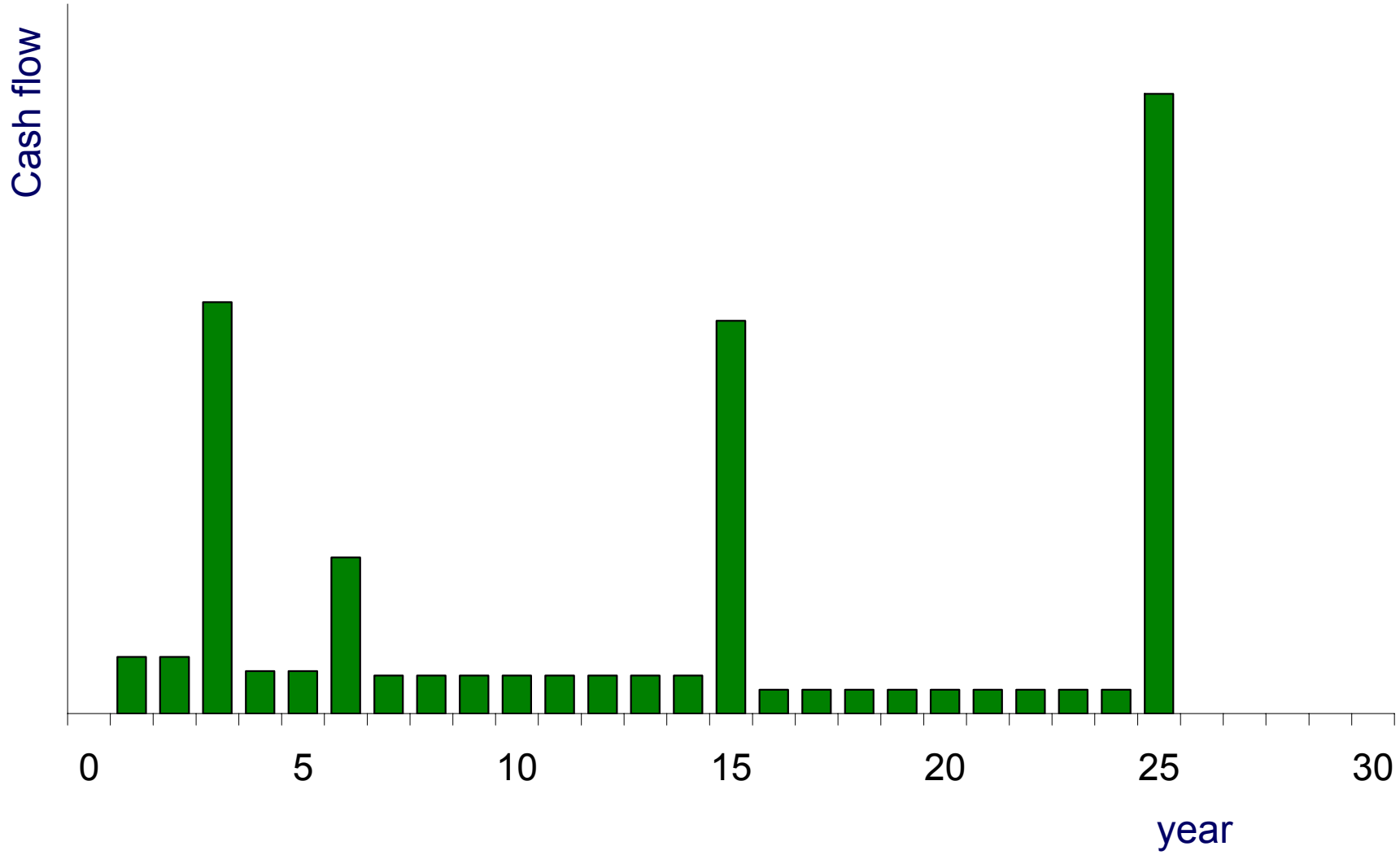
Capital Calculations have high dimensionality. Today we consider an example based on interest rate risk



Example liability cash flows



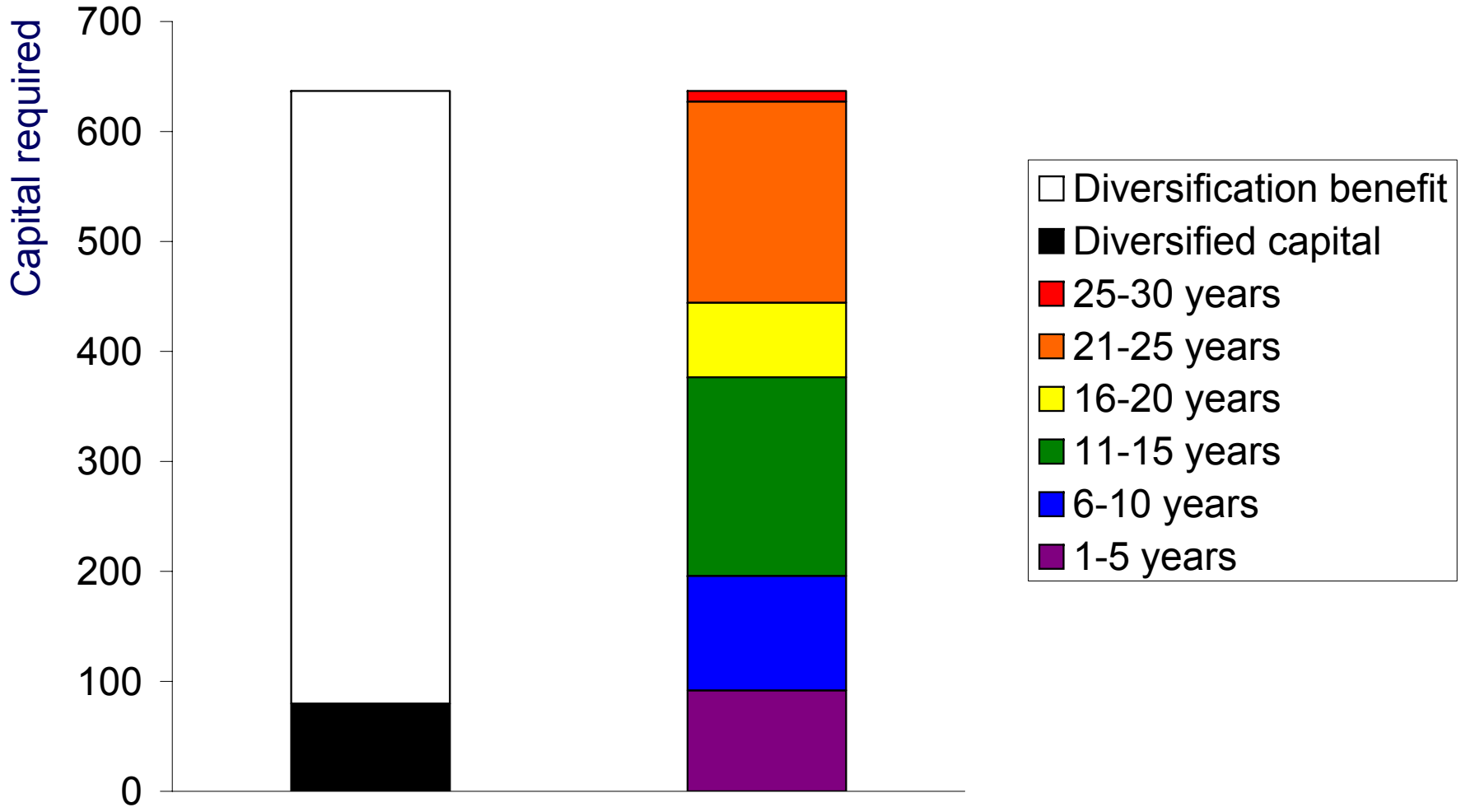
Example asset cash flows



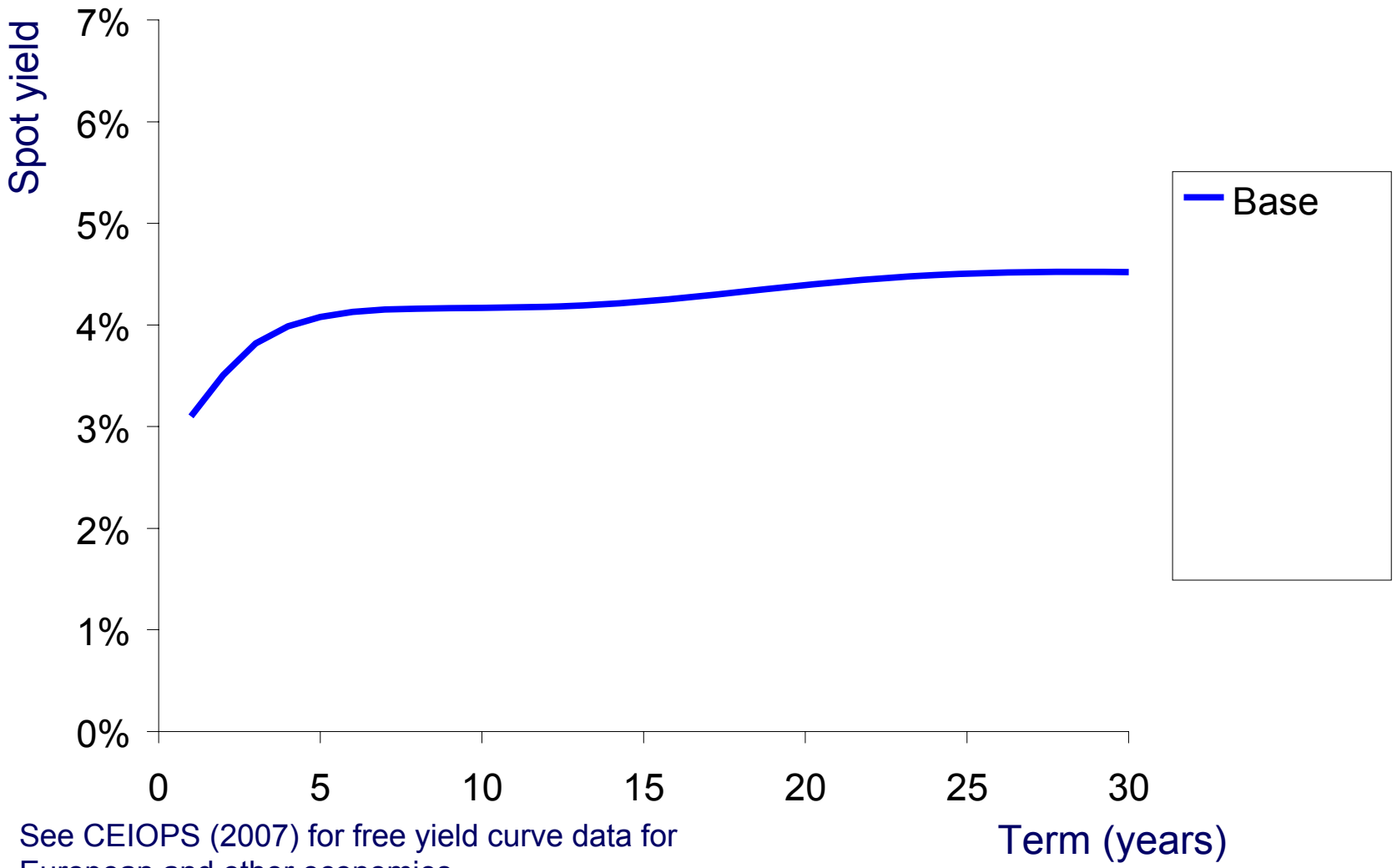
Our base analysis uses a market yield curve Calibrated to market prices of traded bonds

Abbreviation	Definition
● Base	Calibrated to market bond/swap prices of various terms

Diversification has a large effect for yield curve models Because yields at adjacent terms are highly correlated.

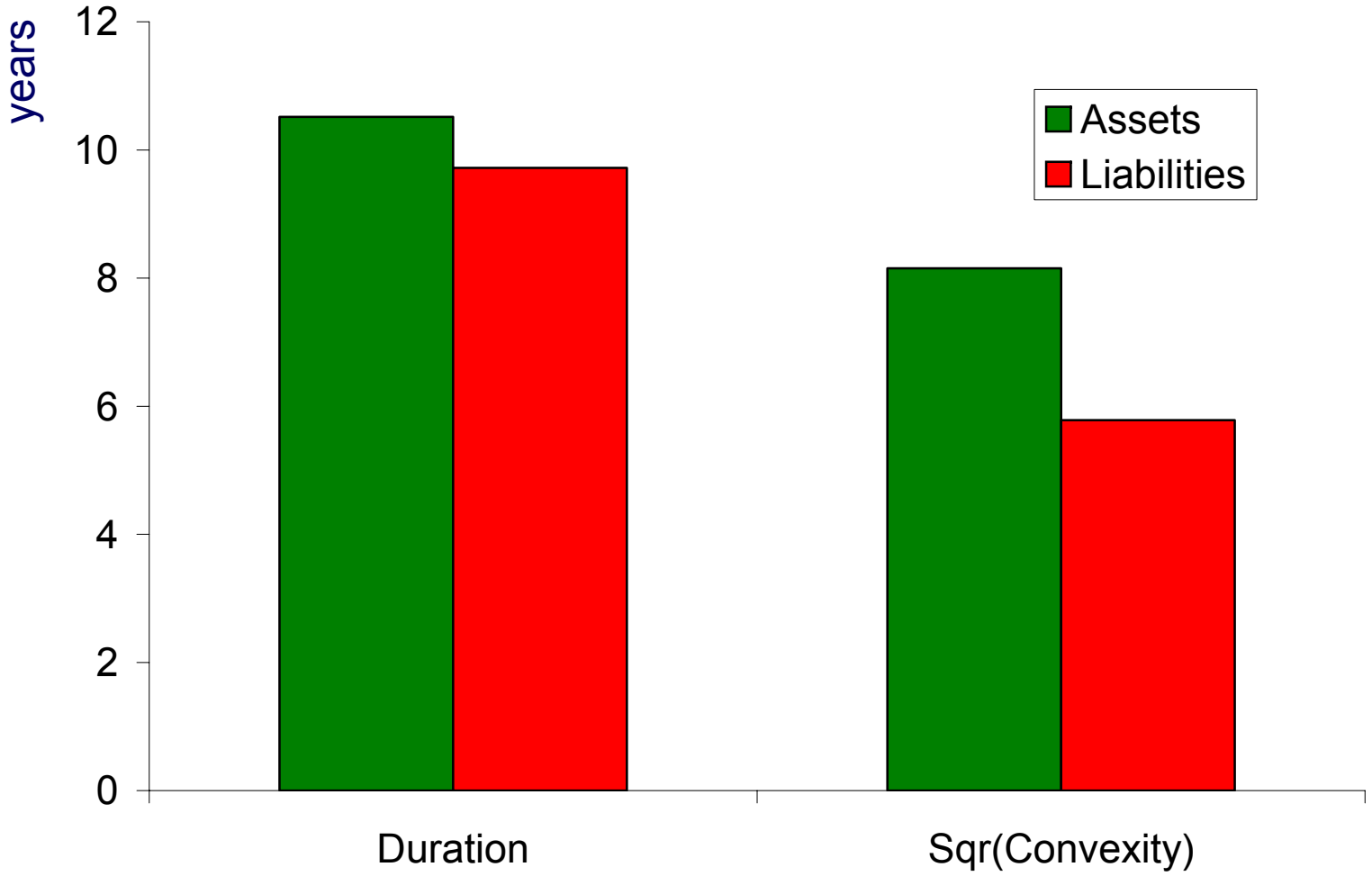


Our example uses this base yield curve.

