

# Market Consistent Valuation

Moody's Analytics and Polish Insurance Association Event

# Agenda – Market Consistent Stochastic Modelling

- » **Market Consistent Valuation** – Solvency II and Market-Consistent valuation of insurance assets and liabilities
- » **Performing Market-Consistent Stochastic Simulation**
- » **Things to note** when handling market-consistent simulations
- » **Case Study** – Using market-consistent simulation in Monte-Carlo valuation of options and guarantee under Solvency II

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# Market Consistent Valuation

# Introduction

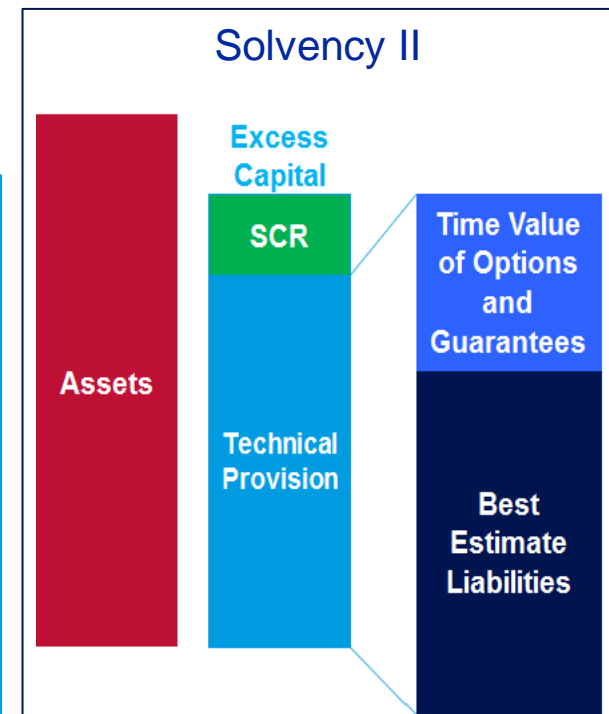
- » Pre-Solvency II regime: Insurers are to define discount rates that are appropriate to their asset and liability exposures.
- » Assets could be projected using their own risky returns
- » Valuation does not converge to Market Value

❖ **Solvency II:** market-consistent valuation

❖ **All assets earn risk-free rate**

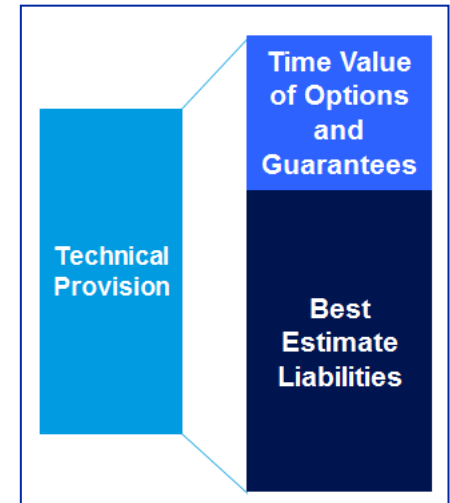
- No arbitrage condition
- Risk-free discounting and Risk-Neutral valuation

❖ Use **Market Value** wherever possible



# Market Consistent Valuation

- » Best estimate liability
  - Best estimate of insurance cashflows discounted at risk-free rate
- » Time Value of Financial Options and Guarantees (TVoG)
  - Valued with “market-consistent” methods:
    1. Market Value of similar options/derivatives traded in the market
    2. Closed-form solutions
    3. Monte Carlo simulation using Market-Consistent stochastic scenarios



# Example – Valuation of Simple Insurance Guarantee

Solvency II valuation of an insurance guarantee

- » Intrinsic Value: Based on best-estimates
  - If current value is larger than guaranteed value, “Solvency II Best Est. Liability” is 0 because you expect the guarantee to be worthless.
  - But the true value of the guarantee is not 0 under Solvency II.
- » Time Value of Guarantee: Based on option valuation techniques



# Comparing the Solvency II TVoG Valuation Methods

## Market Value

- » Preferred method under Solvency II
- » But least-used because it does not work if there are no “similar” derivatives liquidly traded in the market

## Closed form solutions

- » Approximations means there is an inevitable amount of under/over-estimation of TVoG
- » Not all derivatives have a closed-form solution (e.g. American Options)

## Stochastic Simulation (Monte Carlo Simulation)

- » Can value complex options and guarantee (e.g. insurance profit-sharing products, value of dynamic lapse behaviours of policyholders)
- » Much more accurate if models used are sufficiently sophisticated

