ESGs: Spoilt for choice or no alternatives?

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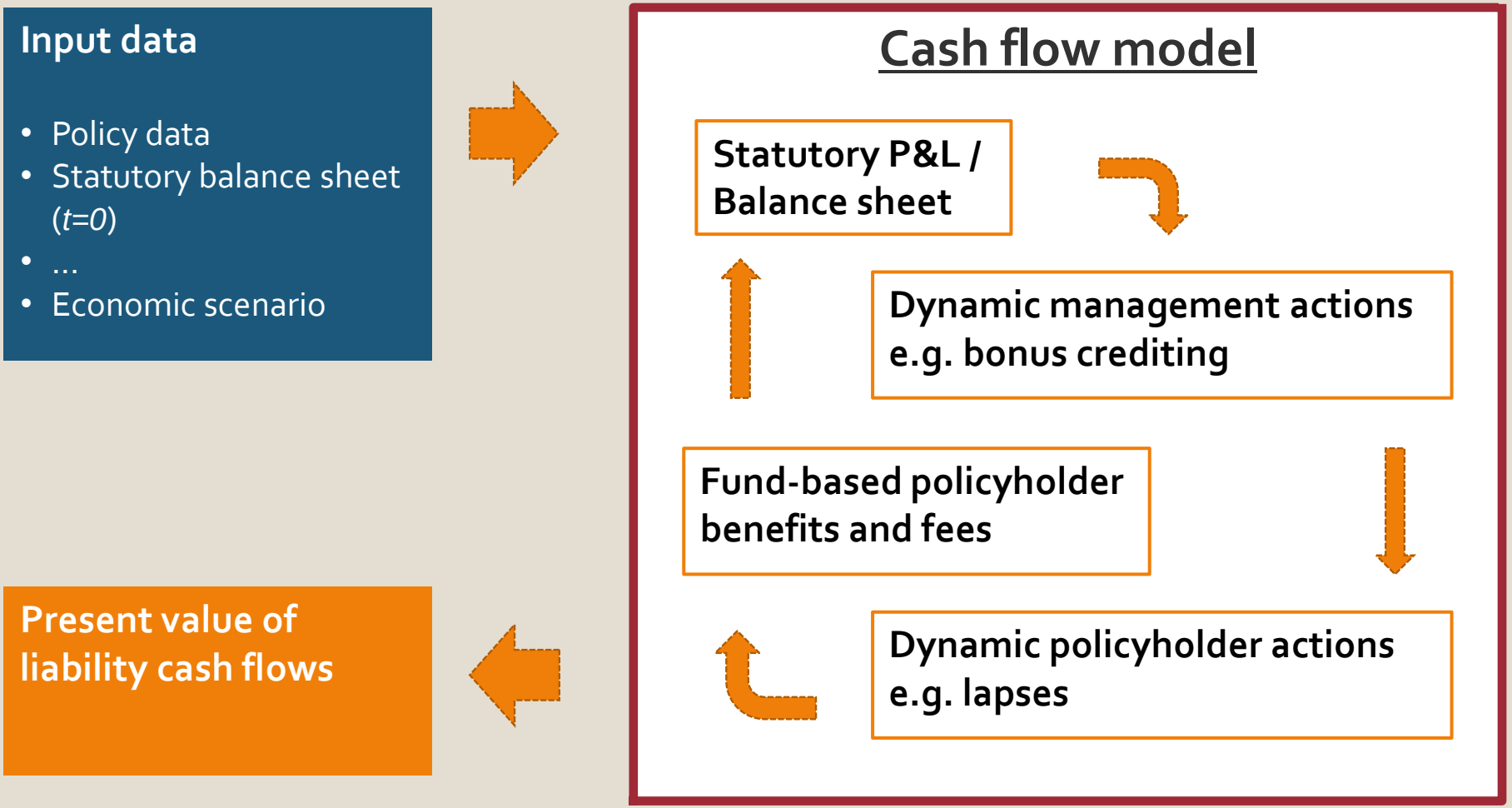
Agenda

1. Why do we need Economic Scenario Generators (ESGs) ?
2. Different uses ask for different types of scenario sets
   A. Valuation of (life) insurance liabilities
   B. Measuring risk
   C. Calibration of replicating portfolios
3. Making a good choice
4. Example: Interest Rate Models for risk-neutral valuation

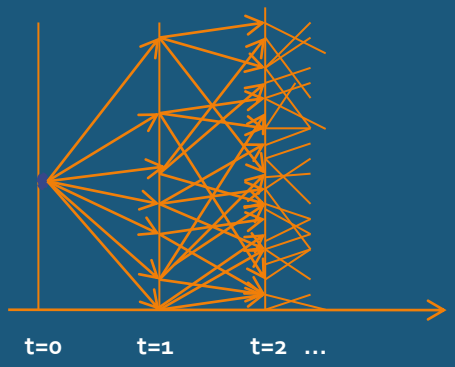
Movements in economic assumptions are often the biggest driver of changes in liability cash flows.