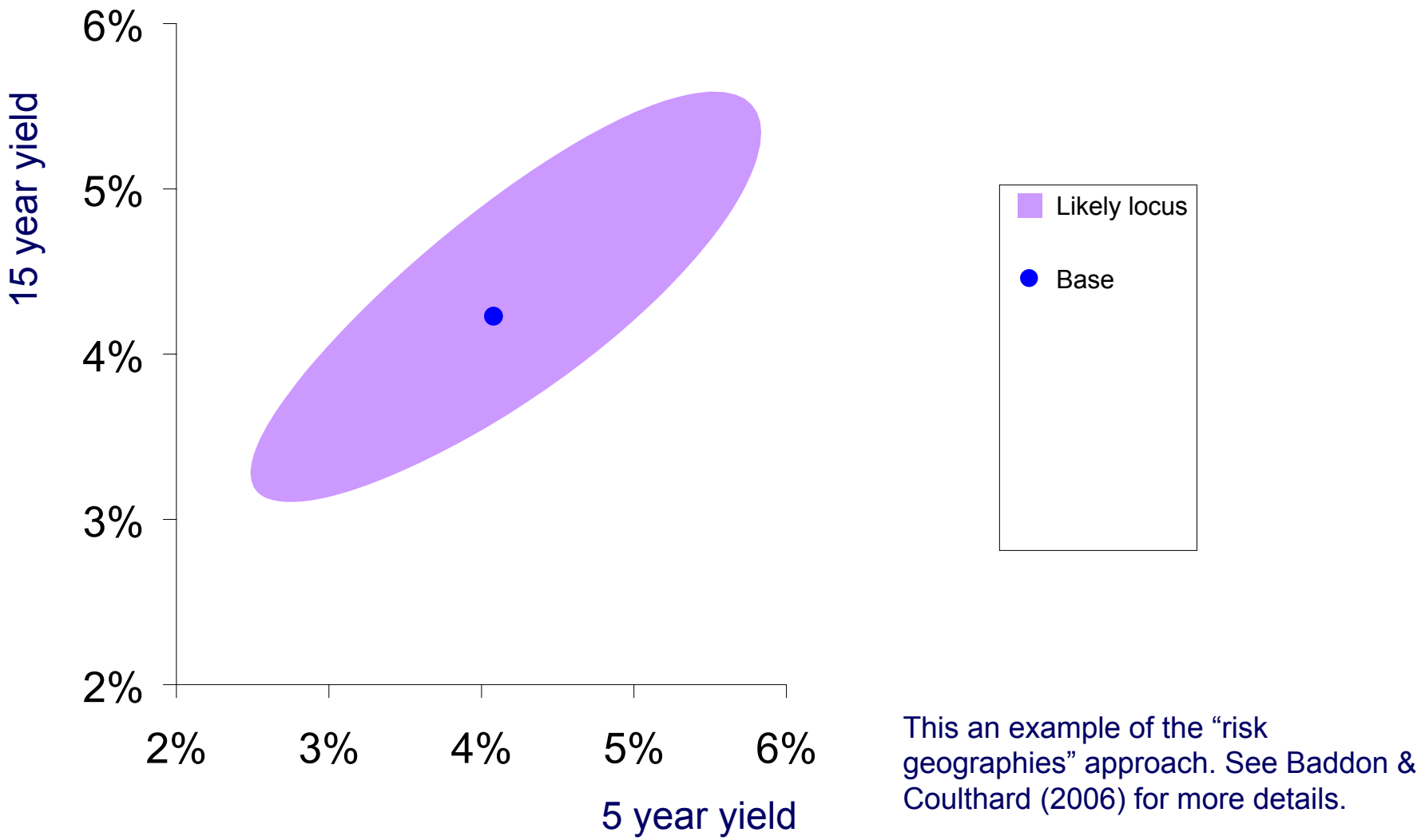


See CEIOPS (2007) for free yield curve data for European and other economies.

Duration and Convexity



The Base Case lies in middle of all likely combinations.



This an example of the “risk geographies” approach. See Baddon & Coulthard (2006) for more details.

We chose the Base Net Assets equal to the Required Capital

Developing management intuition about threat scenarios

Our analysis has shown the traditional capital model outputs:

- Policyholder perspective
- How much capital is at risk of loss
- Sensitivity to parallel moves in interest rates
- Detail on, potentially, hundreds of other risks
- Benefits of diversification

Other things we would like to know:

- What has to go wrong to create financial distress?
- Which risks in combination pose the most significant threats?
- What are the most likely ways to fail?
- How to mitigate the risks of failure?
- What is the shareholder costs of bearing those risks?*

*This presentation focuses on the risk to policyholders. See Exley & Smith (2006) for the shareholder perspective.

Leading firms illustrate their risks by examining a series of stress scenarios

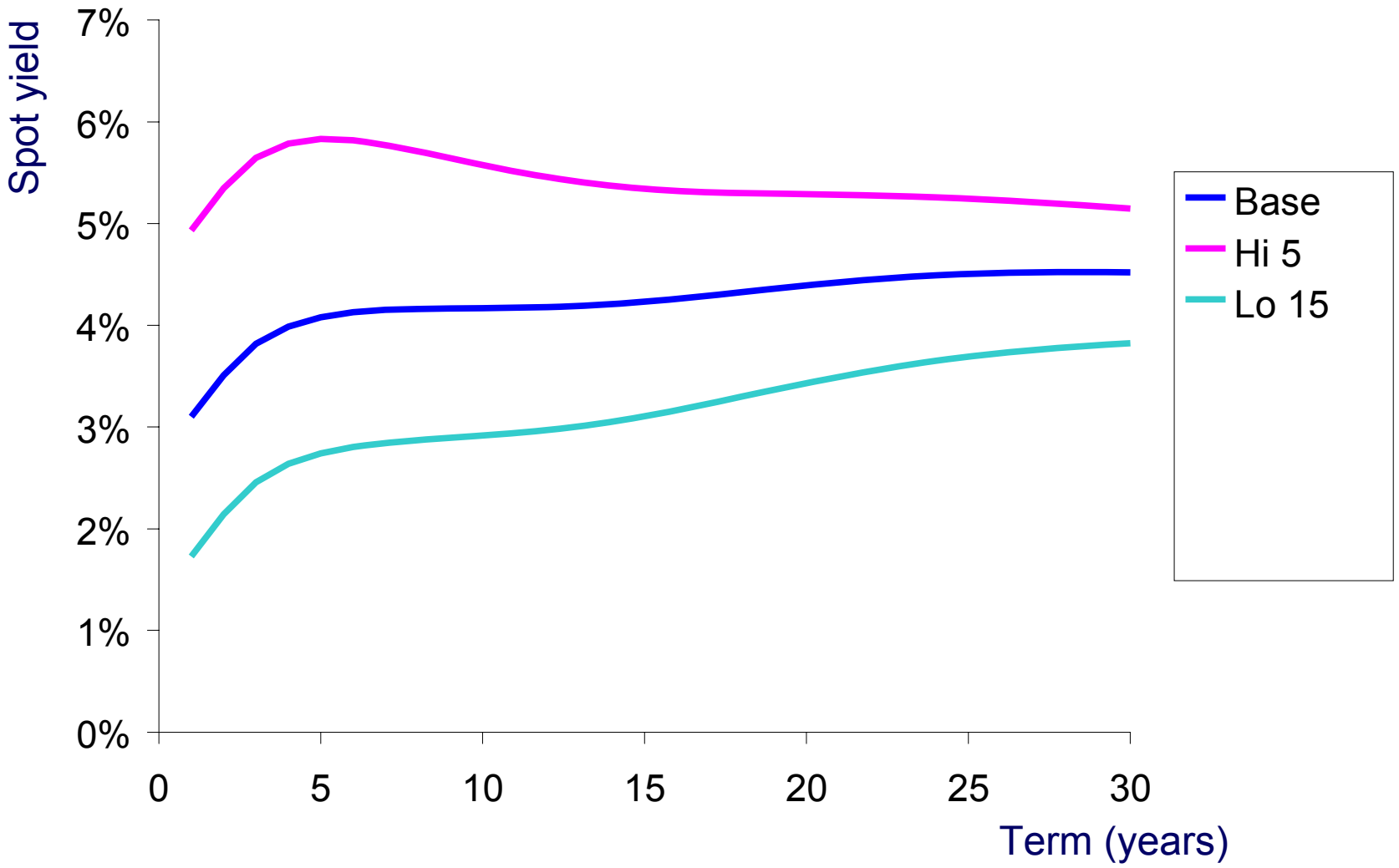
Abbreviation	Definition
Base	Calibrated to market bond/swap prices of various terms
Hi 5	Highest likely 5-year yield

The Hi 5 Scenario considers the highest likely 5 year yield
Other yields are set to their most likely given the 5 year yield

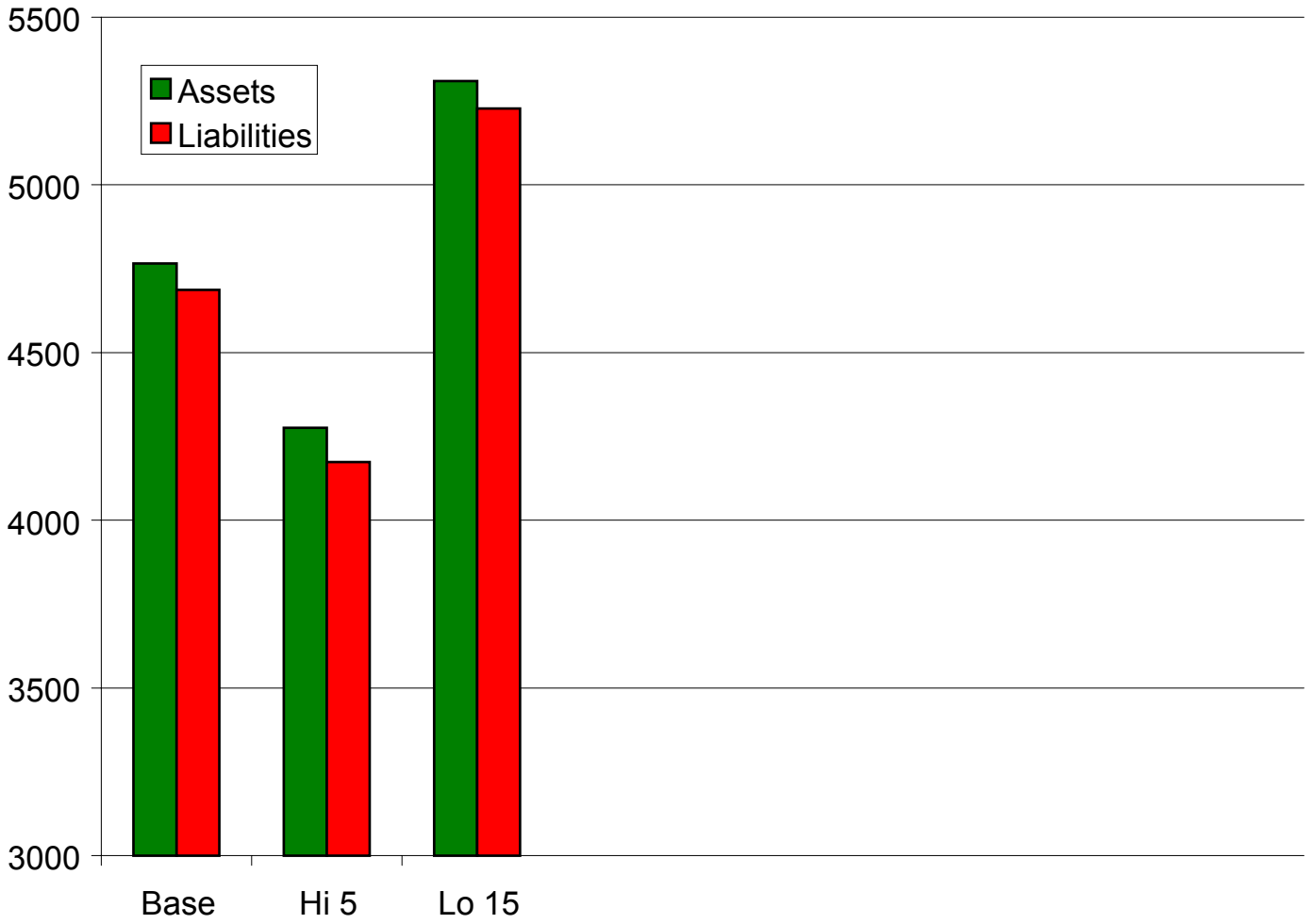
The Lo 15 Scenario uses the lowest likely 15 year yield Other yields are set to their most likely given 15 year yield

Abbreviation	Definition
Base	Calibrated to market bond/swap prices of various terms
Hi 5	Highest likely 5-year yield
Lo 15	Lowest likely 15-year yield