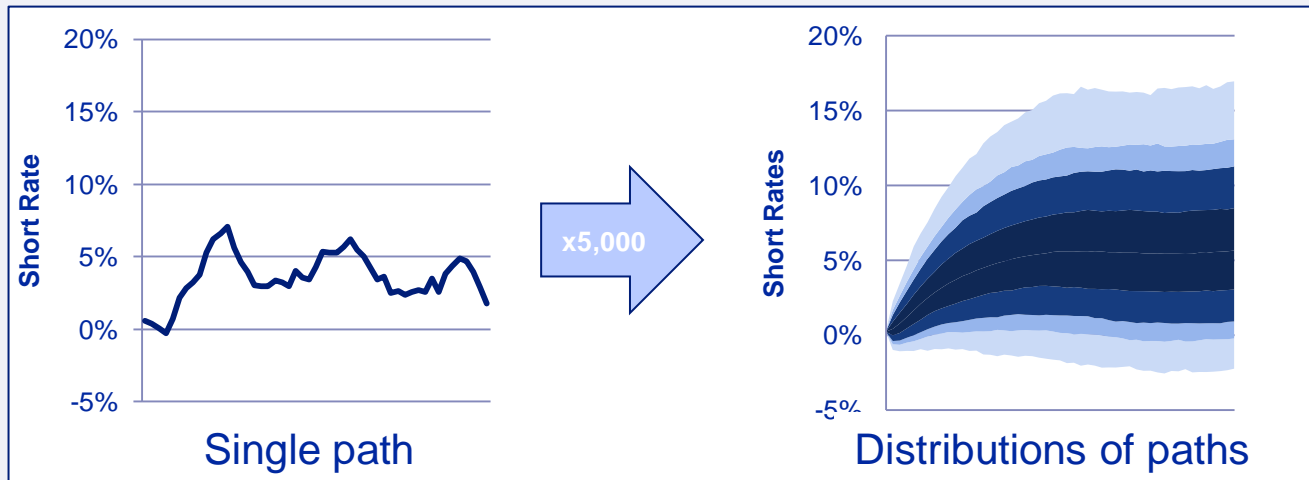
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## Performing Market Consistent Stochastic Simulations



# What are Stochastic Simulations?

- » Future is **unknown**
- » We may have **expectations** about the future but we are never **certain** about it
- » Simulate **many** future scenarios based on stochastic models
- » Use scenarios in **Monte Carlo** simulations by ALM systems
- » **Average** of the **Monte Carlo** valuation converge to our expectation



**Economic  
Scenario  
Generator**

# Definitions of different stochastic simulations

## Market-Consistent

- All assets earn **risk-free rate** (same definition as Risk-Neutral)
- Monte-Carlo simulation **replicates market-price**
- Distribution and statistics are market-implied



## Real-World

- Risky assets earn **risk-free rate PLUS risk-premium**
- Distribution and statistics are meaningful. One can set own assumptions about volatility and distributions of simulated rates.



# Performing Solvency II Market-Consistent Valuation using Stochastic Scenarios

- ☑ All assets earn risk-free rate
  - Asset values discounted by risk-free cash account converges to market price
- ☑ Monte Carlo valuation replicates market price
  - Risk-free discounted cashflow from derivatives converge to market traded derivative prices
  - Market-consistent scenarios agrees with option implied volatility
- ? Quick Check: If I project future equity total returns and discount using risk-free rate will I calculate the same current value as the market value of equity?
  - If not you have mispriced equity under Solvency II

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## Things to Note When Handling Market Consistent Scenarios

# Features of Market-Consistent Simulations

Because Market-Consistent valuation requires replication of **Market Value**

- » Market-Consistent Simulation results may not look reasonable from a “**Real-World**” perspective.
  - E.g. You may not expect ALL assets earn risk-free rate
  - E.g. You may not expect equity to be as volatile as what market traded option implies during the financial crisis in 2008
- » But all such features are required to achieve a market-consistent valuation
- » Otherwise the valuation will not fit Solvency II requirements
  - E.g. Monte Carlo price of a vanilla put option will be lower than the Market Value of the same put option – mispricing under Solvency II