Most life insurers need/require complex stochastic models for valuation of their liabilities at reference day.

Input data

- Policy data
- Statutory balance sheet (*t=0*)
- …
- Economic scenarios



Best estimate (?) liabilities

Cash flow model

Statutory P&L / Balance sheet

Dynamic management actions e.g. bonus crediting

Fund-based policyholder benefits and fees

Dynamic policyholder actions e.g. lapses

ESGs are at the core of stochastic modelling

- An ESG produces forward-looking scenarios for a specified set of risk factors, e.g.:
  - Interest rate term-structures
  - Inflation
  - Index returns, e.g. for equity, real estate, hedge funds, private equity
  - Exchange rates
- Assumption:
  The possible behaviour of risk factors (and their interaction) can be described sufficiently well by certain stochastic models
- Choice of the stochastic model and a set of parameters determines the range of the scenarios produced by ESG

Monte Carlo simulation is currently the only feasible method to value complex (life) liabilities

- Idea behind Monte Carlo method:
  - Generate sample paths for set of risk factors over the modeling period
  - Calculate the discounted cash flows of the sample paths
  - Aggregate the results

- **Key idea & assumptions for valuation:**
  - → We start in a risk-neutral setting by calibrating the ESG to available market prices of options and derivatives (this setting is free of arbitrage)
  - → Best estimate for the liabilities is calculated as expectation
  - → Property of arbitrage-freeness is not affected

- Alternatives to Monte Carlo method (e.g. Fourier inversion) not (yet?) feasible for high dimensions

Mathematically, change of numéraire makes no difference

- Prices are calculated relative to a numéraire
- Most common choice:
  risk-free cash account → risk-neutral scenarios
- Alternative: "real-world" scenarios with deflators

Other examples for valuation purposes:

- Estimation of hedging costs of an insurance guarantee
- Pricing of exotic derivatives

ESGs are used to measure market risk

- Real-world calibration: Risk premiums above risk-free rate to reflect risk aversion of investor e.g. for equity, corporate bonds
- Calibration based on historical observations and expert judgement

- Focus realistic distribution of outcomes, particularly in the tail
- SST: 1-year projection
- Generally, two approaches for calibration:
  - High weight put on recent data
  - Longer timelines

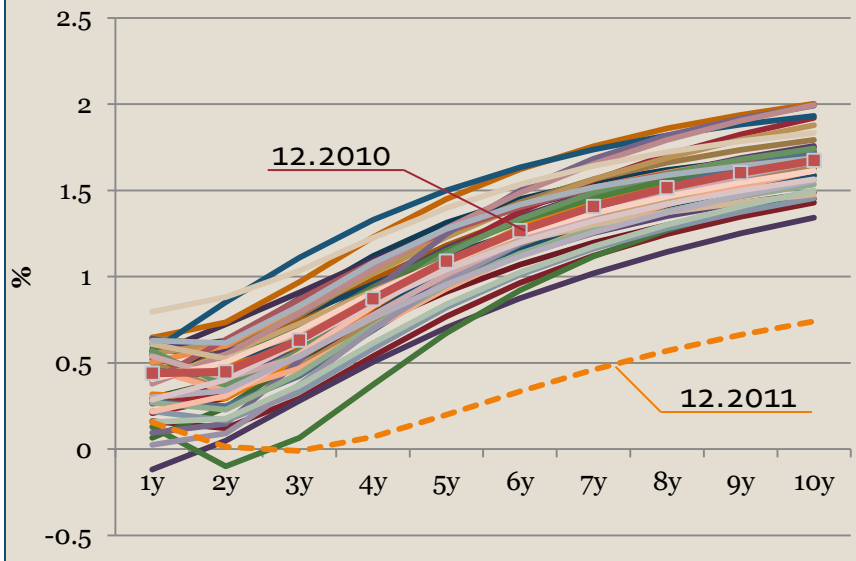
Other example for usage of real world scenarios:

- Impact of hedging strategies on capital requirements

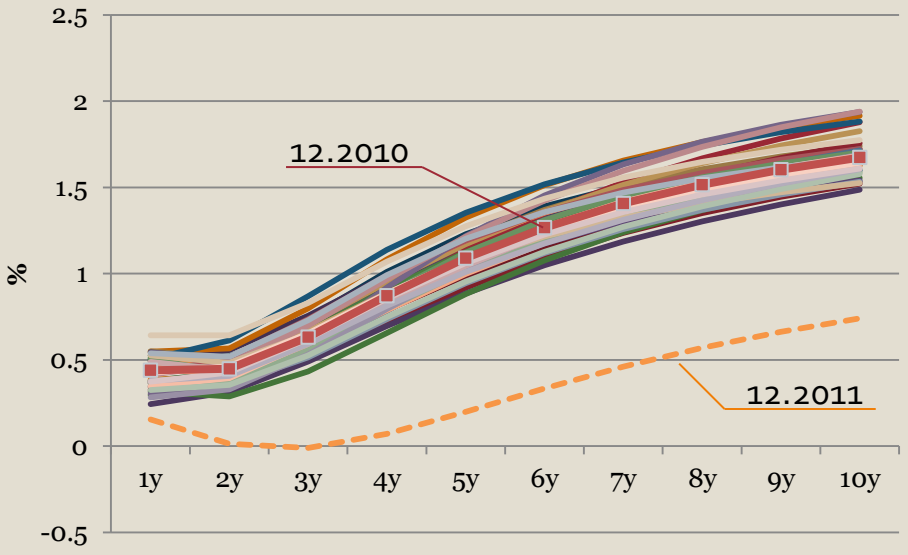
Case study: Implications of the choice of distribution

Starting point: 10y, monthly historical data (SNB); yield curve as of 12.2010

Case 1: Assuming absolute returns multivariate normally distributed



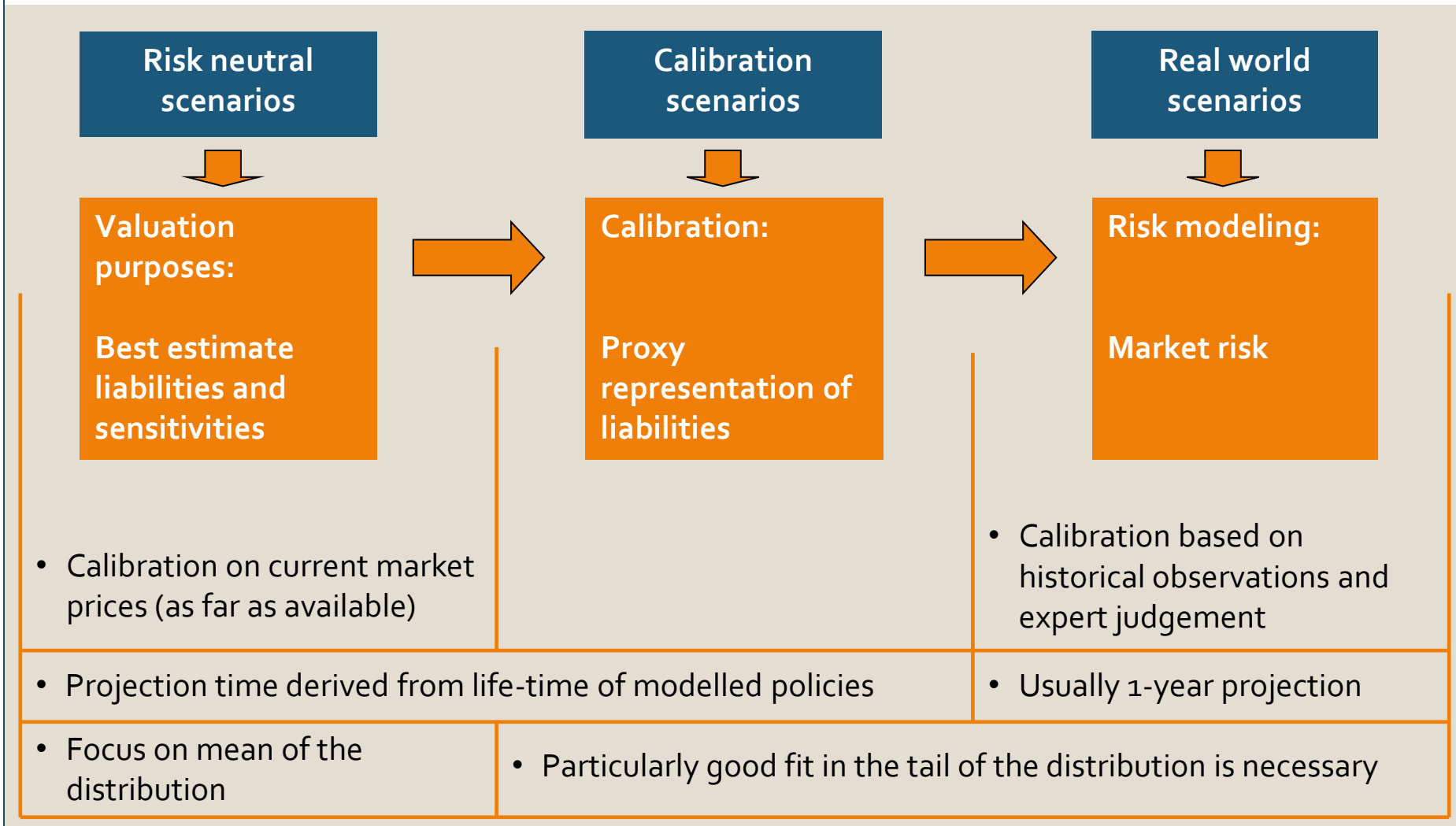
Case 2: Assuming logreturns multivariate normally distributed



