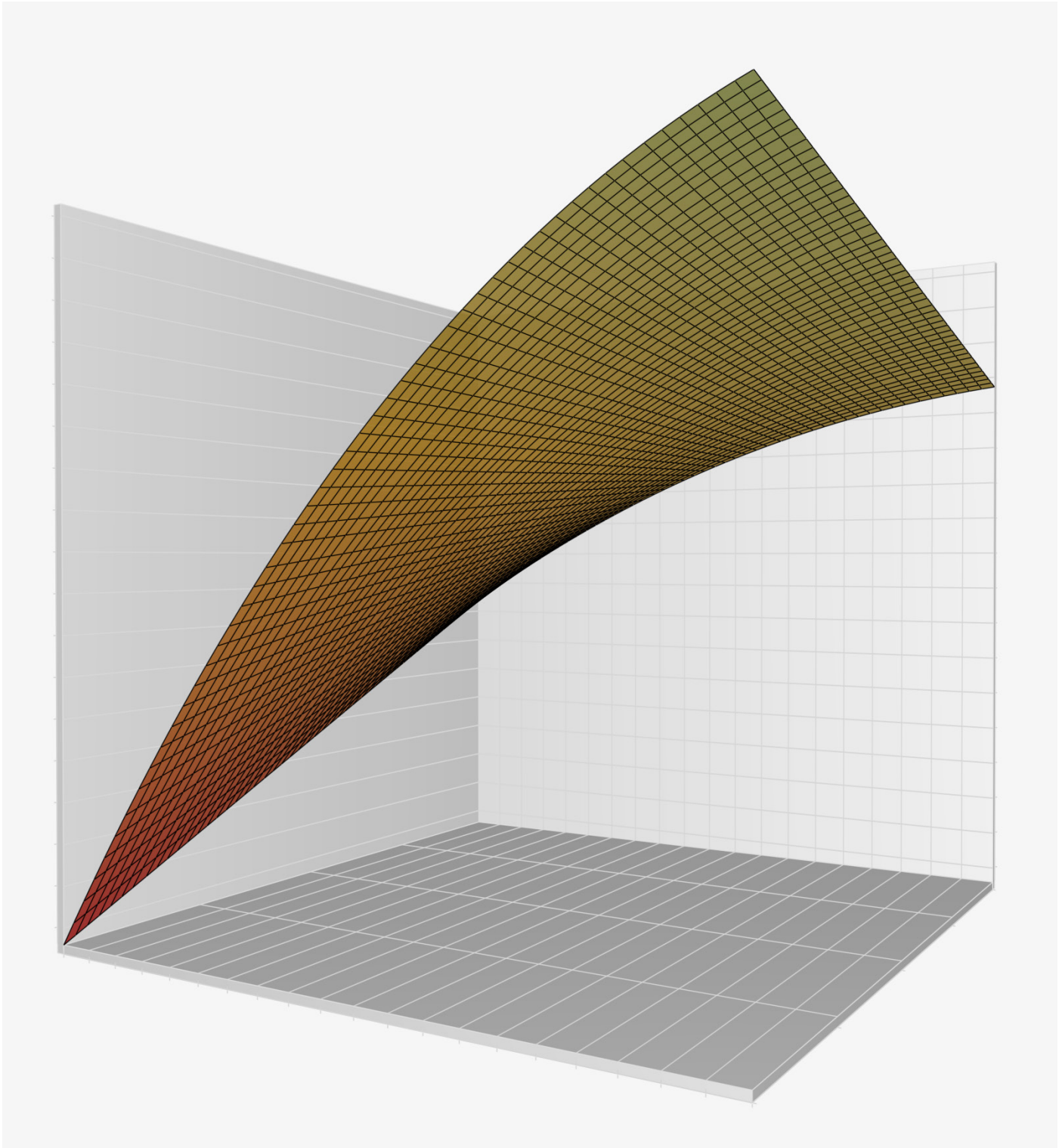
Milliman **STAR Solutions - NAVI®**



Milliman Solvency II Analysis and Reporting (STAR) Solutions

The Solvency II directive is not simply a technical change to the way in which insurers' capital requirements will be calculated. The extent and scope of the reform is such that it affects all operations which are at the heart of the insurance business: pricing, underwriting, assessment and risk management, asset management, internal and external reporting, etc.

From our leading position in Europe in assisting insurance firms with their migration projects towards Solvency II, we have acquired unique expertise of best practices, expectations and needs of the insurance industry. Leveraging our experience, we have launched a software package suite—Milliman Solvency II Analysis and Reporting (STAR) Solutions™—that is compatible with all actuarial and data systems and meets the diverse needs of insurers:

- Standard Formula Solvency Capital Requirement (SCR) calculation & analysis
- Quantitative Reporting Templates (QRTs)
- Enterprise risk management
- Capital allocation
- Estimation methods for solvency indicators

NAVI

Deriving the meaningful value of complex life insurance liabilities has never been more important. But establishing a valid and realistic risk profile of their business and fully understanding their company's risk exposure are some of the biggest challenges that life insurers face today.