Base, Hi 5 and Lo 15 yield curves



Stress Test Effect on Assets and Liabilities



Mathematical Note: Defining Likely Stresses

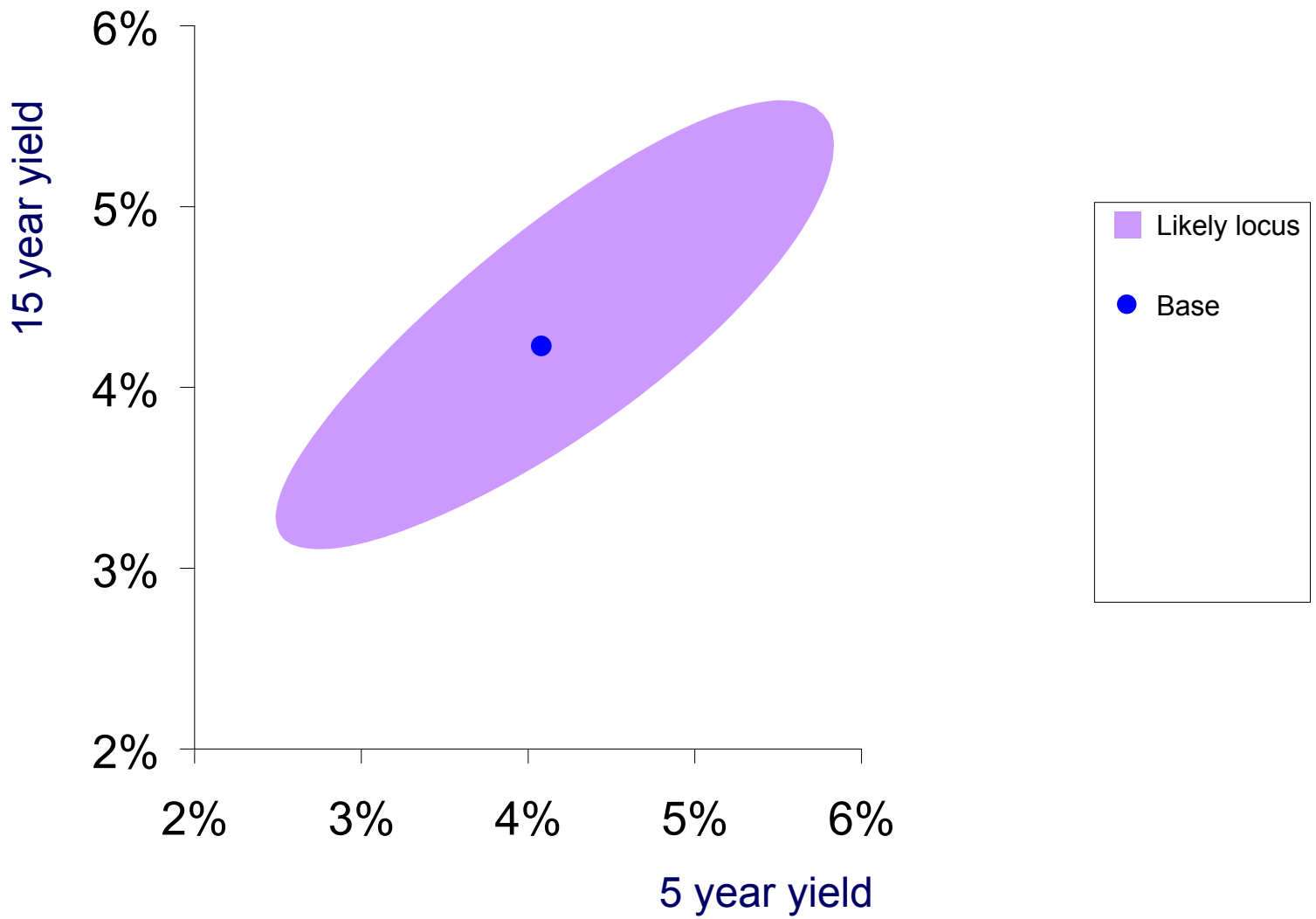
- We need to define what we mean by likely and unlikely scenarios
- Likely yield curve scenarios are
  - Continuous
  - Close to the base case
  - Flat
  - Smooth
- We define the size of a stress test using the Short Rate Stress Equivalent (SRSE)
  - Let P_t^{base} be the time 0 price of a t-maturity zero coupon bond
  - Let P_t^{stress} be zero coupon bonds from an alternative yield curve scenario
  - Pick α > 0 (in our example we use α = 15%)
  - Then define SRSE by:

$$\alpha \int_0^{\infty} \left(\frac{d}{dt} \left\{ \frac{P_t^{stress}}{P_t^{base}} \right\} \right)^2 dt + \frac{1}{\alpha} \int_0^{\infty} \left(\frac{d^2}{dt^2} \left\{ \frac{P_t^{stress}}{P_t^{base}} \right\} \right)^2 dt = SRSE^2$$

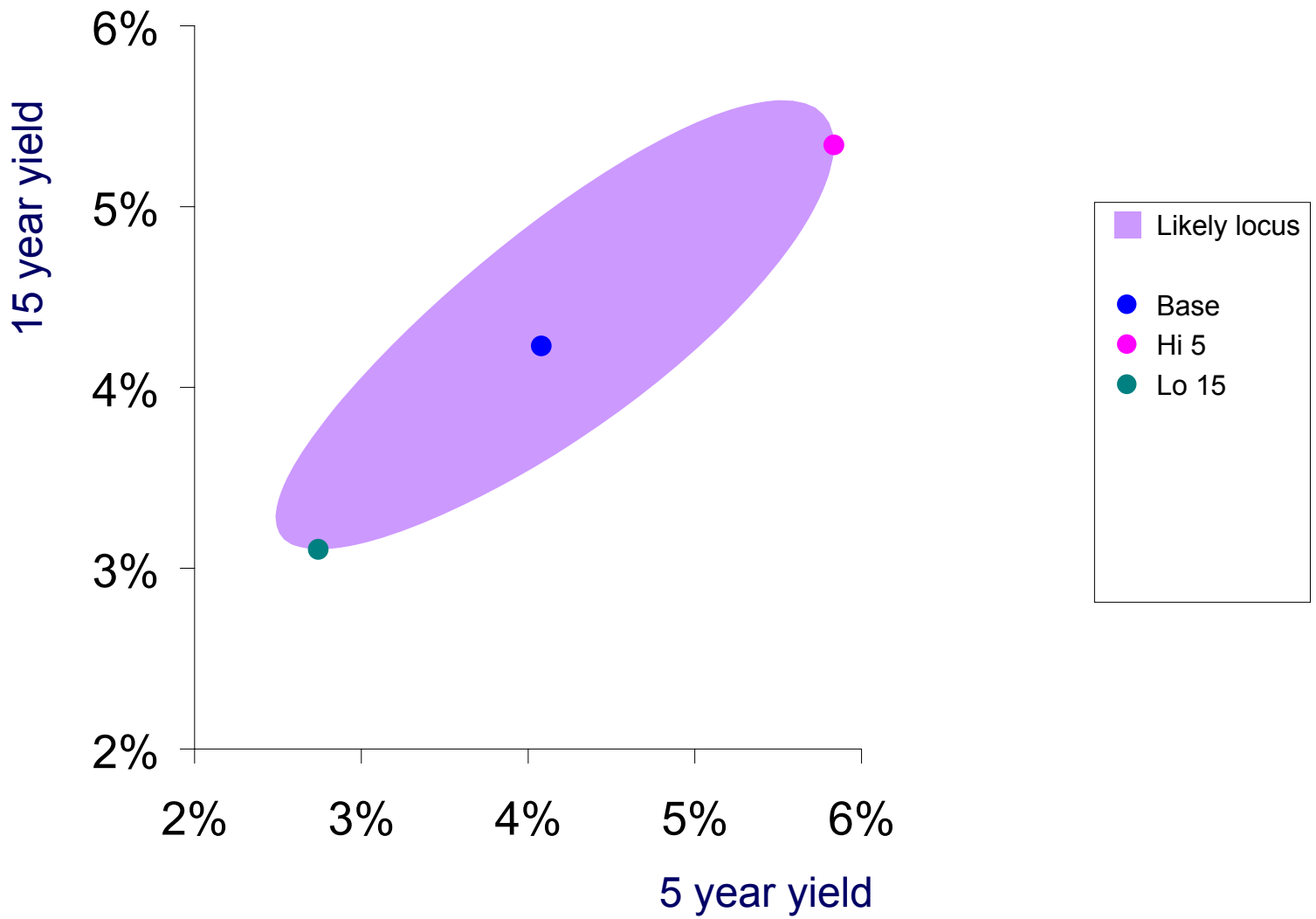
flatness smoothness

  - In this presentation, “likely” is defined as SRSE ≤ 2%
- See Smith & Wilson (2000) for more motivation behind this objective function.

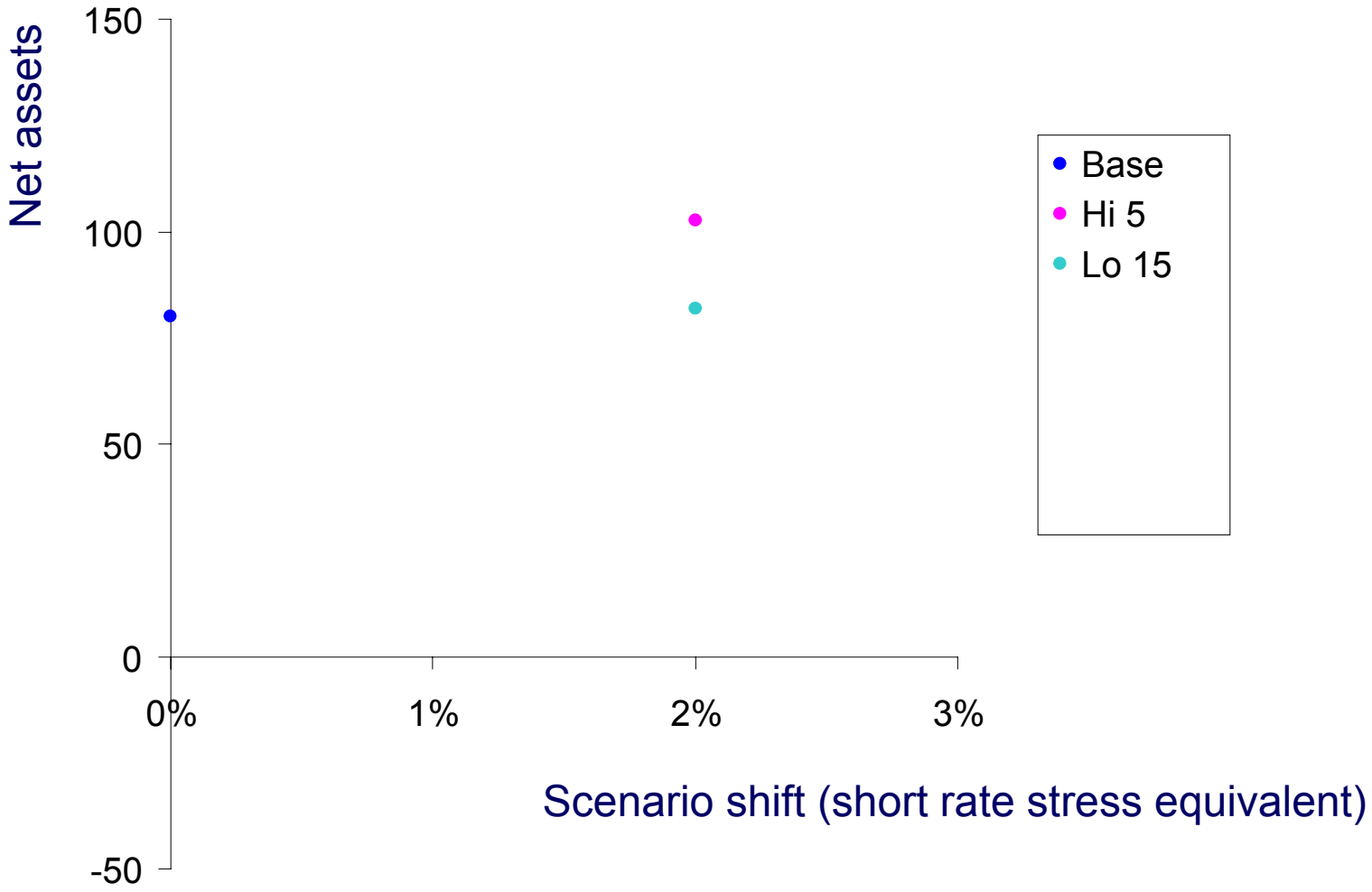
Likely locus contains scenarios equivalent to short rate stress ≤ 2%



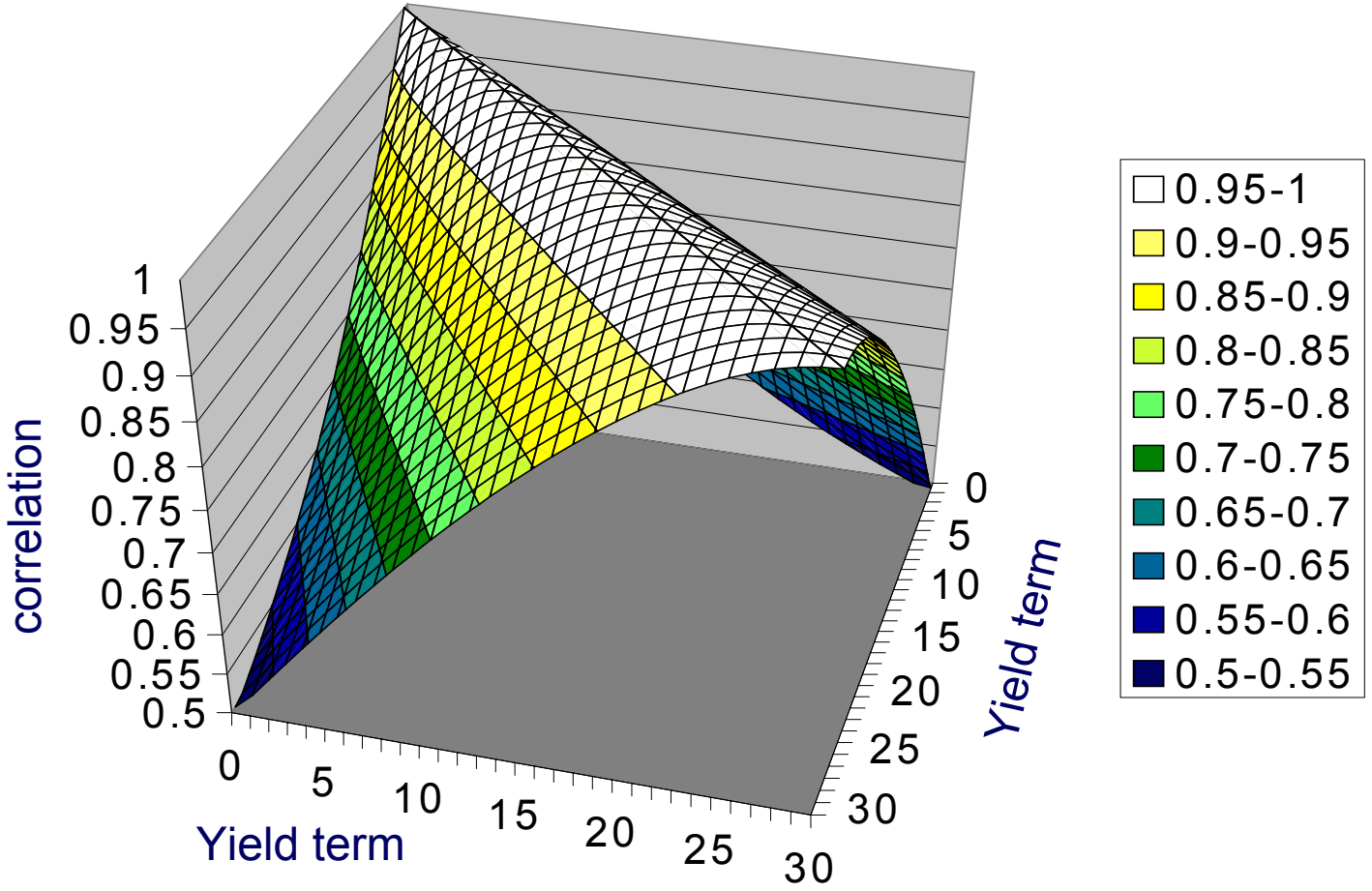
All likely tests lie on the Likely Locus



The Hi 5 scenario is slightly beneficial for net assets, even though the asset duration exceeds the liability duration.



