ORSA and model risk
Focus on Life insurance

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Introduction

- The new regulatory requirements, various stakeholders’ expectations (financial markets, analysts, rating agencies), combined with the intrinsic complexity of many life insurance guarantees, resulted in the development of sophisticated models.

- In this presentation, we will focus on some general aspects of the model risk, and on the particular context of the Solvency II ORSA.

- The presentation is mainly Life insurance – oriented, but most of the remarks are also valid for Health&Disability and Non-Life insurance.
On the one hand, quantitative models in finance and insurance are becoming more and more sophisticated. The analytical tools in both Life and Non life area (options theory, extreme value theory, copulas). These tools have been enhanced by the Monte Carlo approaches. The recent increase of the computational capacities, pushed even further the model complexity.

On the other hand, the financial innovation is also dependent from the model developments. Some authors consider that the complexity is partly self-perpetuating (see [1]) :

- The quantitative techniques allow to built sophisticated products.
- As these products become more familiar, innovation is pushed further and requires even more complex models, greater computational power, etc.

This increasing sophistication is noticeable not only on the financial markets but also in the insurance area.
Financial & insurance products and model sophistication...

- **Financial products**
  - Equity Futures
  - OTC currency options
  - IR swaps
  - Swaptions
  - Credit derivatives
  - Unit linked
  - Variable annuities

- **Life insurance products**
  - OTC currency options
  - Equity Futures
  - Swaptions
  - IR swaps
  - Credit derivatives
  - Unit linked
  - Variable annuities

- **Non Life risk transfer tools**
  - OTC currency options
  - Equity Futures
  - Swaptions
  - IR swaps
  - Credit derivatives
  - Unit linked
  - Variable annuities

- **Model techniques (life)**
  - DFA
  - CAT modeling
  - Traditional EV
  - Market consistent EV
  - SCR approximation: replicating portfolios, curve fitting LSMC, acceleration techniques...

- **Model techniques (non life)**
  - DFA
  - CAT modeling
  - Traditional EV
  - Market consistent EV
  - SCR approximation: replicating portfolios, curve fitting LSMC, acceleration techniques...

- **Regulatory and accounting**
  - IFRS
  - IFRS 4 phase II
  - Intensive uses of Monte Carlo simulations

- **Computational**
  - Numerical approximations
  - Monte Carlo
  - Intensive uses of Monte Carlo simulations

Timeline:
- 1970
- 1980
- 1990
- 2000
- 2010
The model and its characteristics

Possible definition in the risk management area: a model is a simplified mathematical description of a complex reality. A model is built on historical data, past experience and expert opinion.

Some important characteristics of a model:

• **By definition, it is a simplification.**

• **A balance between simplicity and accuracy is needed** (« as simple as possible, but not simpler»*). An excessively simple model does not reflect properly the reality, an excessively sophisticated model bears risks of over-parametrization, instability, lack of robustness…..

• **A clear framework** : the model results are valid only under specific conditions (model assumptions) and for specific purposes.

• **Need for a validation process** : the model should be continuously tested against the reality

• The model is built on statistical data, but also on **expert judgment and experience.**

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* Attributed to A. Einstein
Why model risk matters for risk management and Solvency II?

- Risk management cycle is essentially about identifying, assessing/measuring, managing (accepting, avoiding, transferring, mitigating), and monitoring risk.

- Models are used for valuation, risk quantification and prospective analysis:
  - Valuation
  - ALM
  - Stress testing
  - Capital requirement
  - Product development
  - Risk transfer (reinsurance, securitization…)
  - Strategic planning (mid term plannings)
  
etc…

- Solvency II relies on models (Best estimate under standard formula, USP, internal models, ORSA). Inputs for these models are often the results of other models (interest rate curves, implicit volatilities and volatilities surfaces, diffusion processes, …).

- Therefore, model risk management should be part of the “holistic” risk management process.
Why model risk matters in Solvency II : Best estimate and SCR

Model risk is an import topic not only in the context of an internal model, but also in the context of standard formula and USP (undertaking specific parameters).