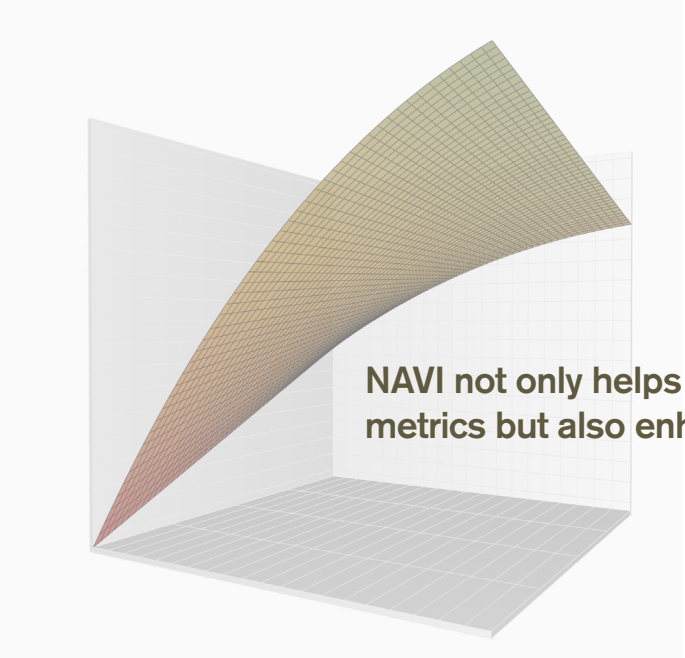
Milliman STAR Solutions – NAVI® offers an innovative solution based on cutting-edge technologies, allowing for a full and flexible valuation of complex life insurance liabilities, serving the following purposes:

- Generation of high-quality valuation scenarios in a highly automated framework
- Calculation of Solvency Capital Requirement and daily updates of key liability figures

NAVI is a powerful software solution that serves as a quantitative engine for key risk management functionalities.

NAVI's scenario generation features allow for a fast and robust generation of validation scenarios for many different purposes and utilize an existing base scenario set that is independent from the software's inherent properties.

NAVI's proxy modelling techniques help life insurance companies enhance their risk modelling by dramatically reducing calculation time via a flexible and robust process.



NAVI offers the following features

- **Automation** All relevant aspects of the scenario calibration and proxy function calibration process are highly automated within a robust implementation framework.
- **Auditability** NAVI allows for full auditability of results. All outcomes can be visualized and tracked back to their input.
- **Speed** NAVI has powerful and fast calculation capacities which dramatically reduce run times and allow it to perform complex calculations of large data volumes.
- **Visuals** NAVI is not simply a black box which outputs metrics. It offers full functionality that allows users to understand and visualize where the results come from and how reliable they are. Incorrect input can thus be detected.
- **Process reliability and confidence** All processes are documented and can be controlled, tracked to their inputs and visualized.

NAVI not only helps insurers gain faster calculation of solvency metrics but also enhances risk modelling and risk aggregation. Its ability to quickly update liability values and economic capital forecasts can enhance strategic business decision making by improving insight into the risks and behaviour of liabilities.

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SCENARIO CALIBRATION: CHALLENGES

The current interest rate environment exacerbates the challenge of deriving a sensible calibration of risk-neutral valuation scenarios within economic scenario generators (ESG). Typical challenges and issues in this context are:

- Interest rate models are often restricted to positive interest rates.
- There can be a bad fit for calibration points on implied swaption volatility surface under consideration.
- Improved calibration fit is often accompanied by scenarios with rapidly increasing interest rates and asset performances, or severe and long-lasting periods of negative interest rates, which both negatively affect the reliability of the liability valuation.
- Interest rate models can only be calibrated to a few points on the volatility surface, and implied volatilities for all other points result from arbitrary and uncontrollable extrapolation.
- Significant deviations in martingale tests occur.