We can also express likelihood using a correlation matrix
A mathematically equivalent formulation to the SRSE*

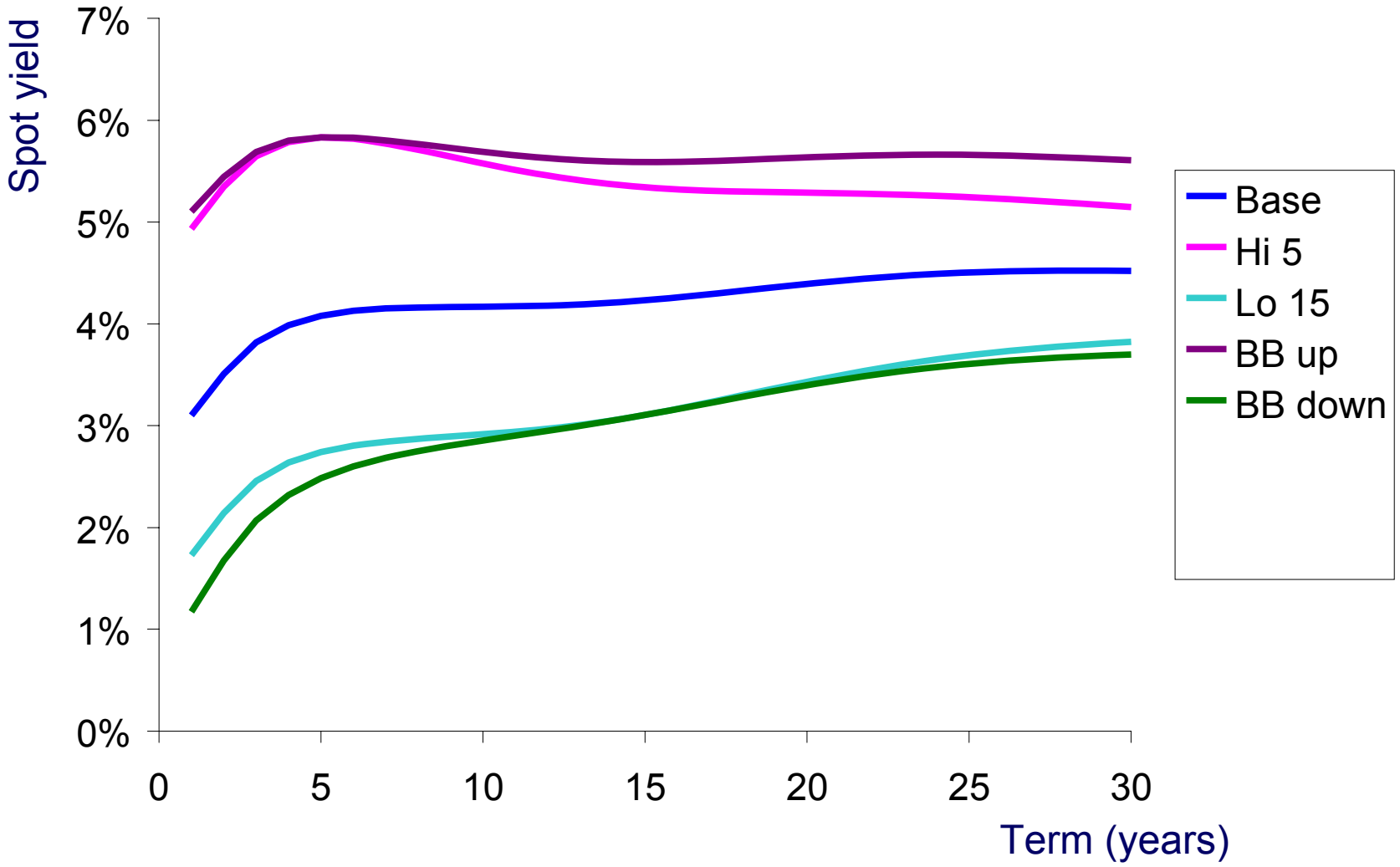


*Technically, the link to SRSE is the concept of "half-space depth." See Rousseeuw & Ruts (1999). The resulting covariance structure is consistent with an infinite dimensional yield model, as described by Cont (2004).

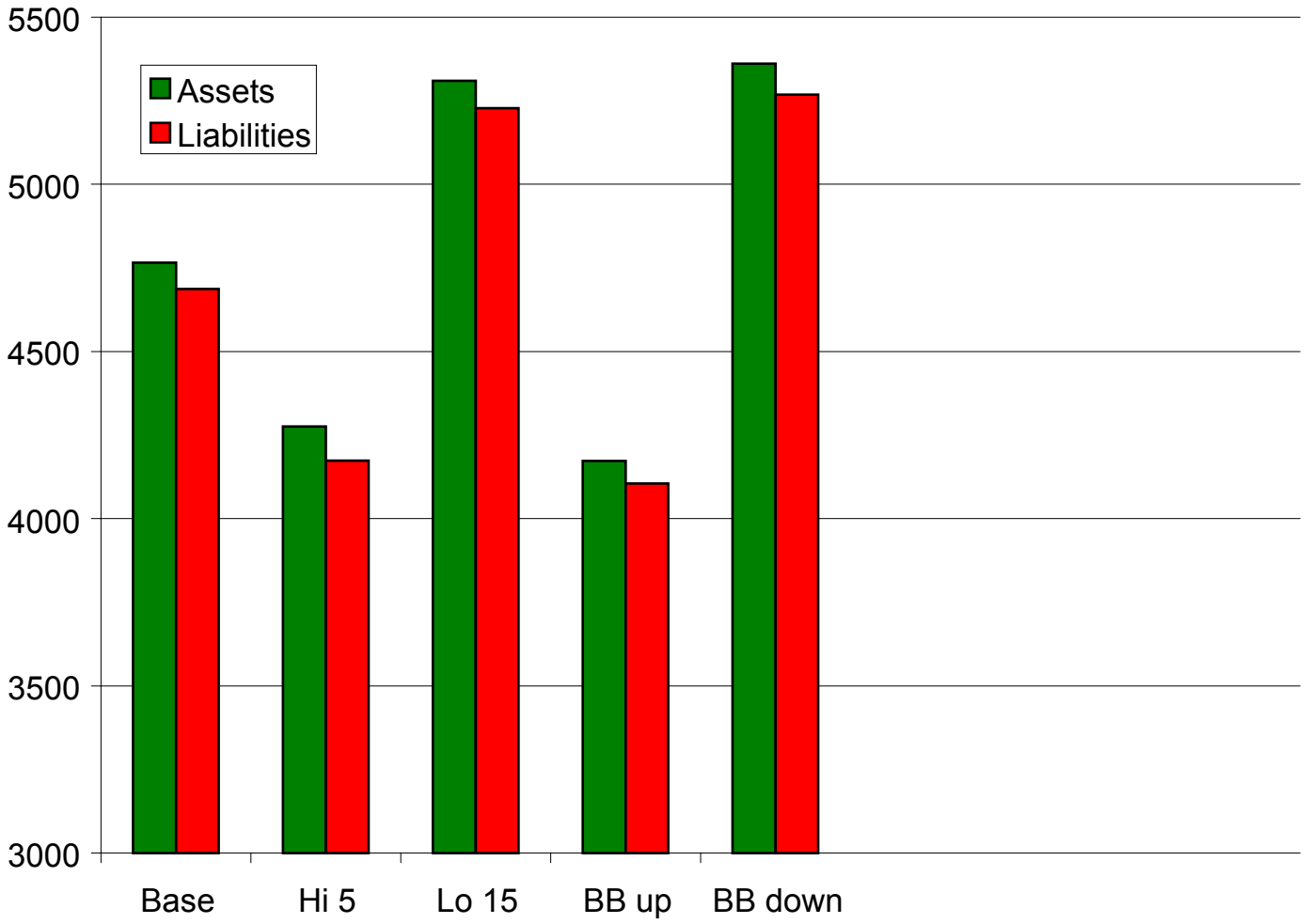
Big Bang sets all risks to their extreme likely values. Correlations make a Big Bang unlikely (SRSE > 2%)

Abbreviation	Definition
Base	Calibrated to market bond/swap prices of various terms
Hi 5	Highest likely 5-year yield
Lo 15	Lowest likely 15-year yield
BB down	Big Bang – all yields to their lowest likely value
BB up	Big Bang – all yields to their highest likely value

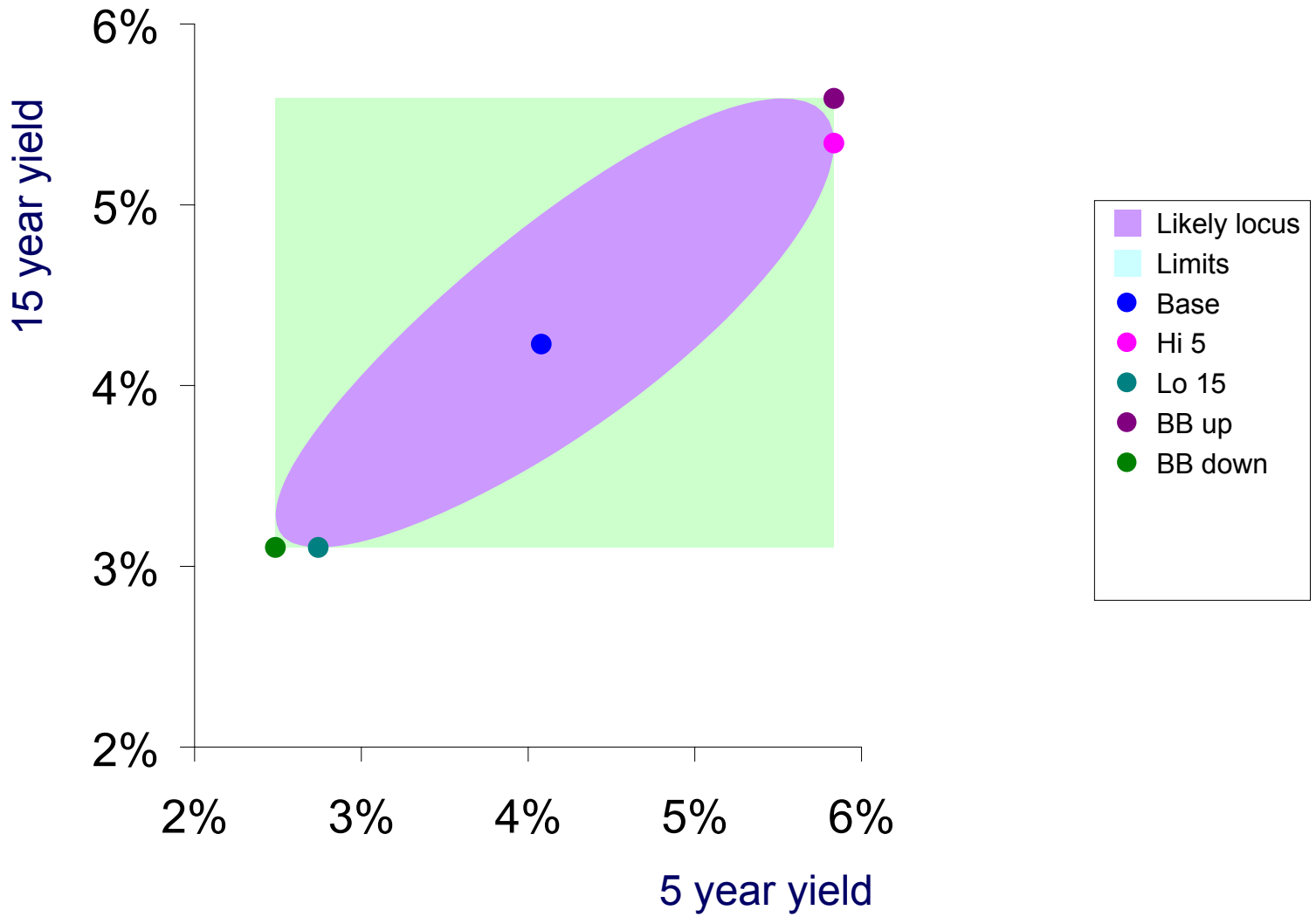
The Big Bang up and down scenarios represent the most extreme values for each yield from the Hi and Lo scenarios.



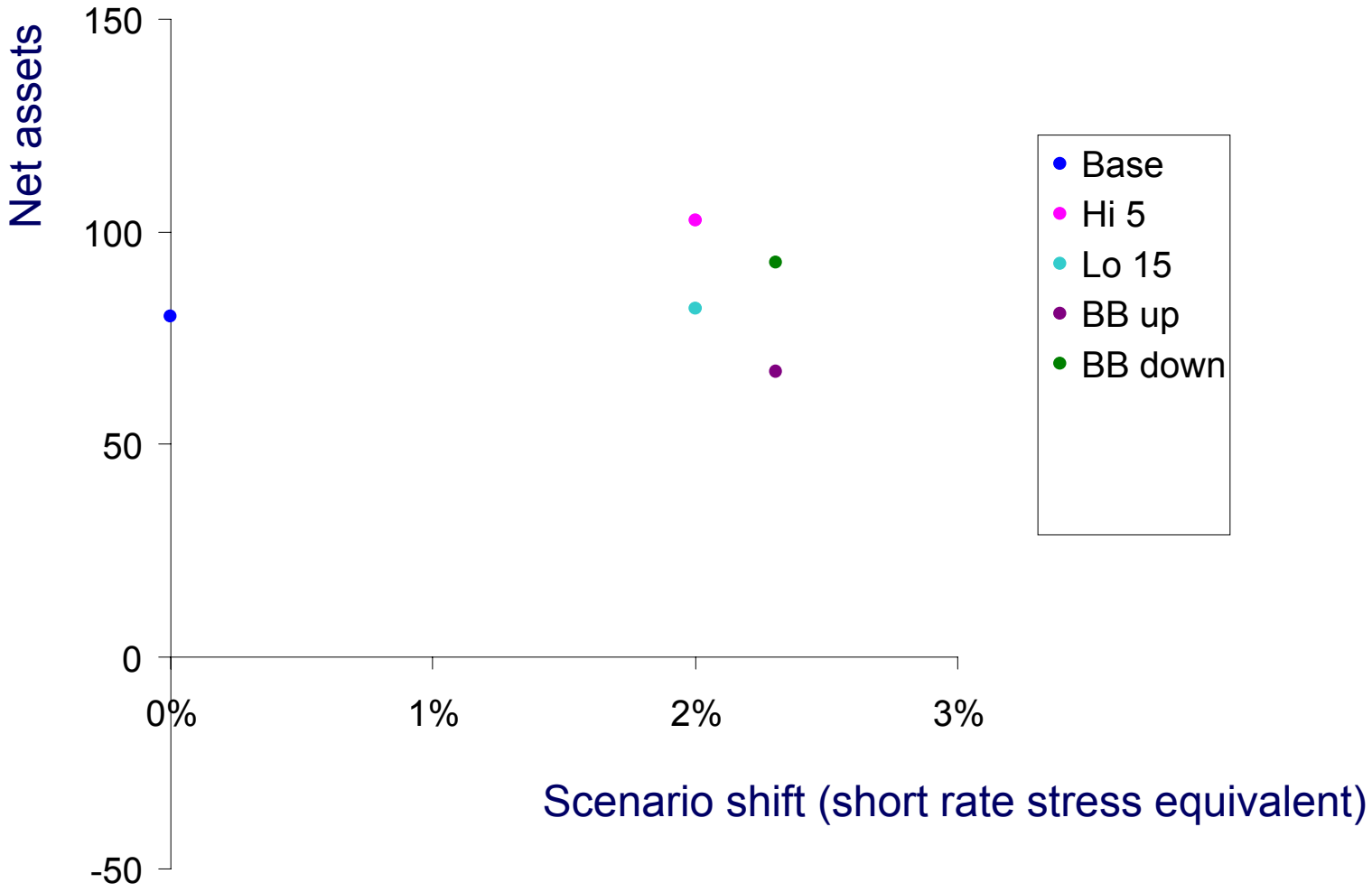
Big Bang test results are more extreme than Hi and Lo likely scenarios



Big Bang scenarios lie outside the likely locus, at the most extreme likely values for each yield.