For Life insurers

Best estimate: The Best estimate will be most likely based on a market-consistent valuation (stochastic) approach. This is especially the case of the French multi-support saving and retirement products with regulatory, contractual and discretionary profit sharing and lapse (or transfer) option.

Therefore, the valuation model is rather complex and reflects market and spread risk, asset-liability interaction, liability guarantees, policyholder’s behavioral risk (lapse, “arbitrage”, conversion into annuity if optional, etc.) and future management actions.

SCR: If a life insurer applies the standard formula, the “shocks” will be performed on the Best estimate stochastic valuation model. Model risk needs to be addressed as well.

For Health&Disability or Non Life insurers

Best estimate: overall, it will require a model which is not conceptually different from the current actuarial liability valuation techniques. However, requirements on the data quality, robustness and completeness are increasing.

SCR: even if the standard formula in non life looks simple, the charges and coefficients are based on the best estimate valuation. Consequently, SCR is also subject to model risk.

In addition, the CAT risk is based on the “sum at risk”. In many cases, “sum at risk” are not directly available. Therefore, the exposures will be derived from a “model”, even simple a simple one.

In the case of USP (undertaking specific parameters), the model is based on a general concept provided by the regulator (i.e. the volumes are a reliable basis for risk assessment), but the estimates are provided by the company.
**Taxonomy of model risk (1)**

1) « Erroneous model, model misspecification or model misapplication »

Various sub-categories are possible (see for example [1], [2])

- **Inapplicability of quantitative modeling**: Example: it seems unlikely that changes in future regulatory environment could be quantitatively modeled.

- **Incorrect model. All model are incorrect at some level**, but major flaws could be (but are not limited to):
  - Errors in the analytical solution
  - Some risk factors are totally neglected (example: liquidity risk)
  - Some factors are assumed to be deterministic while actually these factors are stochastic;
  - Incorrect distributions, especially underestimating the tail because of
  - Stationary process is wrongly assumed, homoscedasticity is wrongly assumed etc…
  - Incorrect dependencies (ie assuming independence), especially in the tail. Other examples: a gaussian copula not reflecting the actual risk profile.
  - etc….

- **Usually, there is trade-off between model complexity and model accuracy.**

- **The underlying assumptions are not met, the model is used in a different context or for different purposes.** This is a key risk since it will not only depend on the model developer, but also on the risk governance. Example: an approximation developed for valuation is used for VaR 99.5% capital requirements calculations.
2) “Incorrect implementation”

The model is appropriate but the implementation is erroneous. Example are:

- programming errors, bugs, especially errors leading to non linear deviations (ie unnoticeable in most of the cases)
- wrong inputs: scale, measurements units, confusion between inputs etc, etc…
- human error during the process, especially when manipulating raw data, inputs and outputs,
- “versioning” risk
- various non specified critical inputs are neglected
- unnoticed IT failures (eg during Monte Carlo simulations), outages
- limited number of Monte Carlo simulations

etc, etc…

The “implementation” model risk increases with the model complexity. However, even relatively simple VaR calculations may differ from one expert to another (because of different understanding of the specifications, errors, rounding, …) as shown by one famous study (cf [3]).
3) “Feedback risk”

- The model output influences the reality. The reality impact negatively the model accuracy (feedback loop).

- There is an on-going debate whether this risk affects the financial markets. This is an important topic for the regulators.

- From an insurer’s point of view, the internal risk framework, risk and underwriting limits could be affected by this risk.

- However, overall the “feedback risk” seems limited.
Why model risk matters in Solvency II : risk processes and ORSA

Model risk is a key topic also for risk processes and ORSA.