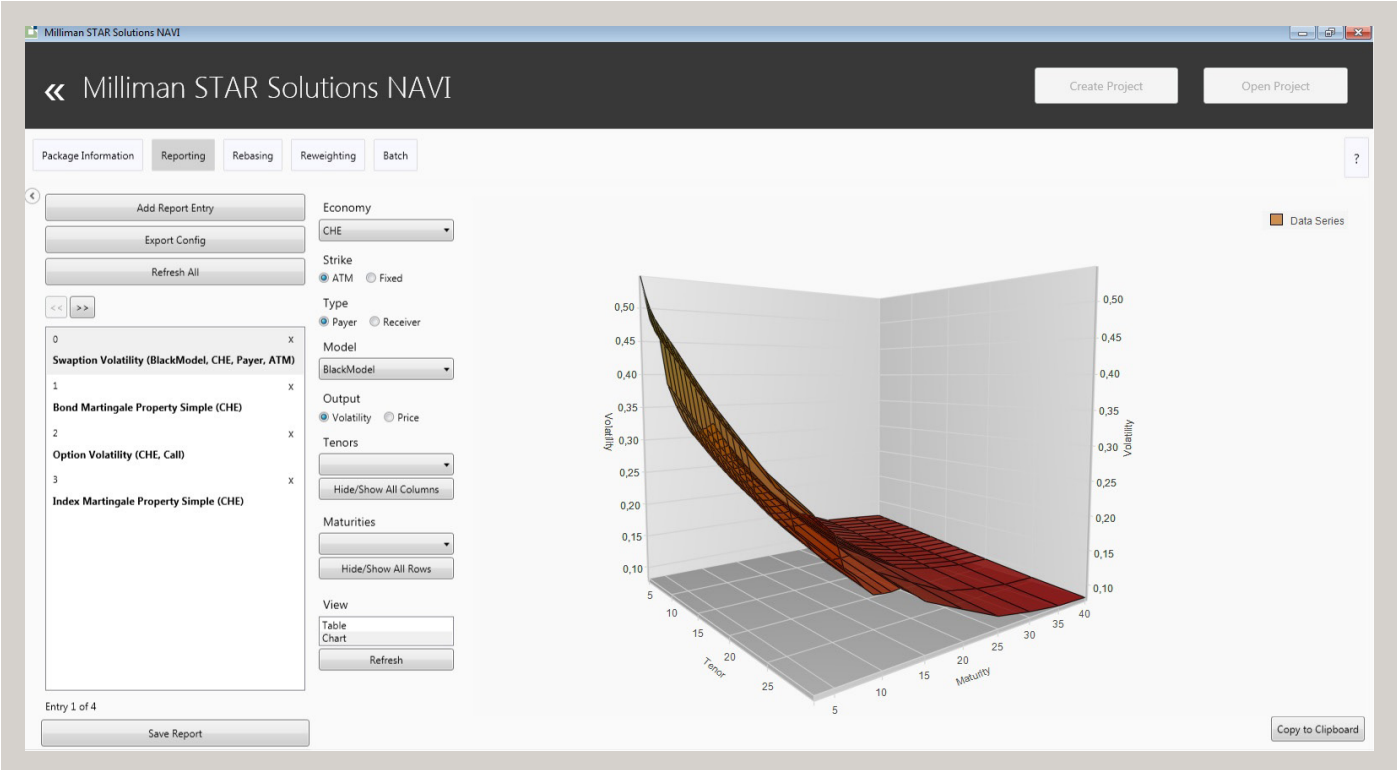
SCENARIO RE-CALIBRATION VIA NAVI

NAVI allows for the re-calibration of an existing risk-neutral scenario changing or refining the present calibration.

Key functionalities

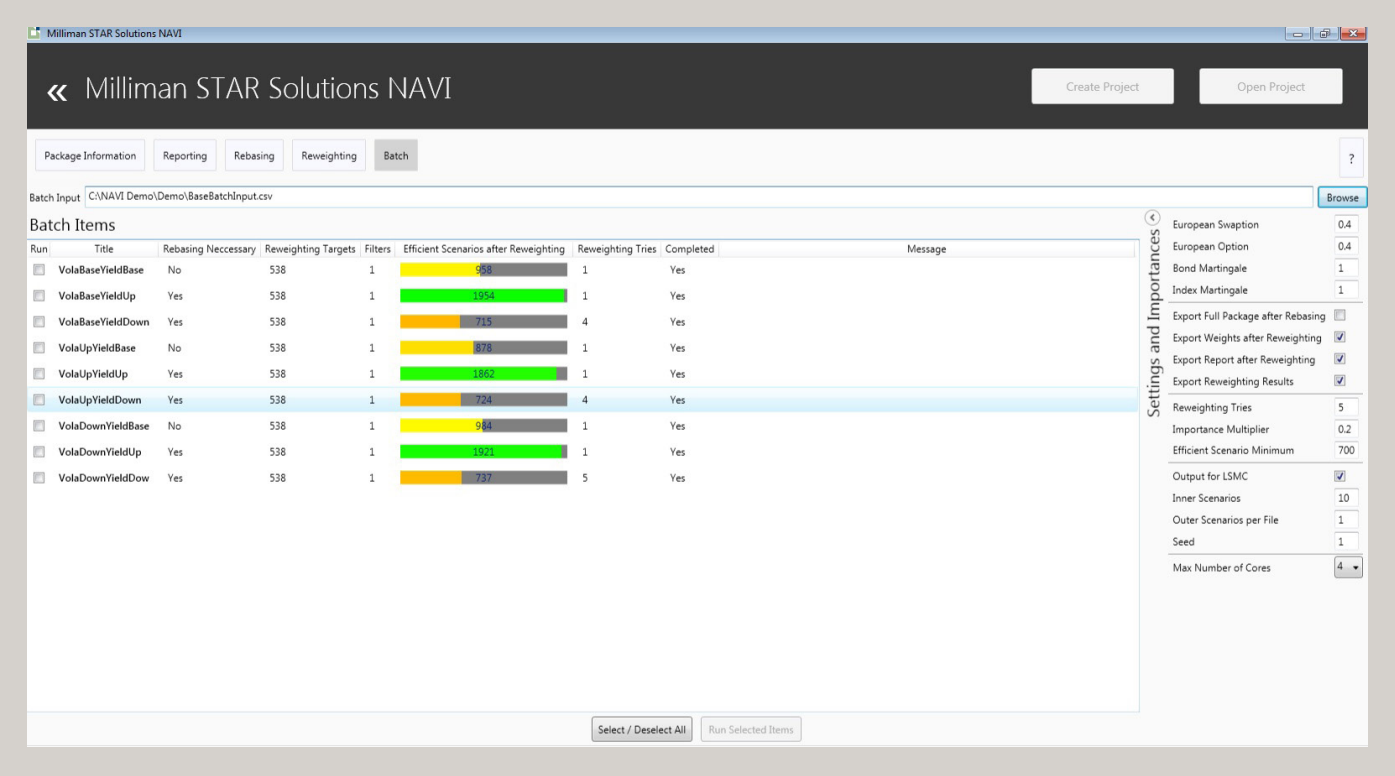
The starting point is an existing set of risk-neutral scenarios that reflect some (but not necessarily the desired) calibration targets. Well-established cutting-edge scenario rebasing and reweighting techniques allow for the ex-post transformation of an existing set of risk-neutral valuation scenarios towards new or refined calibration targets:

- Rebasing enforces a new initial yield curve.
- Reweighting enforces new volatilities by performing a change of measure via assigning weights to individual scenarios.
- Approach is independent from the underlying capital market model and its underlying assumptions.
- The following risk factors are covered:
  - Interest rates (nominal and real rates, including inflation)
  - Indices
  - Stochastic spreads and defaults
  - Volatilities
  - FX
- Comprehensive reporting framework allows for a full assessment of scenario quality.