ESGs are used for the calibration of replicating portfolios

- Replicating portfolios used as proxy for liabilities for solvency capital calculations
- Particularly good fit in the tail of the distribution is necessary
- Choice of the scenario set used for calibration fairly flexible; no direct dependence from valuation scenario set and risk modelling scenario set

Different uses ask for different types of scenario sets



Agenda

1. Why do we need Economic Scenario Generators (ESGs) ?
2. Different uses ask for different types of scenario sets
3. **Making a good choice**
   A. What are the key properties?
   B. What decisions are to be taken?
   C. How to check the adequacy of the choice?
4. Example: Interest Rate Models for risk-neutral valuation

ESGs need to fulfil some key properties

- Arbitrage free (for valuation purposes)
- Technically, fit for purpose
  - Accurate, complete and appropriate
  - Theoretical and empirical basis
  - Robust calibration process
- Adequate
  - No more complex than necessary,
    given the specific purpose and usage (e.g. product portfolio)

Users have to make sure that ESG is not considered as black box:
the models need to be understood, including

- Their limitations
- The choices that had to be made to set the parameters
- The reason why they are used (and not others)

The choice of the ESG poses some key challenges

- Choice of complexity of the model
  - Trade-off between simplicity and (perceived) accuracy
- Choice of calibration targets
  - Limited availability / reliability of market prices
  - Limited relevance of historical data for future predictions
- Relevance of recent extreme events difficult to assess
  - How should the probability of a 2008 scenario be estimated within a real-world-distribution?

→ Actuarial judgement essential

Some ideas how the adequacy of the ESG can be assessed

- Standard set of tests
  - Leakage
  - Quality of calibration
  - Convergence test
  - …

- Does the model capture the optionality in your liabilities?
- Can you use the replicating portfolio to validate the ESG?
- Would a change in model (achieving a lower calibration error) make a material difference?

→ In the sequel, we will illustrate the main points to be considered for the case of interest rate models.