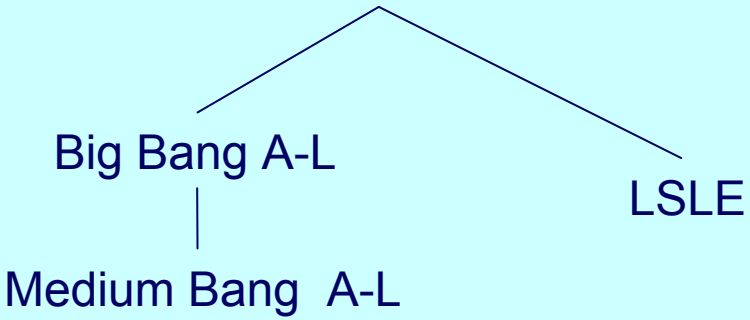
Big Bang effect on net assets



Choosing Combined Scenarios to Illustrate the Effect of Interacting Risks

Classical Approach
Pre-defined scenario tests
One risk at a time
Specified at a chosen level of confidence
Apply risks at full strength simultaneously
Example: Big bang

Scenarios Reflecting My Risks



Monte Carlo
Generate scenarios randomly with equal probability.

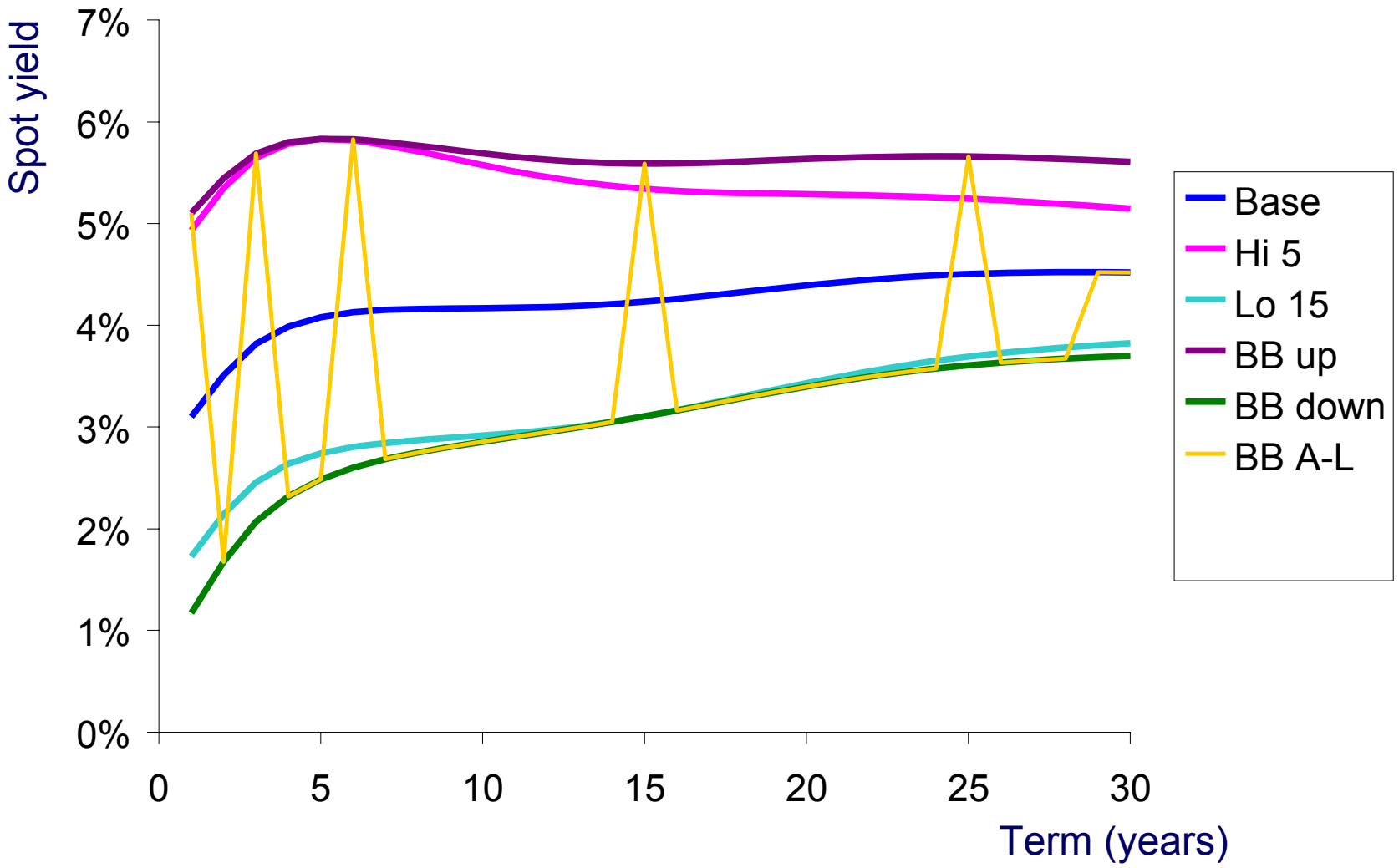
Advantage:
Easy to generate scenarios from a standard model.

Disadvantage:
Waste time computing scenarios that are not relevant or painful for our firm.

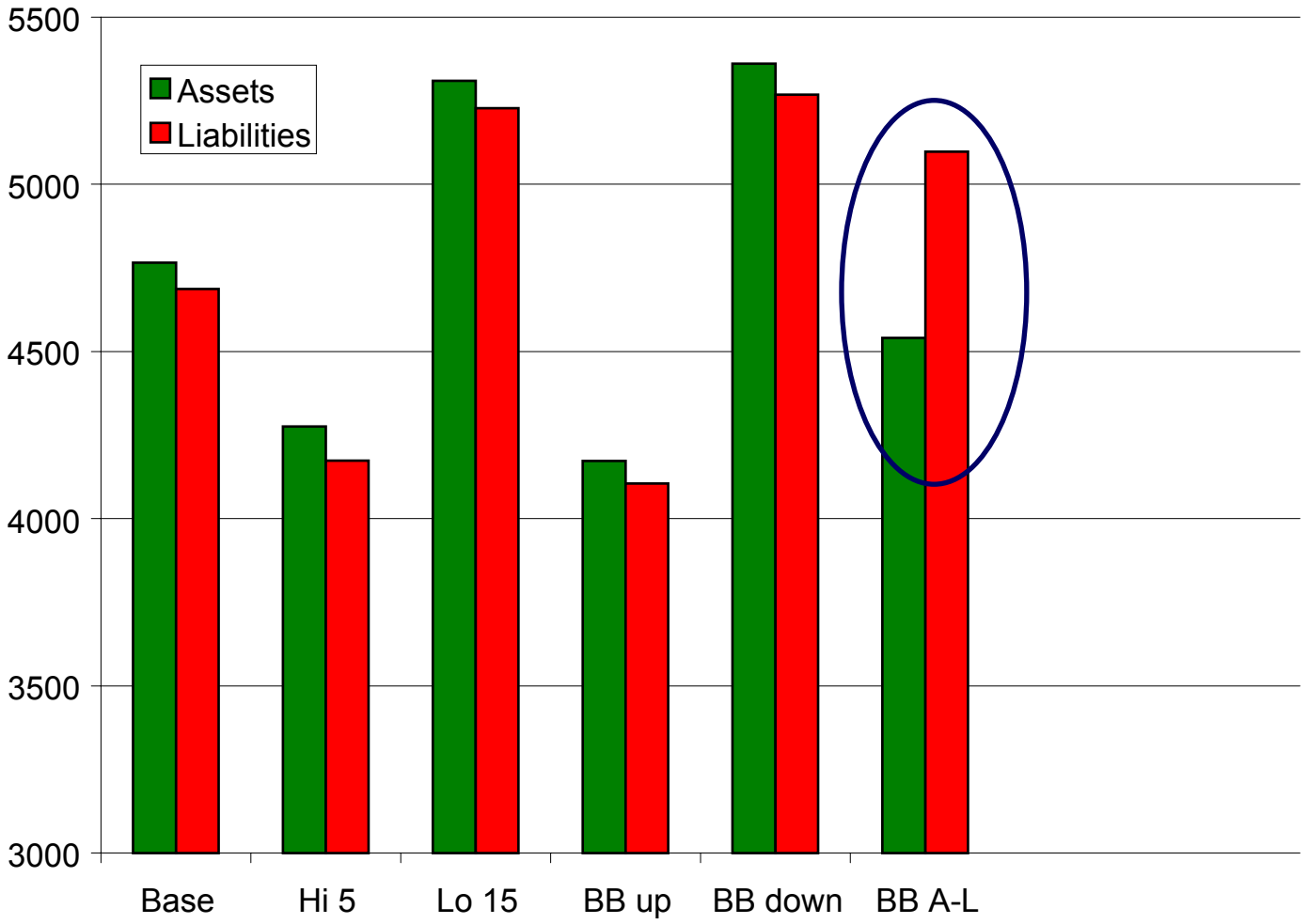
The Asset-Liability Big Bang moves each yield to its least favourable likely value

Abbreviation	Definition
Base	Calibrated to market bond/swap prices of various terms
Hi 5	Highest likely 5-year yield
Lo 15	Lowest likely 15-year yield
BB down	Big Bang – all yields to their lowest likely value
BB up	Big Bang – all yields to their highest likely value
BB A-L	BB Asset Liability – all yields to their least solvent likely value

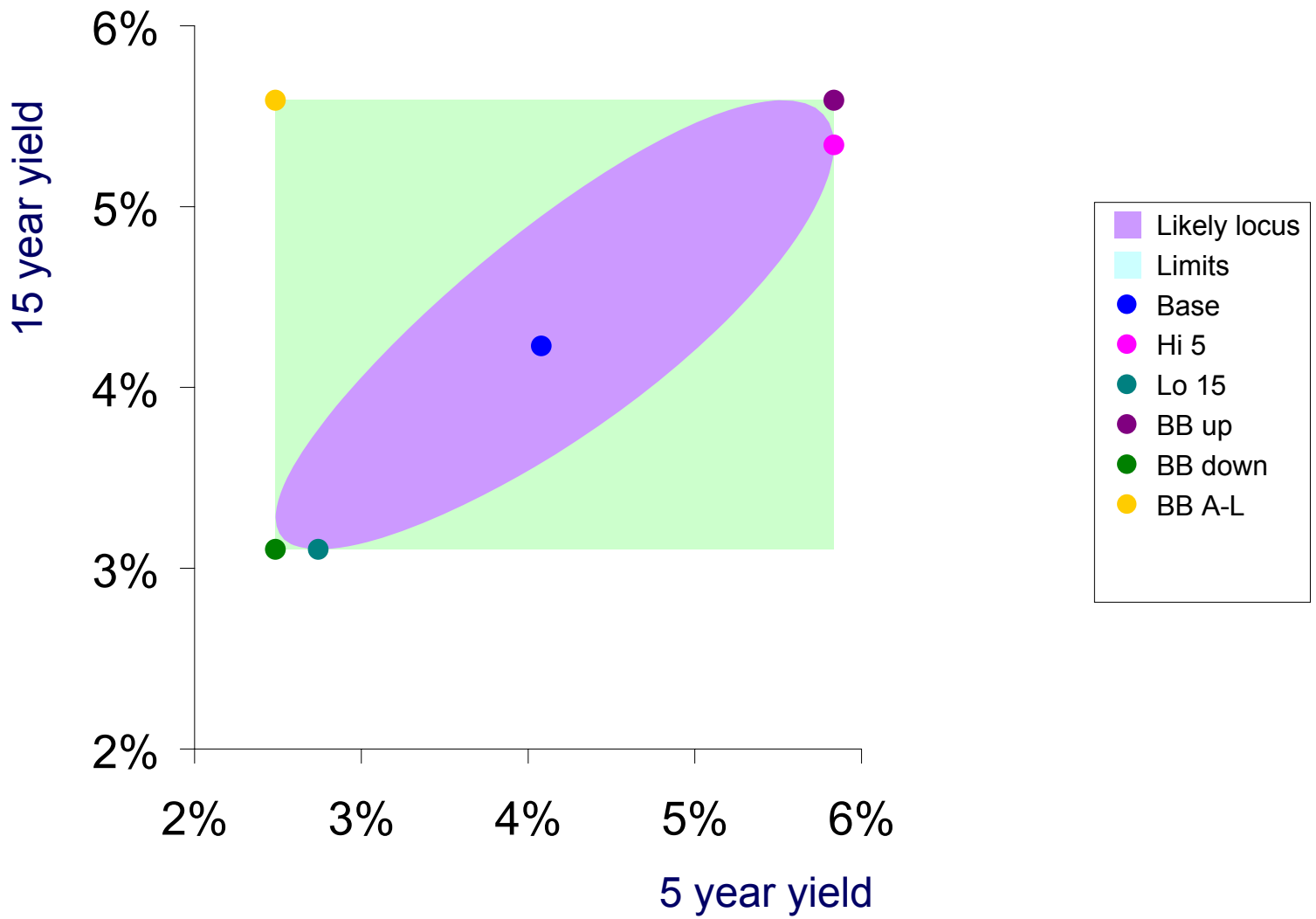
The Asset-Liability Big Bang does not produce a smooth curve, because big bang ignores correlations.