Features and benefits

- Superior goodness-of-fit for calibration targets.
- Calibration speed allows for the generation of any scenario within seconds.
- Focuses on arbitrary set of calibration targets with smooth and sensitive inter- and extrapolation in between.
- Allows for negative interest rate environments even if underlying interest rate model is lognormal.
- Approach is independent from ESG provider and capital market model.
- Fully automated scenario generation combined with multi-processor use allows for delivery of new scenarios within tight deadlines.
- Automatic generation of scenario calibration reports allows for robust validation process.
- Approach is well-established[1] in the insurance community, known by regulators and currently used by our clients across Europe and the United States.
- Achievement of significant variance reduction.



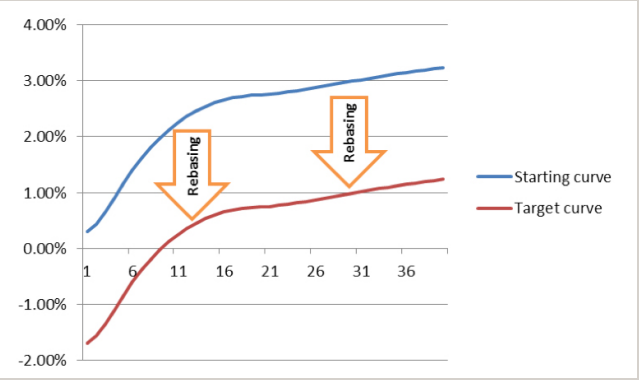
1 See M. Hörig, F. Wechsung: "*Weighted Monte-Carlo for fast Re-Calibration of Pricing Scenarios: Applications in Insurance Risk Management*", Der Aktuar, January 2014

APPLICATIONS

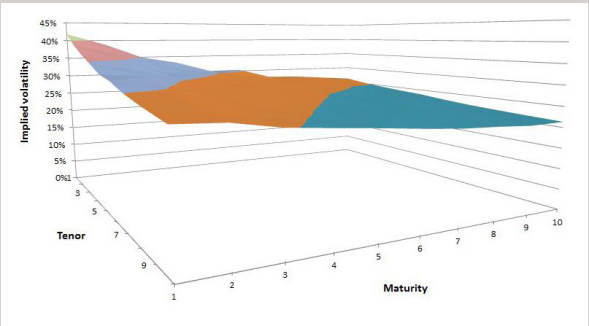
Scenario recalibration

The combination of rebasing and reweighting transforms an existing set of risk-neutral valuation scenarios in order to reflect new calibration targets:

- Shift of initial yield curve enforced by rebasing allows for a reflection of an arbitrary (potentially negative) initial yield curve, independent from the underlying original scenario set and its distributional properties.
- Change of volatility surface enforced by reweighting allows for a reflection of arbitrary volatility targets and hence the improvement of suboptimal calibration tailored to the specific needs.



Initial volatility surface



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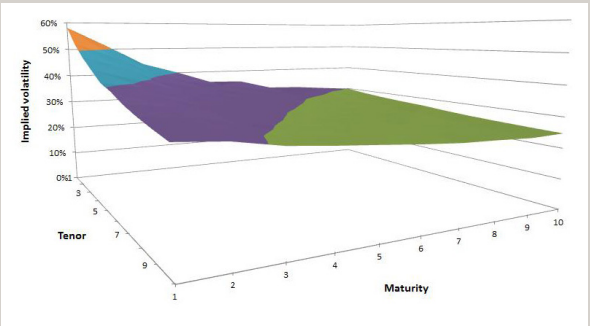
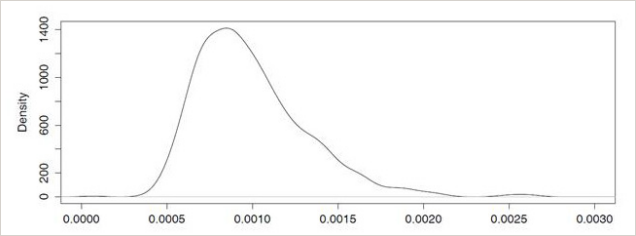
Target volatility surface



Resulting weight distribution



Goodness-of-fit: Deviations from target

Maturity/Tenor	1	2	3	4	5	6	7	8	9	10
1	-3%	-2%	-1%	-1%	0%	0%	0%	0%	0%	0%
2	-4%	-3%	-2%	-1%	-1%	-1%	-1%	-1%	0%	0%
3	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%
4	-2%	-1%	-1%	-1%	-1%	-1%	-1%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%
10	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%

Refine existing calibration

The reweighting approach can furthermore be used to refine an existing calibration in the following ways:

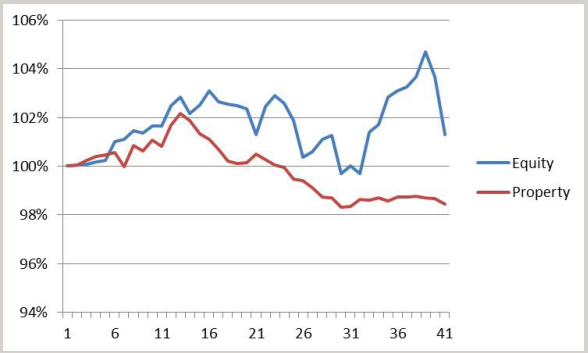
- Improving martingale properties and the related simulation leakage.
- Avoidance of the undesired impact of increasing interest rates and asset performances or severe and long-lasting negative rate periods.
- Reduction of seed dependency of results by enforcing a stronger convergence of simulation results.
- Variance reduction and the generation of test scenarios consisting of as few as 50 paths, allowing for a quick liability valuation.