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1. Why do we need Economic Scenario Generators (ESGs) ?
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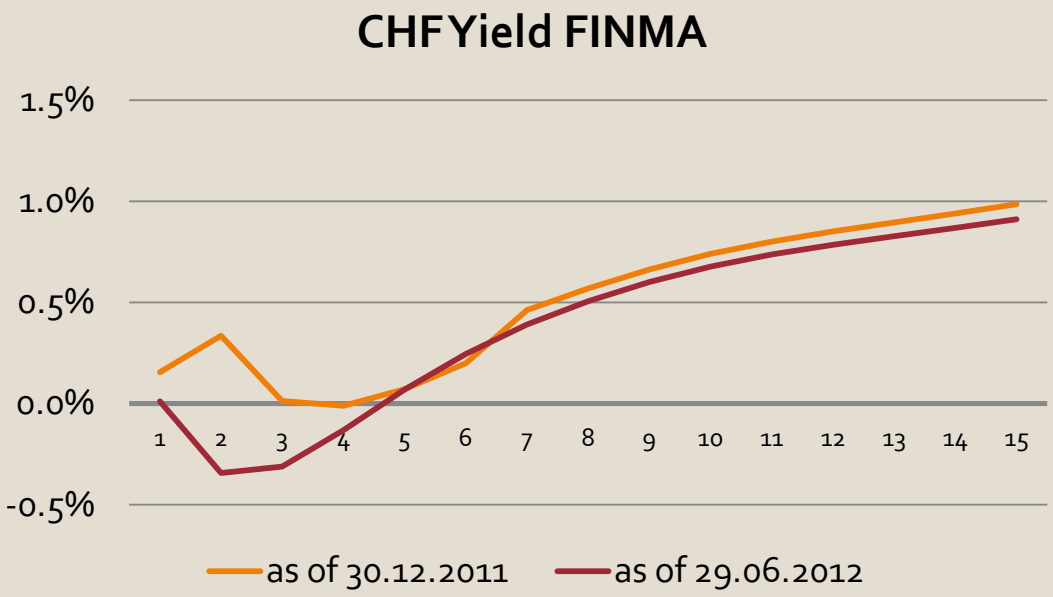
4. **Example: Interest Rate Models for risk-neutral valuation**
   A. Required properties
   B. A popular choice: the 1-factor Hull-White model
   C. What are the alternatives?

IR models for risk-neutral valuation

Required properties:

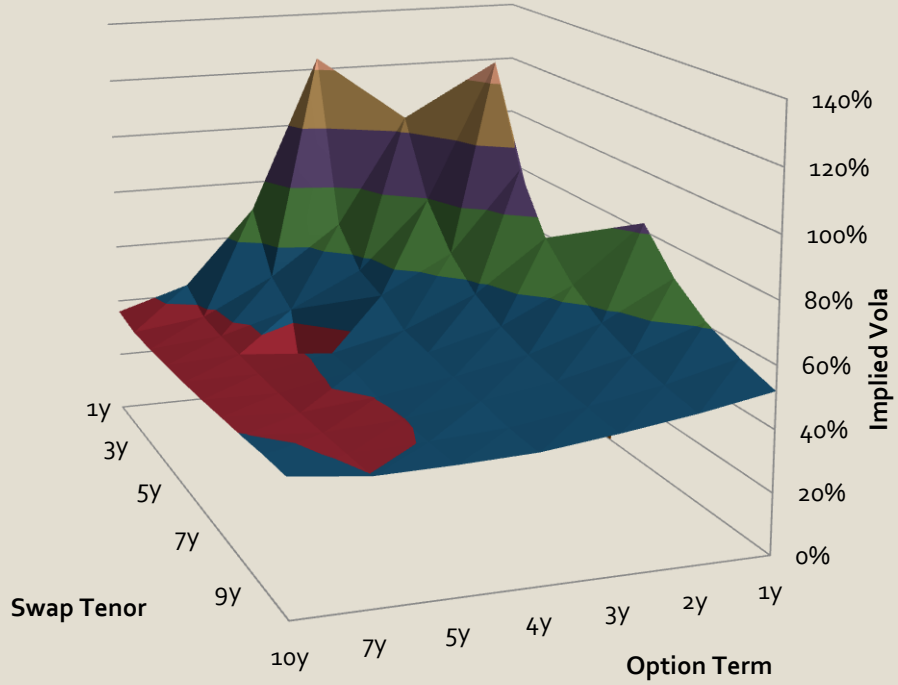
- Arbitrage free
- Can be calibrated to initial term structure



IR models for risk-neutral valuation

Required properties:

- Arbitrage free
- Can be calibrated to initial term structure
- Can be calibrated
  to initial derivative prices