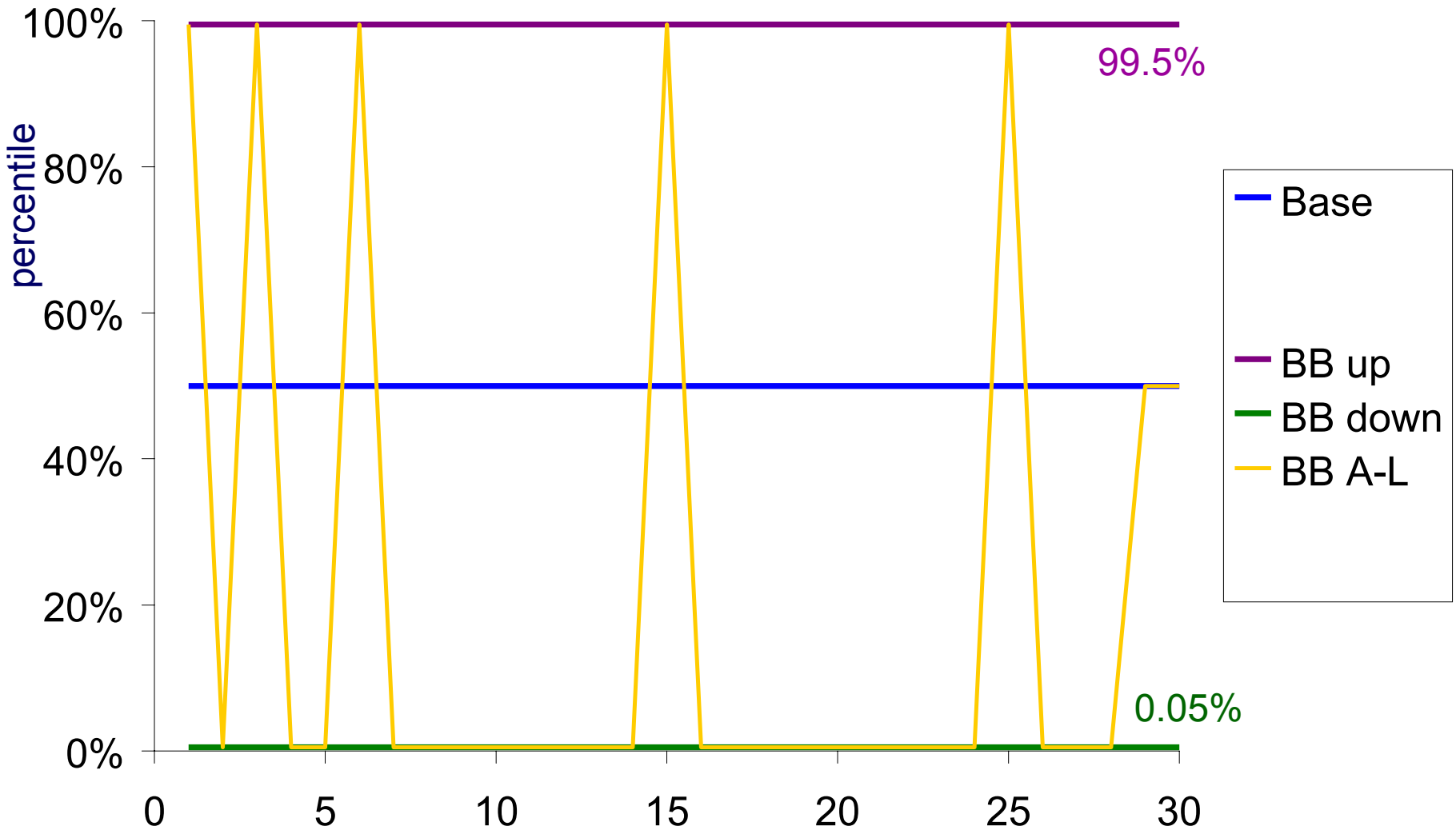
The Big Bang scenario is ruinous, as liabilities > assets
BB is unlikely: this does not contradict capital calculation.



The BB A-L scenario has a low 5 year yield and a high 15 year yield, because 15 years is a bond maturity date.



Big Bang Scenarios Represent 0.5% / 99.5% confidence For each yield viewed on its own



Medium Bang A-L takes all yields at a consistent lower confidence level, selected to allow for diversification

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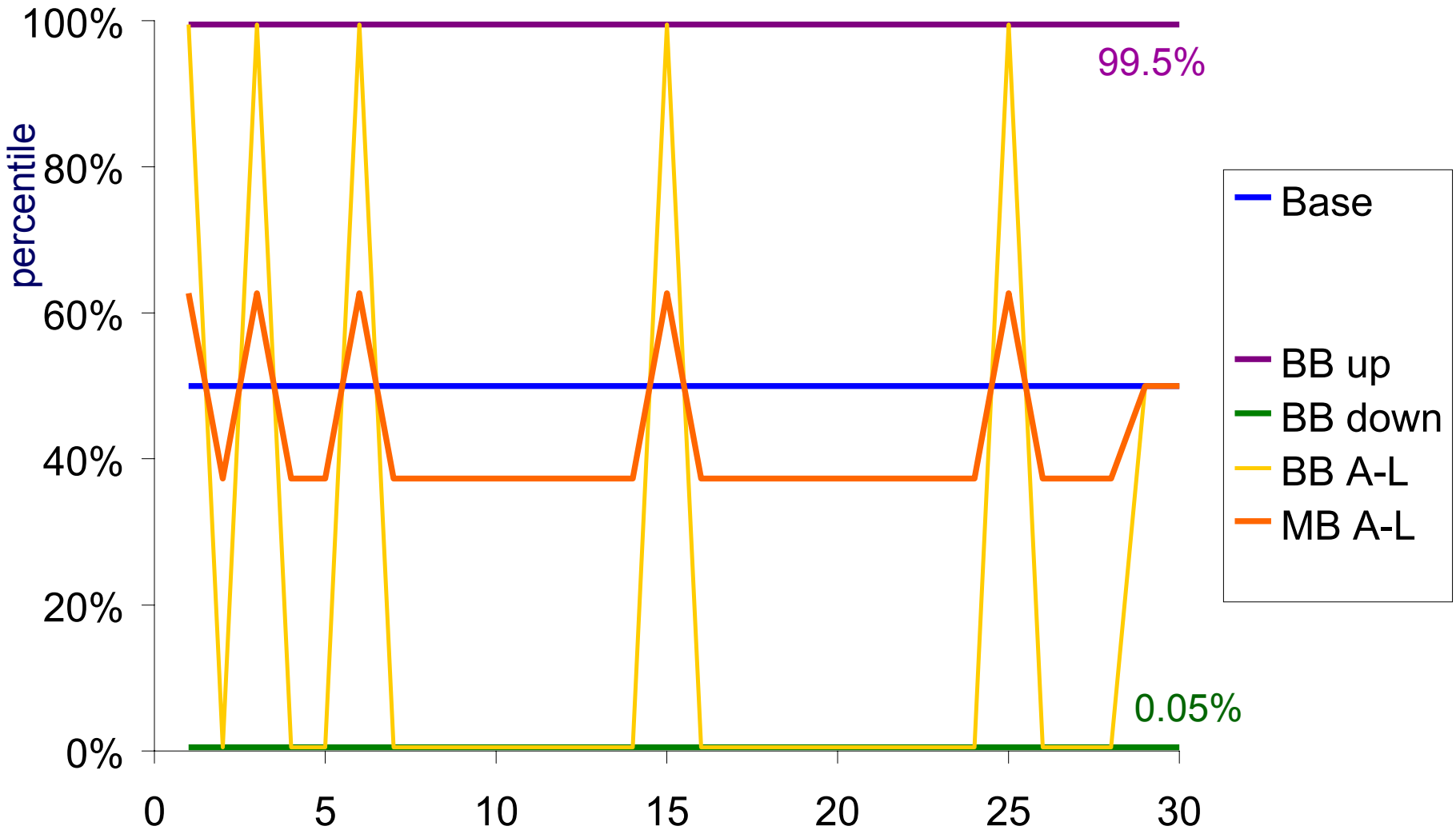
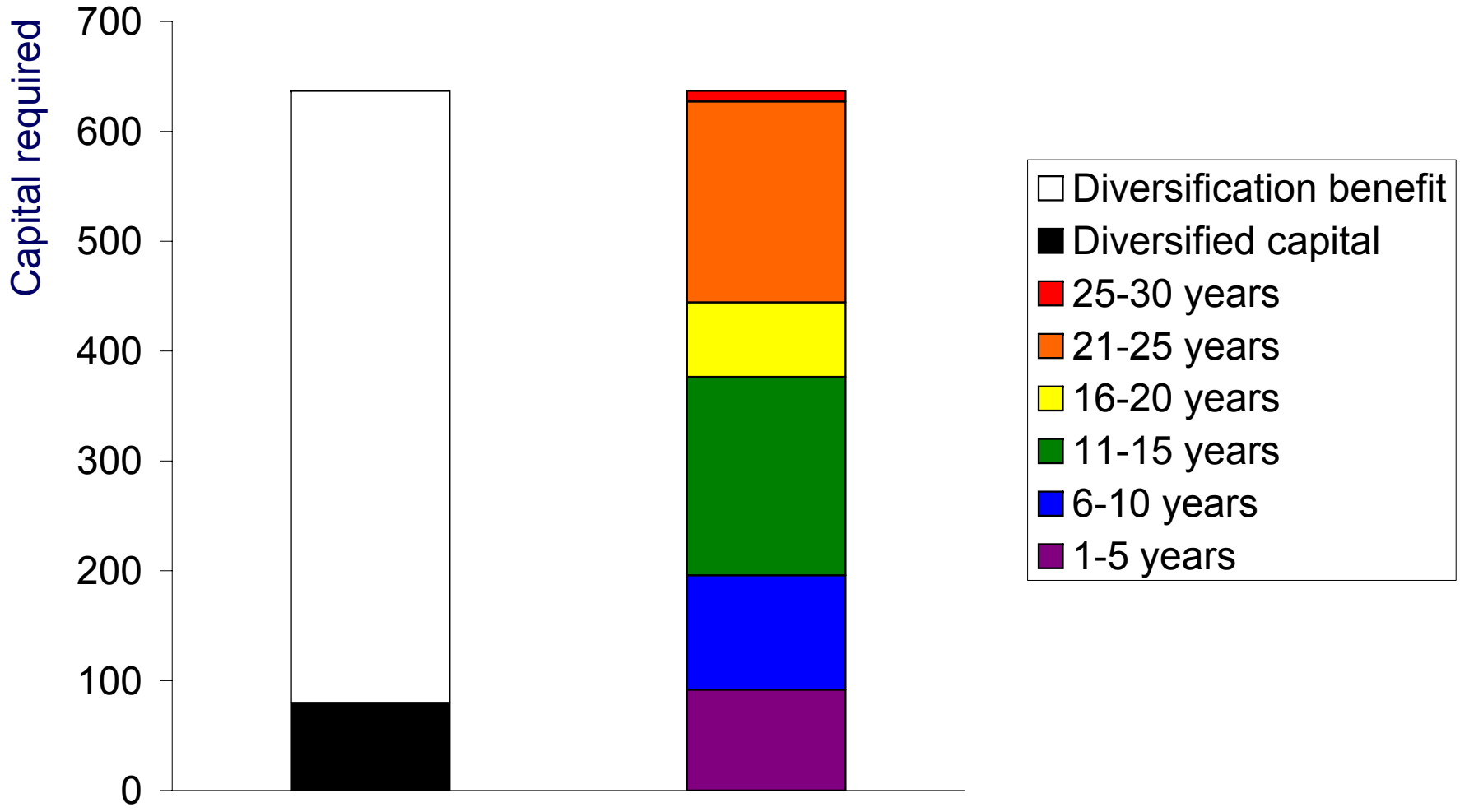
Base	Calibrated to market bond/swap prices of various terms
Hi 5	Highest likely 5-year yield
Lo 15	Lowest likely 15-year yield
BB down	Big Bang – all yields to their lowest likely value
BB up	Big Bang – all yields to their highest likely value
BB A-L	BB Asset Liability – all yields to their least solvent likely value
MB A-L	Medium bang – as for BB, but scaled back for diversification

In our example, 99.5% confidence after diversification implies 62.7% confidence before diversification*

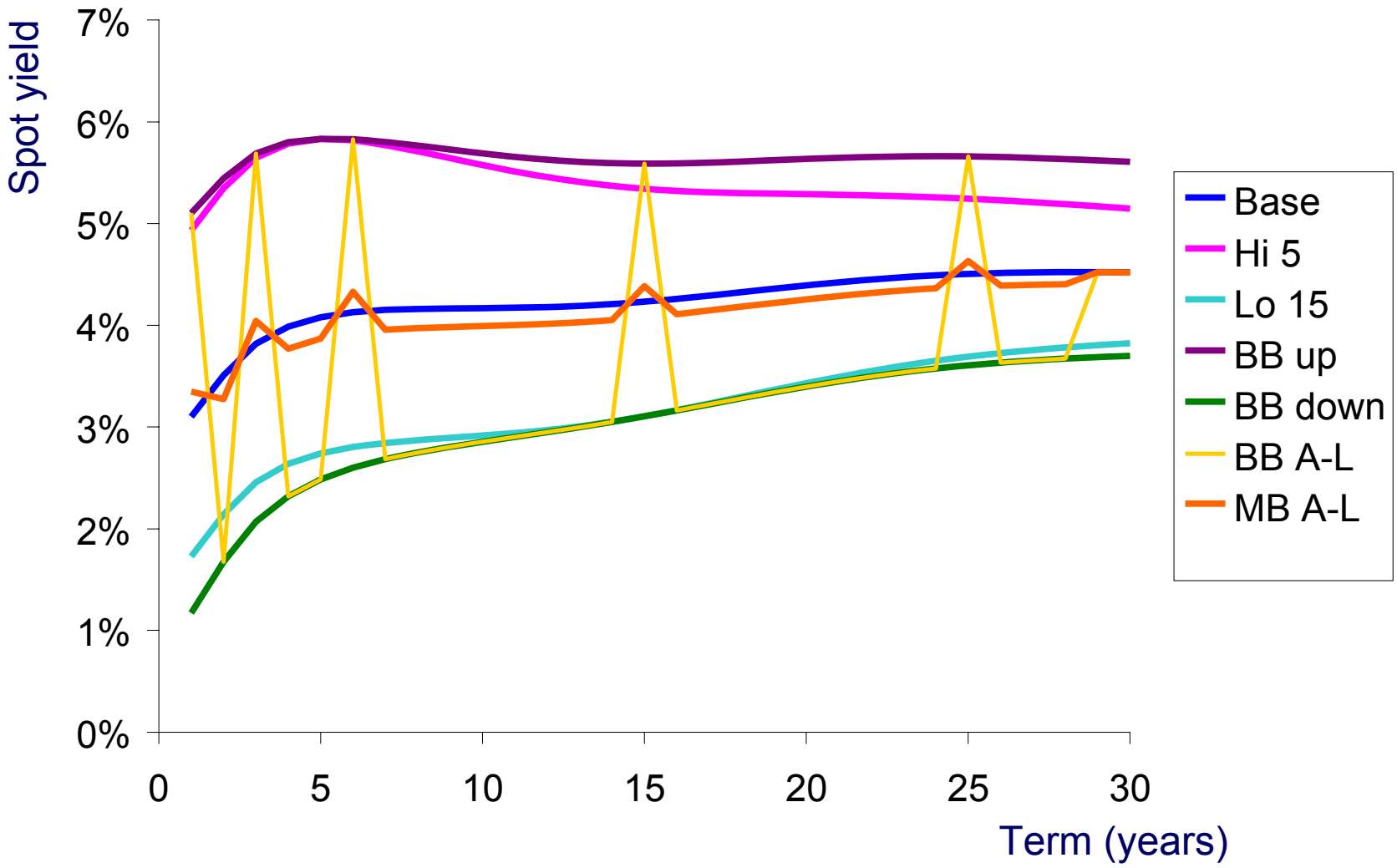


*FSA (2005) suggests 94% is a more usual medium bang confidence level, when all risks are taken into account.