Generation of stress and proxy model calibration scenarios

NAVI offers the automated generation of an arbitrary number of scenario recalibrations, including:

- Calibration scenarios for replicating portfolios, LSMC and curve fitting
- Solvency II standard formula and SST stress scenarios
- Stress scenarios for as-if-analyses, ORSA and similar purposes

Martingale test prior to reweighting



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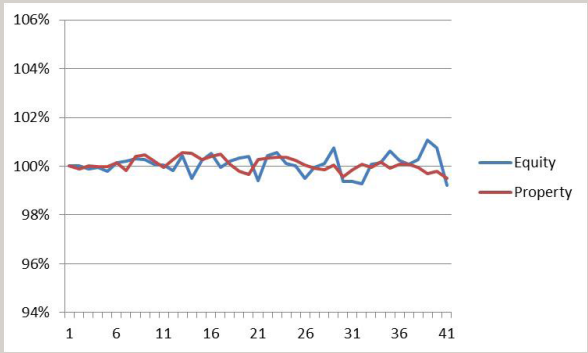
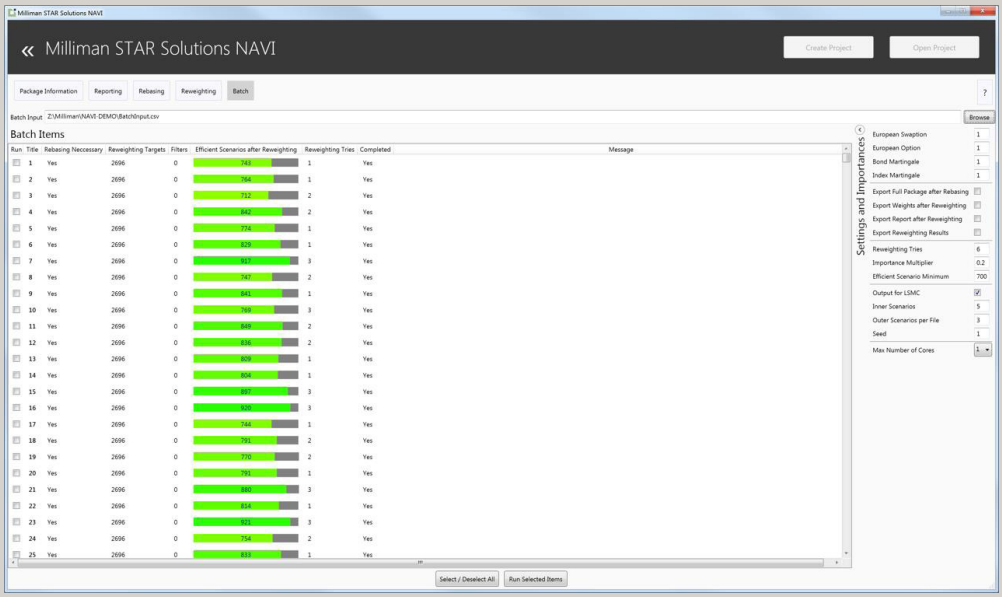
Martingale test after reweighting