# How Do I Know My Scenarios Are Market-Consistent?

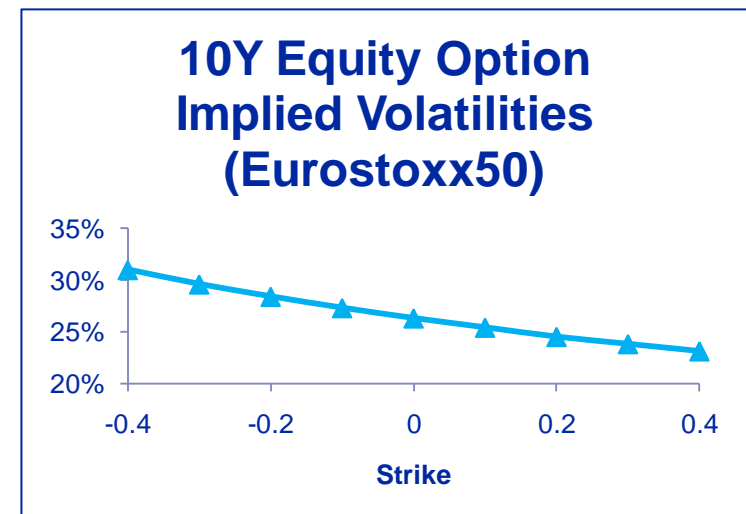
- » Do all assets earn *risk-free rate* on average?
  - Check that the *average* risk-free discounted future price equals to the current price
  - This check is called a *Martingale Test*
- » Do Monte-Carlo option prices equal to Market option prices?
  - At different maturities?
  - At different strike prices?
  - With sophisticated models Monte-Carlo prices converge to Market option prices if Market Price exists

# Pitfalls of using Closed-Form Solution

Why do we need Stochastic Simulation if we can use Black-Scholes?

Using Closed-Form Solutions are simpler and costs less to operate, but there are major pitfalls when it comes to insurance valuation.

- » Solvency II requires
  - Market-consistent valuation of insurance options and guarantees
  - Modelling and valuation of dynamic behaviours
- » Standard Black-Scholes mis-prices of out-the-money/in-the-money derivatives,
  - Causes issue under stresses
  - Leads to mis-calculation of SCR
- » Closed-form solution does not exist for e.g.
  - Profit-sharing products
  - Path-dependent options and guarantees
  - Dynamic behaviours such as dynamic lapses



# Using Market Consistent Scenarios

Inferring 99.5<sup>th</sup> Percentile from the Distributions

Can I use Market Consistent scenarios to determine the 99.5% percentile of my risk-capital calculation for SCR or ORSA?

- » **No.** You need to use Real-World scenarios where assets earn *risk-free rate PLUS risk-premium*
- » To **project** insurance asset-liability forward into the future, whether one-year (SCR) or through business planning period (ORSA), Real-World simulation is required NOT Market-Consistent simulation
- ❖ [Rule of thumb]
  - To Value – Market-Consistent Simulations
  - To Project – Real-World Simulations

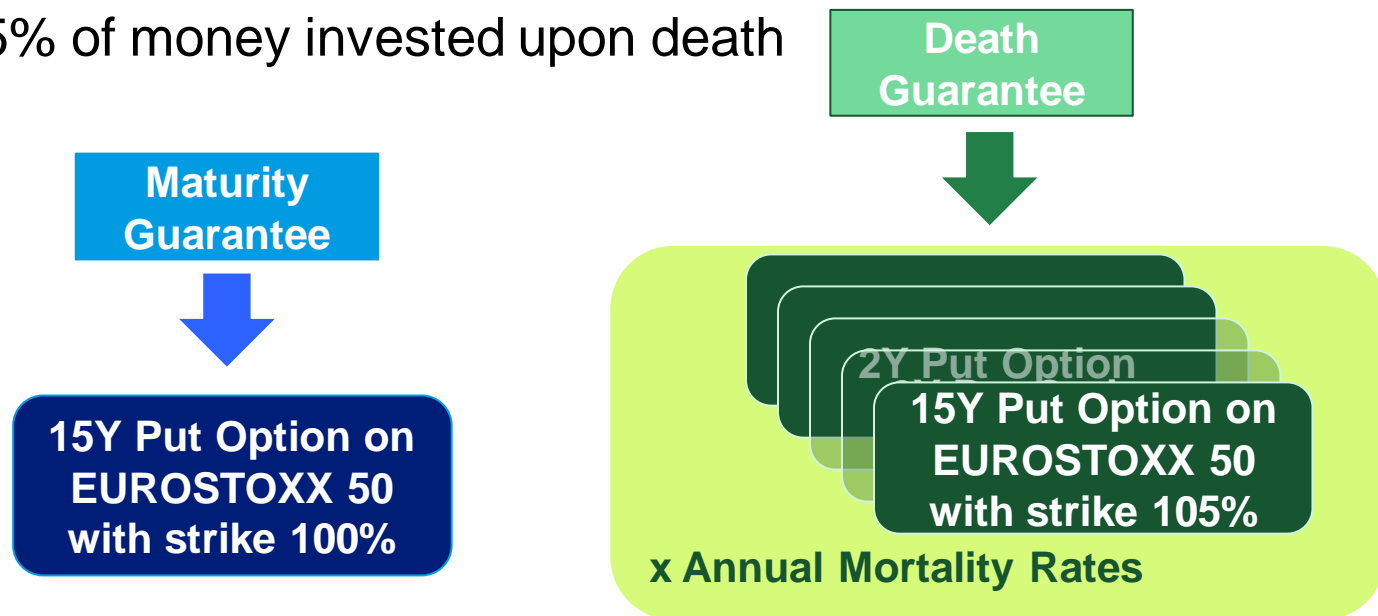


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## Case Study – Valuation of a Simple Insurance Guarantee