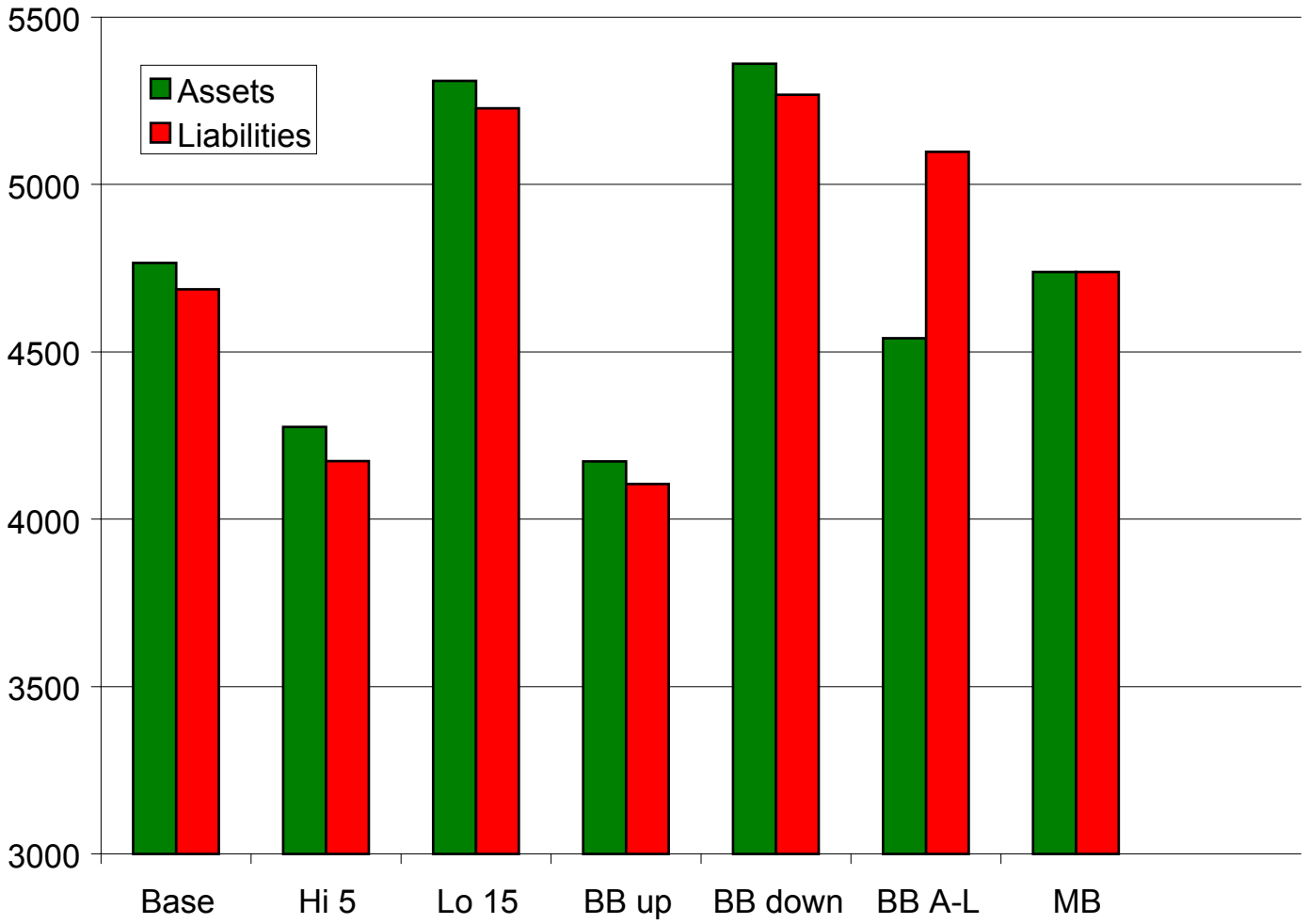
The scale factor to go from BB to MB is defined from the ratio of diversified capital to undiversified capital.



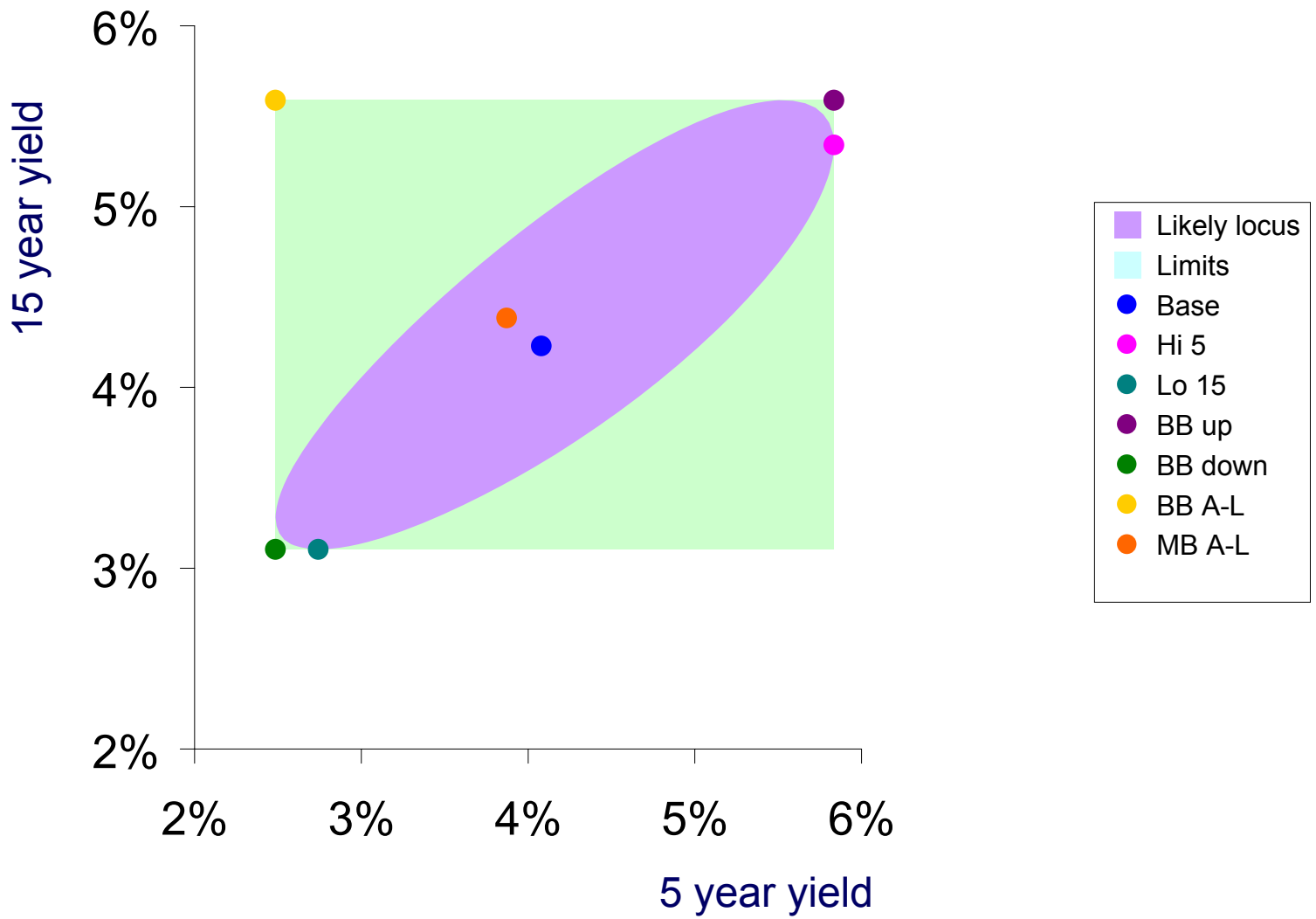
MB A-L is a scaled version of BB A-L. Because of the scaling, the MB A-L yields are close to base case, but less smooth.



If net assets are a linear function of bond prices, then the MB scenario exactly exhausts the required capital



The Medium Bang scenario is unlikely. Its appearance in this chart is an artefact of the projection into 2-D.



The Least Solvent Likely Event minimises net assets, over all likely scenarios with SRSE ≤ 2%

Abbreviation	Definition
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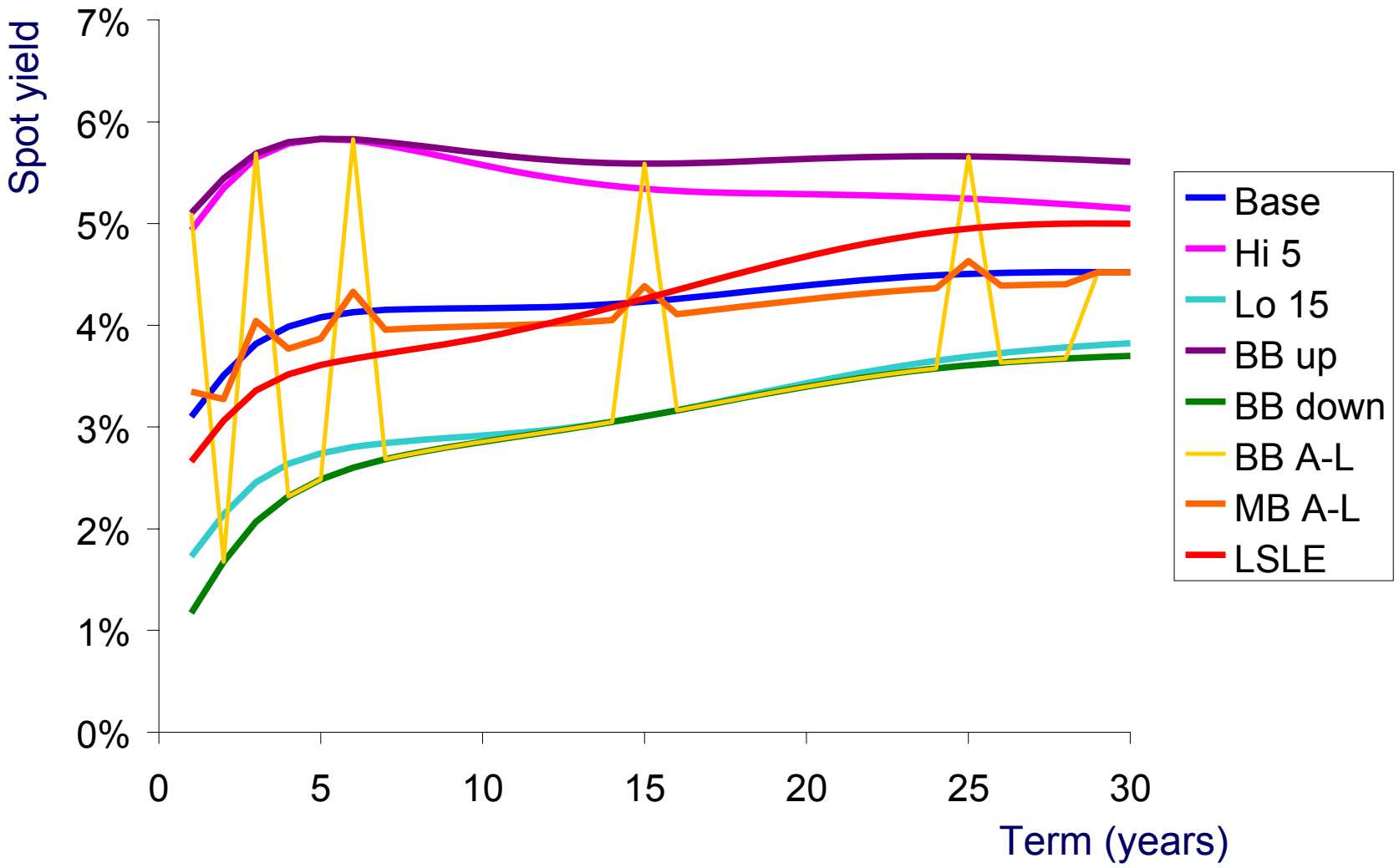
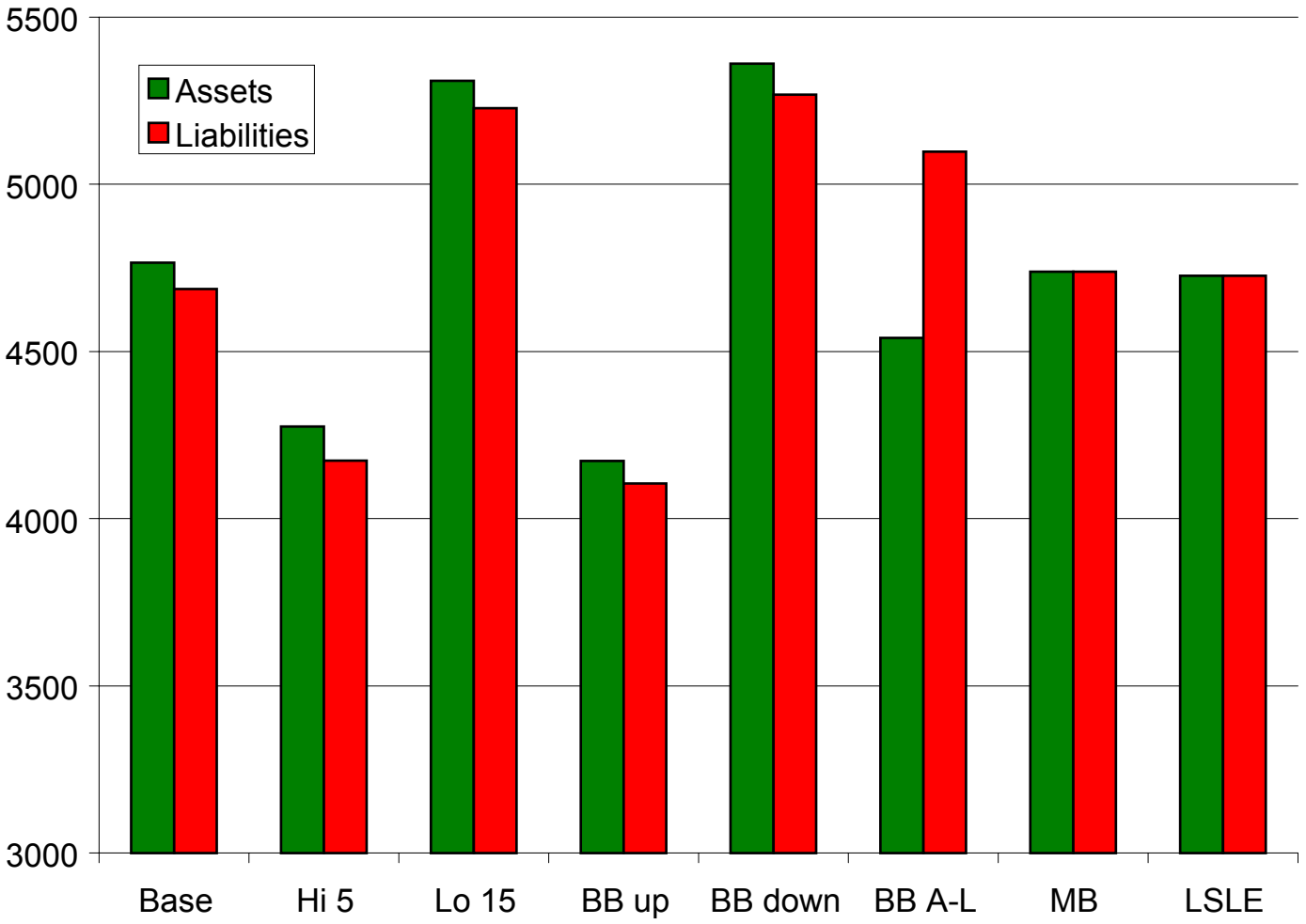
BB up	Big Bang – all yields to their highest likely value
BB A-L	BB Asset Liability – all yields to their least solvent likely value
MB A-L	Medium bang – as for BB, but scaled back for diversification
LSLE	Least solvent likely event

LSLE is the mean of a *generalised scenario* considered by Artzner et al (1998).