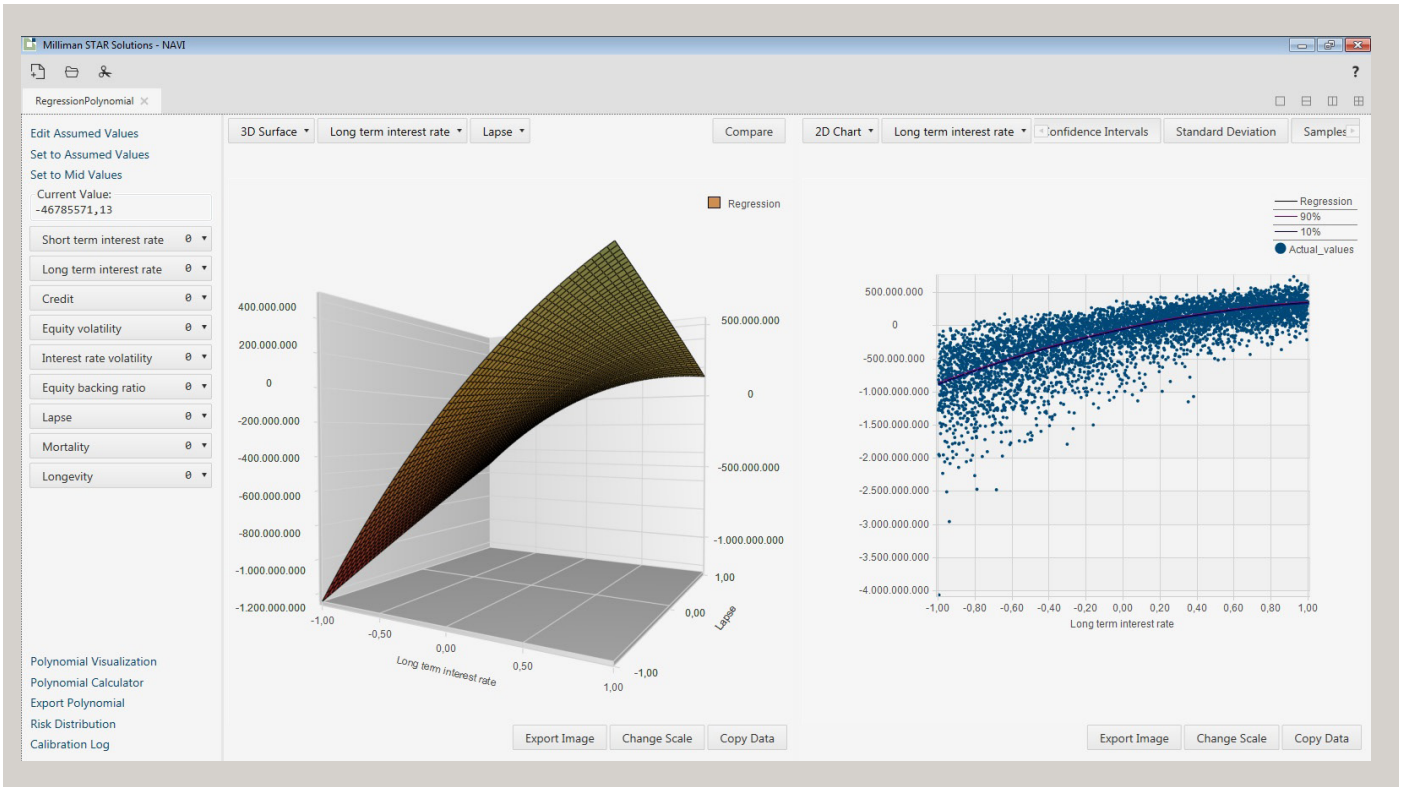


PROXY MODELING

NAVI's functionalities include the calibration of proxy models based on least squares Monte Carlo (LSMC), replicating portfolio and curve-fitting approaches, visualizations of key risk figures and assessment of calibration quality.

Key functionalities

- Calibrate polynomial proxy models for both curve-fitting and LSMC-style approaches including market and insurance risks; alternatively, a replicating portfolio calibration can be performed based on the same techniques. User can choose between different statistical methods to calibrate proxy models.
- Assess quality of the calibration intrinsically by deriving confidence intervals and standard deviations for liability values.
- Perform an analysis-of-change for subsequent calibrations, both graphically and numerically.
- Plot 2D and 3D risk dependencies for any combination of risks involved.
- Generate liability forecasts and risk distributions by either user-supplied real-world scenarios or included feature to generate real-world scenario based on user views.
- Reporting framework that allows for extraction and use of the resulting data and figures in other software environments.