- **Appetite, risk limits :**
  
  Results (valuation, sensitivities, capital requirements) from the models :
  
  - will probably be used for the risk appetite definition (eg. partly or fully based on SCR)
  
  - might be used for risk limits framework (example : risk limit on equity risk based equity after interactions with liabilities (eg SCR equity only (w/o Real estate) ; interest rate sensitivities etc…)

- **ORSA.** In a nutshell :
  
  - ORSA is a process and not a simple report
  
  - ORSA has to be part of the strategic planning (e.g. mid-term planning) and needs to consider risk, return and capital coherently
  
  - ORSA is a forward-looking process
  
  - ORSA should encompass all material risks (“quantitative” and “qualitative”)
  
  - ORSA process should be documented

By definition, ORSA will be based on a model (more or less sophisticated) reflecting the company’s view on its own risk.
According to ORSA Guidelines:

Guideline 2 – Role of the administrative, management or supervisory body (top-down approach) The administrative, management or supervisory body should take an active part in the ORSA including providing steering on how the assessment is to be performed and challenging its results.

Guideline 4 – ORSA policy
1.17. The ORSA policy should comply with the guidelines established under General Governance – Policies and include additionally at least:

a) a description of the processes and procedures in place to conduct the ORSA including how the forward-looking perspective is addressed;

b) consideration of the link between the risk profile, the approved risk tolerance limits and the overall solvency needs;

c) information on:

(i) how stress tests, sensitivity analyses or reverse stress testing are to be performed and how often they are to be performed;

(ii) data quality requirements; and

(iii) the frequency and timing for the performance of the (regular) ORSA and the circumstances which would trigger the need for an ORSA outside the regular timescales.

Guideline 7- Assessment of the overall solvency needs
1.20. If the undertaking uses recognition and valuation bases that are different from the Solvency II basis in its assessment of its overall solvency needs, it has to explain how the different recognition and valuation bases ensure better consideration of the specific risk profile, approved risk tolerance limits and business strategy of the undertaking, while complying with the requirement for a sound and prudent management of the business.

1.21. The undertaking should quantitatively estimate the impact on the overall solvency needs assessment of the different recognition and valuation bases.
## Guideline 8 - Assessment of the overall solvency needs

The undertaking should express the overall solvency needs in quantitative and qualitative terms and complement the quantification by a qualitative description of the risks.

For this, and where appropriate, the undertaking should subject the identified risks to a sufficiently wide range of stress test/scenario analyses to provide an adequate basis for the assessment of the overall solvency needs.

## Guideline 9 – Forward-looking perspective

The undertaking’s assessment of the overall solvency needs should be forward-looking.

## Guideline 10 – Regulatory capital requirements

As part of the ORSA the undertaking should ensure that the assessment of compliance on a continuous basis with the regulatory capital requirements includes, at least, an assessment of:

- a) potential future changes in the risk profile and stressed situations;
- b) the quantity and quality of its own funds over the whole of its business planning period; and
- c) the composition of own funds across tiers and how this composition may change as a result of redemption, repayment and maturity dates during the business planning period.

## Guideline 13- Link to the strategic management process and decision-making framework

The undertaking should take the results of the ORSA and the insights gained in the process into account at least for the system of governance, including medium term capital management, business planning and product development and design.
The company should define:

- The horizon (consistent with the internal strategic planning process)
- The probability (VaR 99.5%, other ?)
- How the business development is projected (eg new business: volumes, characteristics,.....)

It is up to the company to answer these questions consistently with the way business is effectively managed and with its own Risk management framework.

The overall consistence with the strategic planning is a key requirement.

As a consequence, the company will use risk-adjusted indicators and develop “risk-adjusted” strategic planning.

In other words, the insurance company have to answer the following questions:

- How the value is created: what are the drivers, the role of the management decisions, the impact of the competitive pressure, etc…?
- To what extent the value creation is sustainable?
- How the strategy contribute to this process?
Strategic planning and ORSA

The key assumptions are:

- Future New Business: volumes, characteristics,
- Future management decision: cost reductions, launching new products, strategic goals in term of business mix, changes in tariffs.
- All these assumptions need to be dynamic. Examples:
  - Link between tariff increase and PH behavior (lapses)
  - Link between new business volumes and costs
  - Link between market conditions and contingency measures

Etc….