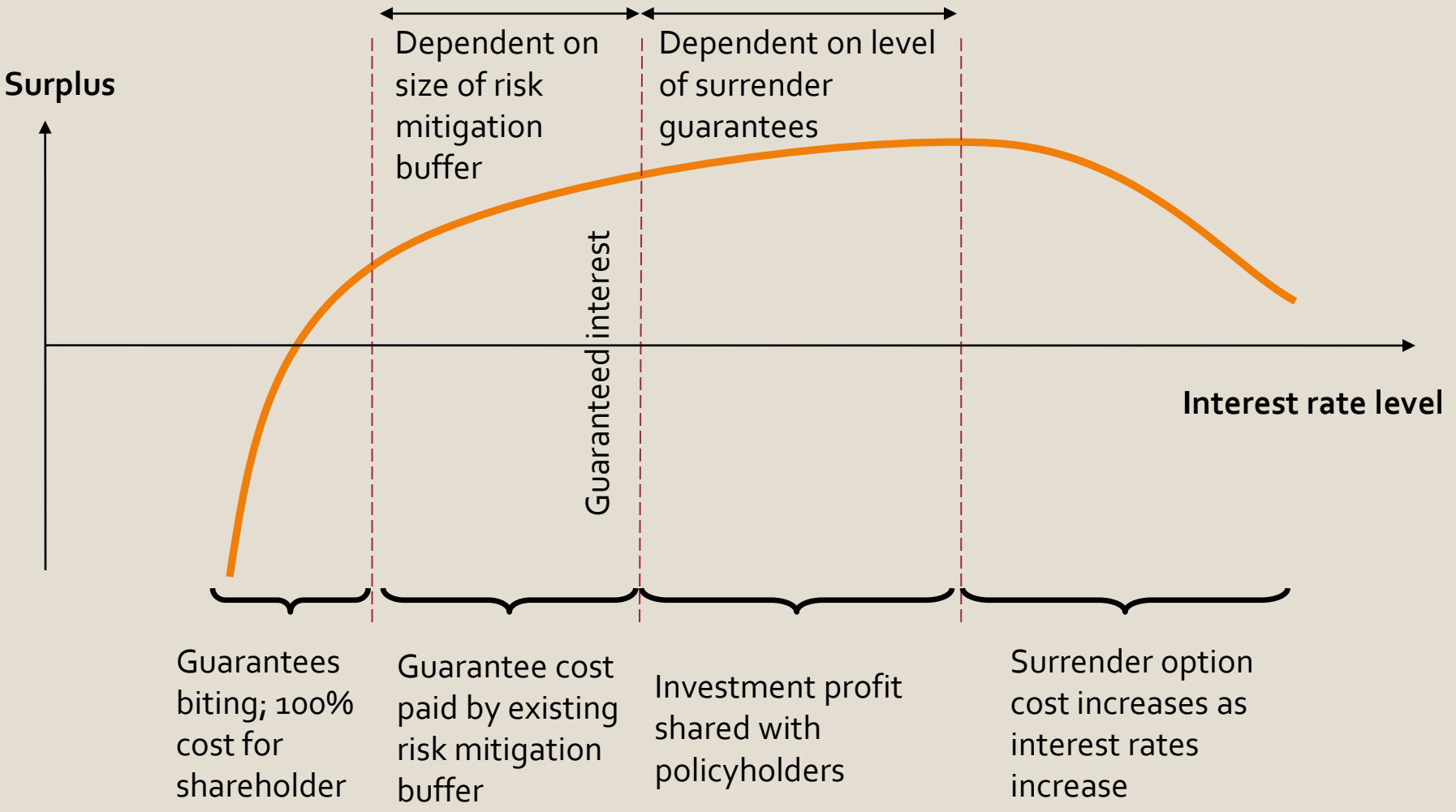
CHF implied swaption vol
as of 30.06.12
Source: Bloomberg

IR models for risk-neutral valuation

Required properties:

- Arbitrage free
- Can be calibrated to initial term structure
- Can be calibrated to initial derivative prices
- Produces sufficiently rich set of yield curve movements

Possible impact of interest environment on surplus



A popular choice: the 1-factor Hull-White model

$$\mathrm{d}r(t) = \left(\theta(t) - \alpha r(t)\right)\,\mathrm{d}t + \sigma\,\mathrm{d}W(t)$$

α and σ positive constants,
θ chosen so as to exactly fit the term structure of current interest rates