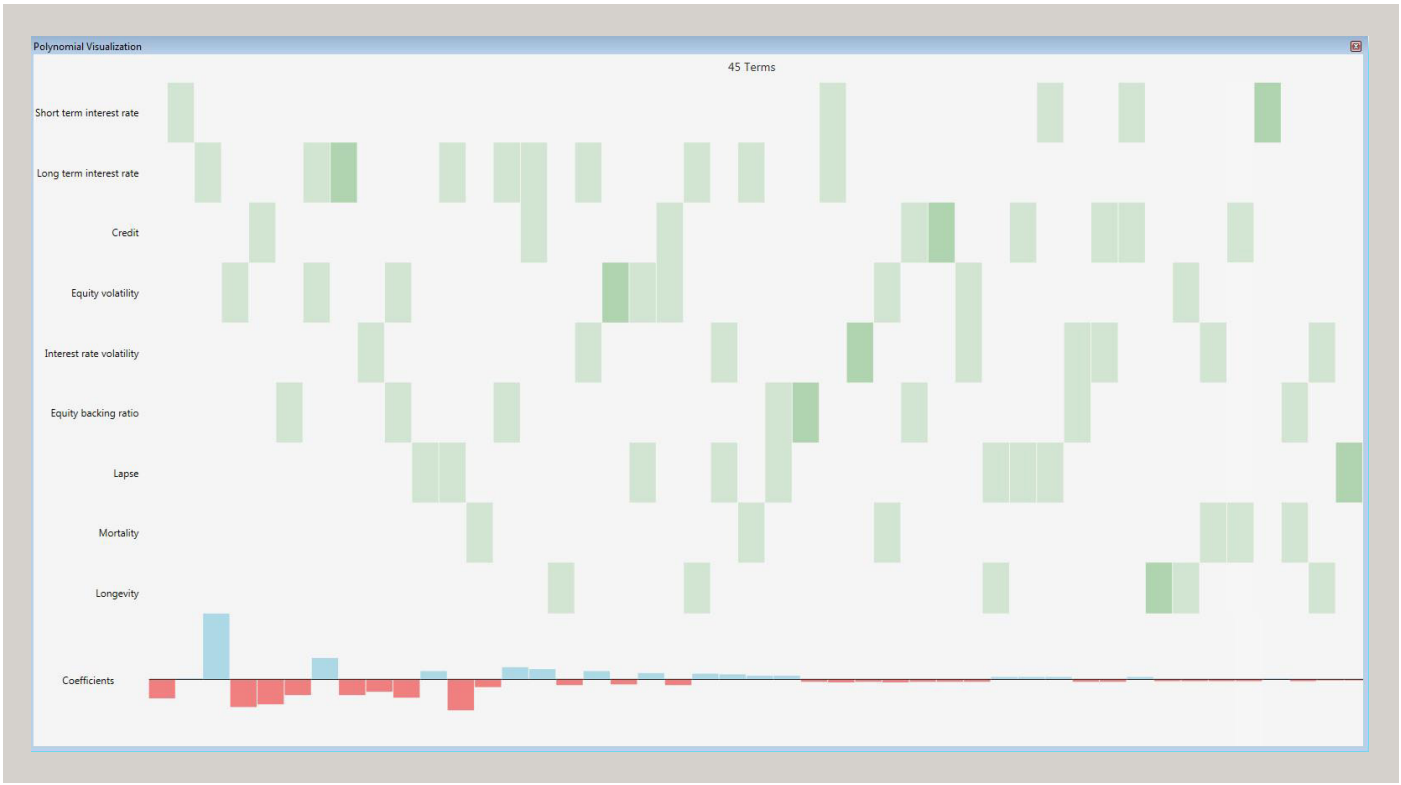


CALIBRATION

NAVI allows for a fully automated proxy model calibration process. The user can select different calibration methodologies based on well-established advanced statistical methods that allow for replicating portfolio, curve fitting and LSMC calibrations. The key features are:

- Automated and robust calibration process and fast runtimes thanks to enhanced numerical methods.
- Visualization of calibration process and results that allow for simple assessment of final proxy model.
- Choice of different statistical models and parameters allow user to optimize the calibration method and adapt it to the very nature of its liabilities.
- Consistent treatment of market and insurance risks.
- User can trace back any step of the calibration process.
- Generic calibration works for replicating portfolio, curve-fitting and LSMC-style calibrations; no information on specific nature of the data is required.
- Can be run from console to allow for automated data processing.

The user is fully in charge of the overall process but does not need to provide feedback or additional information about the risks involved for the intermediate steps of the calibration process. This leads to a high level of auditability of the overall calibration process.



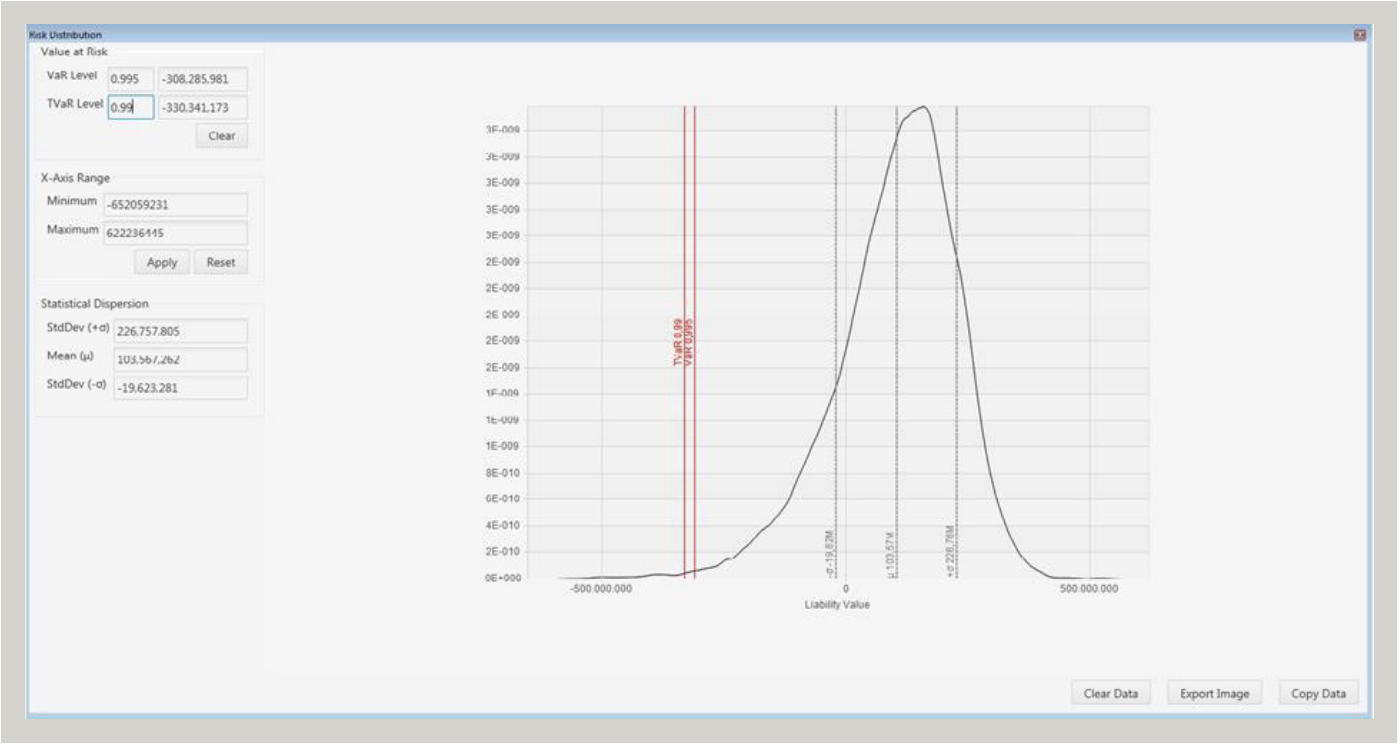
GENERATION OF RISK DISTRIBUTION AND LIABILITY UPDATES

- Can quickly update liability values using the calibrated proxy model.
- NAVI allows for the automated generation of the risk distribution:
  - User can provide real-world scenarios.
  - Feature to generate real-world scenarios from family of distributions.
  - Automated plot of resulting risk distribution.
  - Derive and plot key figures (such as VaR and TVaR) of liability distribution.