Possible approaches to define the horizon, the probability and the “event” to avoid:

1. Avoid a situation where eligible elements are <0 at all points N+1, N+2, N+3… in X% (eg 99%) of the cases
2. Avoid a situation where the solvency ratio is < Threshold at all points N+1, N+2, N+3… in Y% of the cases
3. Avoid a situation where eligible elements are <0 at 1 point, eg N+3 in Z% (eg 99%) of the cases
4. Avoid a situation where the solvency ratio is below a given threshold according to various deterministic scenarios over the next years
5. Others (Solvency assessment not anymore required at the end of each projected annual period)……
6. Etc…
The definition of the event will most probably require a nested simulations approach. Therefore, simplifications are needed.

Various tools can be used for multi-year projection in the context of ORSA (replicating portfolios, curve fitting, LSMC, adjusted MCEV projections).
Risk measure and model risk

- Solvency II relies on VaR 99.5% over 1 year. In comparison the Swiss Solvency Test (SST) relies on ES (expected shortfall) 99% over 1 horizon.
- The advantages and drawback of both measures are well known (eg VaR is not necessary sub-additive, is only a quantile and does not reflect the amount of the loss beyond the quantile (eg “how bad is bad”). ES tackles these issues.

- Insurance regulatory framework horizon is longer (1 year) and the capital requirement are based on the strict threshold.
- A 99.5% (or 99%) threshold leads to capital requirements naturally prone to model risk: small changes of distribution parameters (which can be due to lack of historical data) leads to significant difference between risk measures.

Illustrative example: Comparison between VaR 99.5% et ES 99% for 3 well known distributions, resp. with « light » to « moderate » (normal and lognormal) or « heavy » tailed (Generalized Pareto). The difference is measured by \( \frac{(ES_{99\%}(X) - VaR_{99.5\%}(X))/VaR_{99.5\%}(X)}{\text{Sigma}} \). Similar examples could be given with copulas.
The solvency ratios (Solvency II or Swiss Solvency Test) are based on:

1. Economic worth (Eligibles funds in SII)
2. Required capital (SCR)

These models are pro-cyclical because:

- The method used for valuation (« market consistency ») is naturally pro-cyclical. The LTGA proposals, if approved, may mitigated to some extent the pro-cyclicity.
- The required capital (SCR), despite some countercyclical features in Solvency II, doesn't offset the overall pro-cyclical effect.

The Life insurance companies have to fulfill not only the Solvency ratio> 100% requirement, but also to define strategies in order to tackle the « volatility » issue of the solvency ratios.

This “volatility” is an additional challenge regarding the model risk.
For a Life company, after the projection of a major financial market drop (or improvement), the conditional distribution of the own fund has to be re-examined even if the liability structure and the SAA remained unchanged.

Even if for a given ORSA scenario, the assumptions and the inputs adequately reflect risks, the complexity of the ALM mechanism is leading to a potential model risk.
The Solvency ratio is intrinsically « volatile » as illustrated by this theoretical example (LTG countercyclical measures not included).

This “volatility” is an additional challenge regarding the model risk.
ORSA scenarios: the importance of the holistic view

■ Simple examples demonstrate that the way correlations in the tail are considered is key.

■ ORSA scenarios should reflect a “holistic” view of the tail risk, not only sensitivities per individual risk factor

Illustrative dummy example (« portefeuille fictif »)

■ Scenario 1 is a « flat » economic scenario (spread, interest rates and equity market slightly improving). New Business volumes, lapses, and « arbitrage » are projected.

■ Scenario 2 is a shocked financial scenario but the NB volumes, lapses and « arbitrage » are maintained unchanged.

■ Scenario bis takes into account the impact of lapses/arbitrage and the loss of new business volumes.