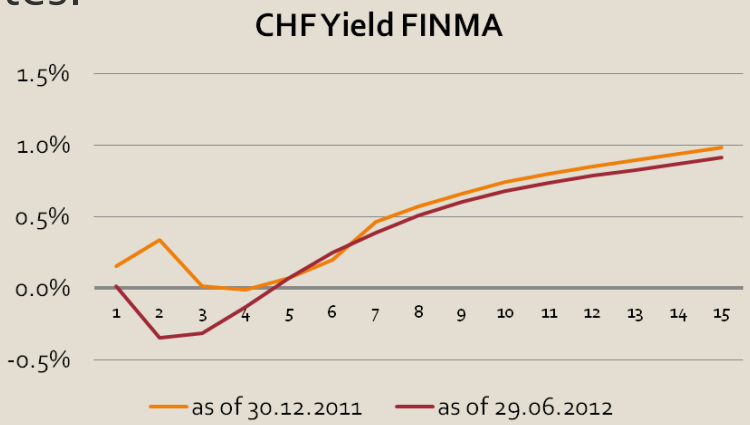
- Short rate model (*r(t)*)
- W: Brownian motion
- Assumes normal distribution for short rate
- Mean reversion

A popular choice: the 1-factor Hull-White model

Property 1: Admits negative interest rates

Brigo, Mercurio (2007): "*The risk-neutral probability of negative rates (…) is almost negligible in practice*".

In fact, current (CHF-) interest rates will lead to a significant number of scenarios assuming negative interest rates.



→ **Does your model know how to deal with negative interest rates ?**

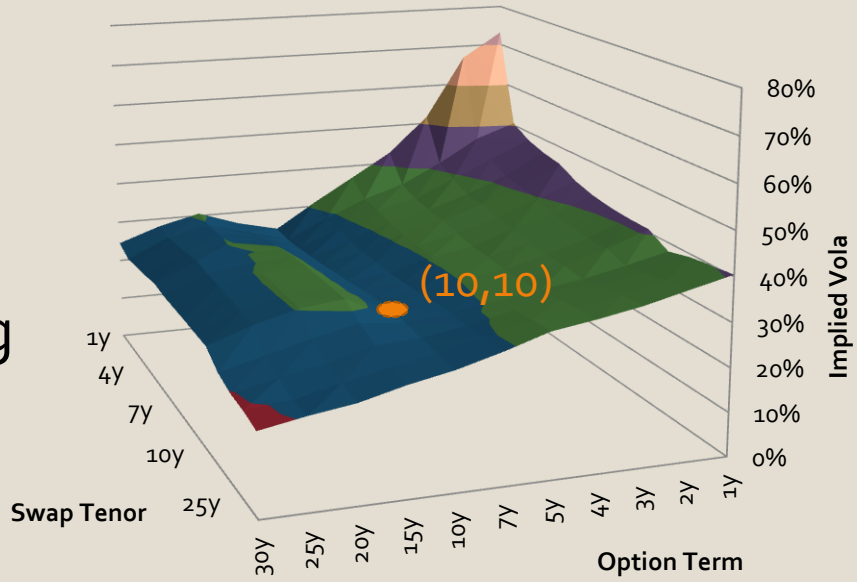
A popular choice: the 1-factor Hull-White model

Property 2:

Robust calibration of swaption prices possible but only for one term/tenor

→ difficult choices to make

EUR implied swaption vol
as of 30.06.12
Source: Bloomberg



But:

Might still be sufficient depending on current level of guarantees / duration of liabilities / …

Relevant criteria:

Change in calibration does not lead to material differences

A popular choice: the 1-factor Hull-White model

Property 3:

Rates at different maturities are perfectly correlated.

→ Unrealistic distribution of interest rate curves.

But:

Don't we only care for the mean!?

→ Insurance liabilities contain typically path-depending options. They will be mispriced.

What are the alternatives?

1-factor Hull-White	Alternative	Goal
Short rate model	Simultaneous modelling of the full term structure	- Increasing variety of yield curve movements - Better fit to market prices
1-factor	Multi-factor	
Normally distributed interest rates	Other distributions e.g. lognormal	- Avoid negative interest rates

Alternatives that are currently used in the market:

- 2-factor Black Karasinski
- Libor Market Model

→ Key question: What is the impact of a change of the interest rate model?

We are definitely not spoilt for choice – but need to understand the alternatives

- Fixing one problem (locally) usually does not come for free.
- There is a wide range of interest rate models – but none without problems, restricting the choice.
- There is a considerable model risk.
- There is a number of providers, unfortunately not all equally active and innovative.
- There is no "one fits all" – you need to take a choice – and you need to understand it and be able to explain it!

Thank you!

The views expressed in this presentation are those of the presenter.

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