Deriving overall risk distribution allows for full assessment of the risks involved.

ANALYSIS OF RISK DEPENDENCIES

Plots of 2D and 3D risk dependencies provide additional value and allow for a deeper understanding of the nature, significance and interplay of the risks involved. NAVI's user interface has been specifically designed to allow for a user-friendly analysis of these dependencies and a quick extraction of the key findings, both visually and quantitatively.



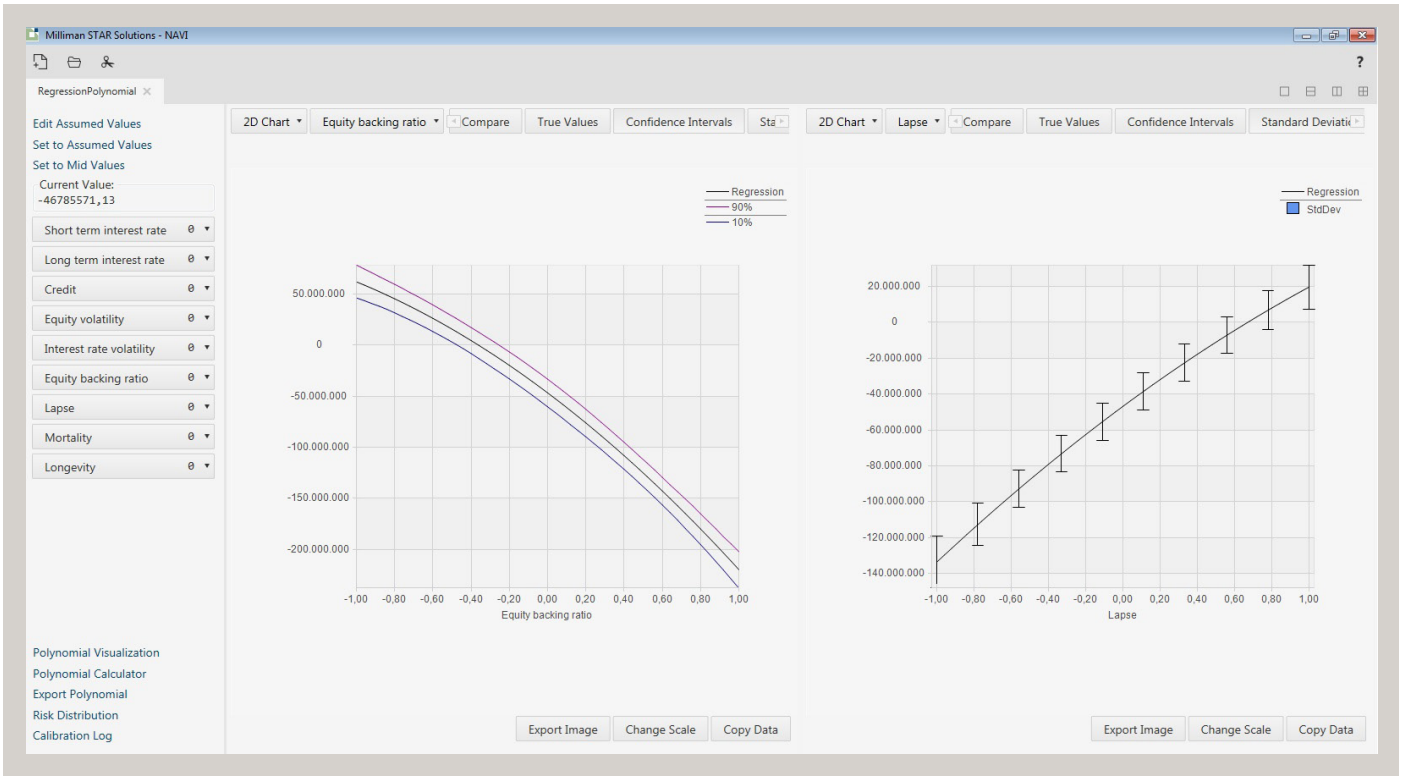
QUALITY ASSESSMENT

Don't just ask for results, also ask 'How much can I trust these numbers?'

Updating liability values and assessing the risks of a liability portfolio are some of the most critical but also the most challenging actuarial tasks. NAVI has been designed to support insurers in each key step of this vital process. All functions go hand in hand in order to guarantee consistency. Innovative graphic features also allow the user to quickly gain key insights.

By their very nature–the simplification of complex valuations–proxy models tend to have a black-box character. NAVI surmounts this issue this by providing visual and numerical documentation of all steps involved, allowing for a qualitative and quantitative analysis of the quality of the results.

Furthermore, additional statistical figures such as confidence intervals and standard deviations of the estimated proxy values provide feedback with respect to the quality of the proxy model and address the question 'How much confidence can I have in my results?'



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ABOUT MILLIMAN

Milliman is among the world's largest providers of actuarial and related products and services. The firm has consulting practices in life insurance and financial services, property & casualty insurance, healthcare and employee benefits. Founded in 1947, Milliman is an independent firm with offices in major cities around the globe.

MILLIMAN IN EUROPE

Milliman maintains a strong and growing presence in Europe with more than 250 professional consultants serving clients from offices in Amsterdam, Brussels, Bucharest, Dublin, Dusseldorf, London, Madrid, Milan, Munich, Paris, Stockholm, Warsaw, and Zurich.

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CONTACT

For more information, please contact your local Milliman consultant or:

Mario Hörig
mario.hoerig@milliman.com