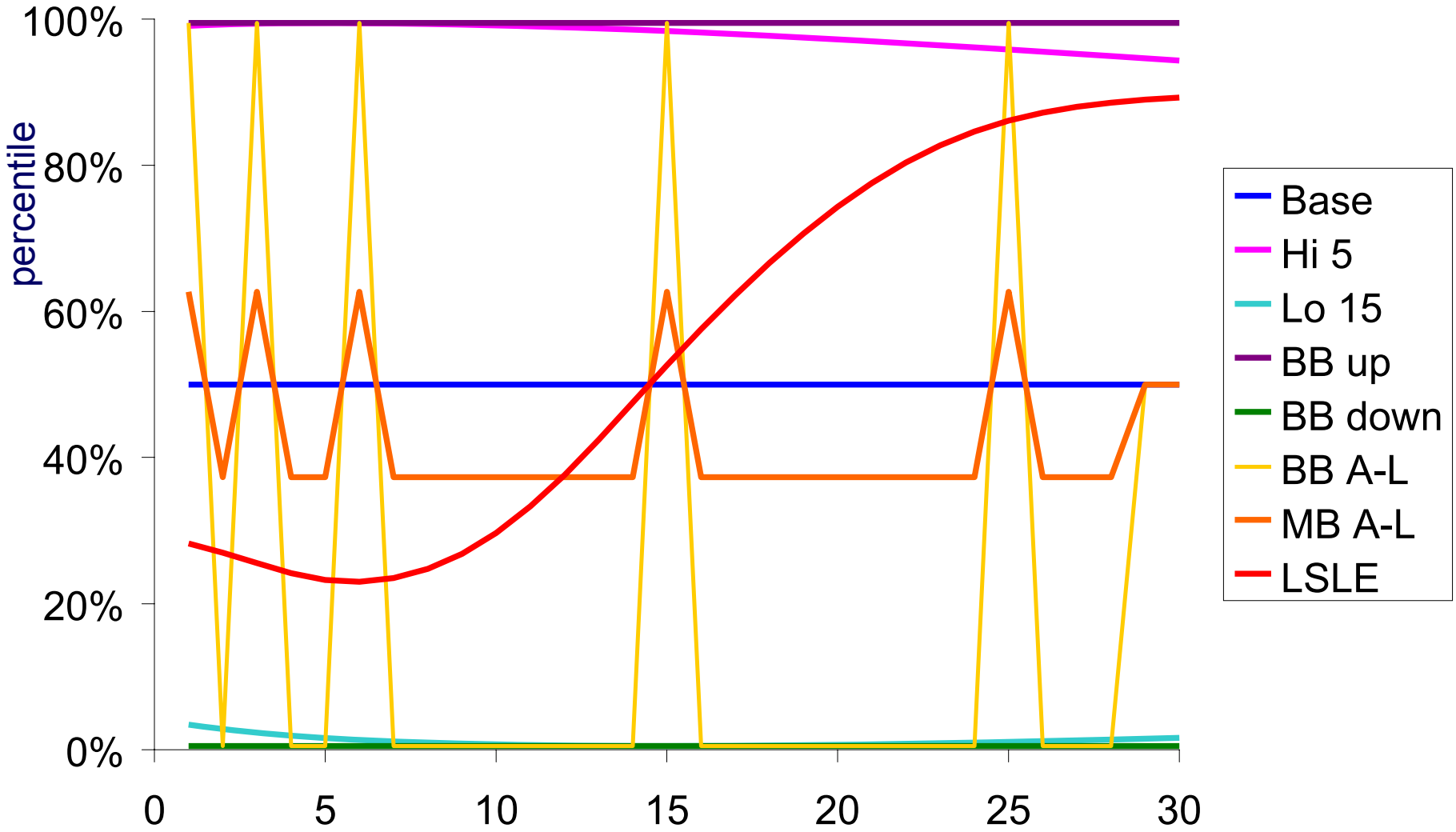
LSLE is a smooth curve which finds the vulnerabilities in a firm's net cash flow pattern



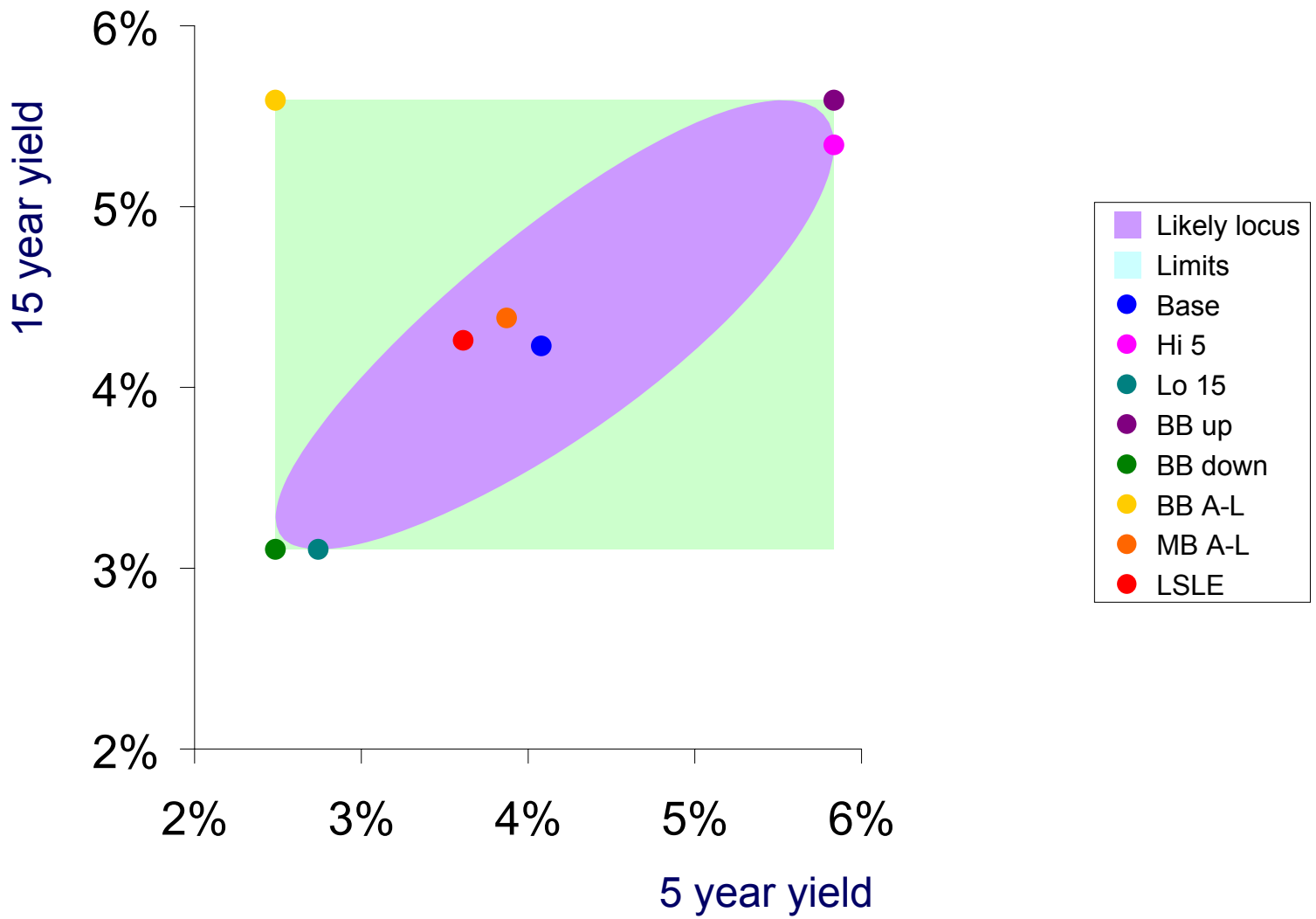
The LSLE also exhausts the required capital exactly. It shares this property with Medium Bang A-L



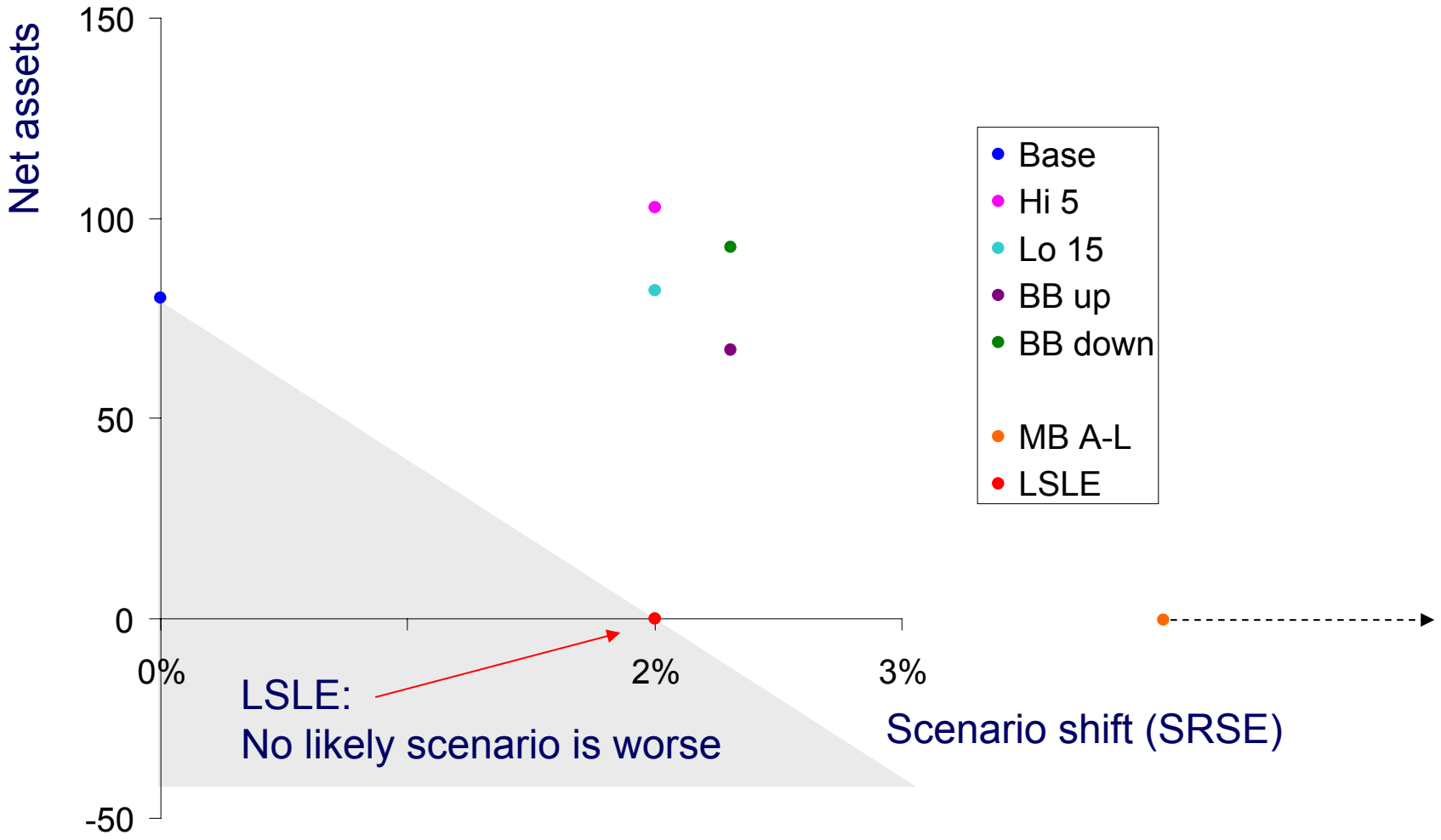
The LSLE represents 99.5% confidence overall, but other levels of confidence for each yield taken individually.



LSLE is a likely test, unlike Medium Bang. Appearances can be deceptive: MB A-L hides behind likely locus



The Base Case, the LSLE and a straight line between them, represent the least solvent scenario for a given level of SRSE.



Examples using LSLE for better decision making

Interest Rates and Mortality
An annuity book matches projected asset and liability cash flows. The LSLE combines increased longevity with lower interest rates. Efficient interest rate hedges focus on the improved longevity scenario.

Market / Policyholder Behaviour
Savings products with guaranteed surrender values may imply a LSLE with increased lapses and higher interest rates.

Policyholder / Operational
LSLE revealed a threat from high lapses in particular market stresses. This highlighted the operational challenge of processing surrender payments, which had not previously been identified as critical.

Policyholder / Volatility
A savings product offers guarantees in exchange for monthly charges. The LSLE shows market falls, lower than expected lapses and a rise in market implied volatilities.

Conclusions

- Events are easier to communicate than distributions
- But you need to choose events that matter for the business
  - Painful enough to exhaust capital
  - Believable enough that they may happen
  - The LSLE is different for different firms
- It is tempting avoid the best models to make explanation easier
  - Dumbing-down is unnecessary, and self-defeating
  - We need to get better at communicating good models
- Capital requirements and allocations are of limited use on their own
  - Need to understand effect of key assumptions
  - The most significant threats must be clearly understood
  - And the likely effect of alternative business decisions

Further Technical Reading

- Anderson, N, Breedon, F, Deacon, M, Derry, A and Murphy, M (1996). Estimating and interpreting the yield curve. John Wiley & Sons. ISBN 0-471-96207-4.
- Artzner P, Delbaen F, Eber, J-M and Heath, D. (1998). Coherent measures of risk. http://www.math.ethz.ch/~delbaen/ftp/preprints/CoherentMF.pdf
- Baddon, Richard and Coulthard, Paul (2006). Risk Geographies – understanding risk in *n* dimensions. http://www.actuaries.org.uk/files/pdf/proceedings/erm20060703/Coulthard.pdf
- CEIOPS (2007). Term structures for QIS 3 http://www.ceiops.org/media/files/consultations/QIS/QIS3/QIS3TermStructures.xls
- Cont, Rama (2004) Modelling Term Structure Dynamics: An Infinite Dimensional Approach http://ssrn.com/abstract=148408
- Exley, C J & Smith, A D (2006) The Cost of Capital for Financial Firms http://www.actuaries.org.uk/files/pdf/sessional/sm20060123.pdf
- Financial Services Authority (2005). ICAS one year on. http://www.fsa.gov.uk/pubs/other/isb_icas.pdf
- Rousseeuw, P.J. and Ruts, I. (1999), The depth function of a population distribution, *Metrika*, 49, 213-244. ftp://ftp.win.ua.ac.be/pub/preprints/99/Depfun99.pdf
- Smith. A.D. & Wilson, T. (2000). Fitting yield curves with long constraints. Financial Options Research Centre, Warwick. http://www-cfr.jbs.cam.ac.uk/archive/PRESENTATIONS/seminars/lent2001/asmithyield.pdf
- Or email AndrewDSmith8@deloitte.co.uk