## Case Study – Simple Insurance Guarantee Fund

- » Single Lump Sum investment
- » 15 Year Term, Launch Date 01/01/2008
- » Underlying fund: EUROSTOXX50
- » Guarantee 100% of money invested at maturity
- » Guarantee 105% of money invested upon death

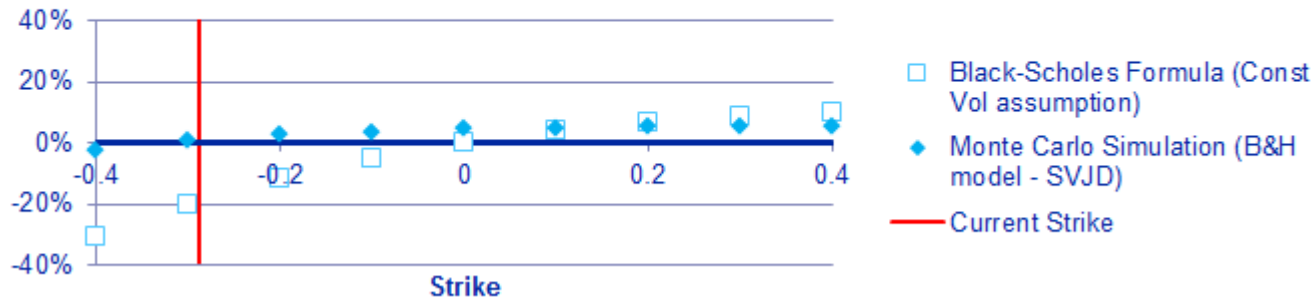


# Base Scenario: No Stress

## Valuation of Maturity Guarantee

- » Valuation Time: 31/12/2012 (5 years after launch date)
- » Remaining Maturity 10 Years
- » EUROSTOXX 50 Total Return index at 71% of 2008 value
- » Control Method: Market Price of 10-Year Put Option at -29% strike
- » Method 1: Black-Scholes Formula; Method 2: Stochastic Simulation

### % Difference to Market Price by Valuation Method



- » Black-Scholes under-estimating value of the guarantee by about 20%

# Stress Scenario

What if I am only exposed at-the-money options and guarantee at the moment? Why should I worry about out-the-money or in-the-money valuations?

- » Price of the underlying will change with time
- » Similar situation arises when you perform a stress (e.g. -20% equity stress)



- » Gets more complicated with Swaptions (for valuation of annuity guarantees such as Guaranteed Annuity Options)
  - In swaptions, there are tenors, maturities and strikes, resulting in a 3-D volatility cube

# From Simple Guarantee to Complex Liability

When there is no replicating derivatives

- » Insurers can usually **hedge** simple guarantees such as the one in the case study with market-traded derivatives. Hence the value of the maturity guarantee is simply the value of a Put Option.
- » However, it is very difficult to hedge **path-dependent** guarantees.
  - E.g. A fund which guarantee 1% year-on-year return.
  - Possible with advanced hedging techniques but the techniques themselves require stochastic simulations and frequent rebalancing
- » Or it is plainly impossible to hedge: E.g. “**dynamic lapse behaviours**”.
- » To model and value these, **advanced stochastic models** have to be used.
  - Simple models perform poorly with skewed implied volatilities
  - To capture behaviours beyond *Normal* distribution requires sophisticated models.

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## Question and Answer

# Summary

Solvency II Market Consistent Valuation of *Insurance Liability* in general

- » Discount using risk-free rate

Solvency II Market-Consistent Valuation of *Time Value of Options and Guarantee*

## 1. Market Value of Replicating Derivatives

- Most insurance options and guarantees cannot be replicated by market derivatives

## 2. Closed-Form Solution

- Close-form solution does not exist for complex insurance cashflows

## 3. Market-Consistent Stochastic Simulation

- Takes scenarios by an Economic Scenario Generator (ESG)
- Covers complex options, path-dependent guarantees and dynamic behaviours

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