■ This simple example shows that the interdependencies need to be captured in order to avoid an underestimation of the risk.

■ Another examples of tail correlations:

  - pandemic risk: death/disability/health risk materializes; stressed market conditions, BCM issues
  - major Non Life event effecting the loss ratio and the reinsurer’s solvency etc…
Focus on policyholder behavior and liquidity risk

- Policyholders behavior is an area sensitive to model risk (see [5]).

- Usually, Life company Best estimates projections rely on the so called “dynamic lapses”. The concept is based on the idea that the difference between the served rate and a general market indicator (i.e., interest rates) will influence the PH’s decision.

**Advantages**: simple, intuitive, reflects an idea of PH rationality

**Drawbacks**: lack of historical data (most of the points in the curve have never been observed), fiscal incentives difficult to model, difficulties to isolate the dynamic component in the observed lapse rate (example: the current negative inflow on the French Life market is not “dynamic” in the sense of an opportunity cost because the average served rate is higher than the risk free rate).

![Diagram showing the relationship between benchmark ref rate and served rate](image)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>%VIF Euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio 1</td>
<td>118%</td>
</tr>
<tr>
<td>Portfolio 2</td>
<td>106%</td>
</tr>
<tr>
<td>Portfolio 3</td>
<td>100%</td>
</tr>
<tr>
<td>Portfolio 4</td>
<td>89%</td>
</tr>
<tr>
<td>Portfolio 5</td>
<td>99%</td>
</tr>
<tr>
<td>Portfolio 6</td>
<td>108%</td>
</tr>
</tbody>
</table>

The valuation is impacted by the parameters. SII mass lapse risk and the SST additional scenarios mitigate indirectly the model risk related to PH behavior.

It is necessary that the ORSA process takes into account this uncertainty.
Focus on policyholder behavior and liquidity risk

- Usually, the liquidity risk is not captured by the models. The stochastic scenarios may assume that even after a major financial shock, all instruments are perfectly liquid.

In addition there are a strong interdependencies with lapse risk and or « arbitrage feature» (for French multisupport contracts).

Therefore, indicators like duration gap, liability convexity are strongly model dependent. This is a moderate issue in case of liability valuation (ie average of risk neutral scenarios) but it is a topic for risk management.

An appropriate and simple way to capture tackle the model risk is through stress scenario and reverse –stress scenario (what are the assumptions leading to a solvency and/or liquidity issue) into 3 steps:

- Assessing the market value under 2-3 scenarios (sudden increase of interest rates, reputational issue combined with depressed market).
- Simulate (stress testing and reverse stress testing) a major increase of lapse and “arbitrage” (for French multisupport product) rate

These scenarios should be somehow part of the ORSA process, especially for a life company, in order to tackle model risk regarding liquidity, policyholder behavior: lapse, “arbitrage” (multisupport); the correlations between both risk factor in the tail.
The quantitative model is a major building block of the risk management framework. However, bear in mind that:

- There is a natural trend that well-known risks are modeled with greater accuracy ("known unknowns")*) than recently identified/emerging risks or risks that have never been observed (« black swans »**) , “unknown unknowns”). Examples: tail correlations, EU/EEA GOV credit risk.

- These “unknown” risks can put in danger the insurer's solvency and business model.

- The risk management cycle should contribute to the continuous improvement of the risk assessment/measurement.

- Besides quantitative techniques, operational, strategic and business risks have to be considered as well.

*) N.N. Taleb’s book “The Black Swan”, **) Attributed to D.Rumsfeld and quoted in several Risk management books

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**Monitoring/Reporting**

Risk management: avoid, accept, mitigate transfer....

**Identification**

All significant risks have to be taken into account

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**Management/Implementation**

**Assessment/measurement**

Quantification: statistical distribution, aggregation methodology, assumptions. But also assessment methods for « qualitative » risks (strategic, operational, legal).

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**Based on [1]:**
Can we mitigate the model risk? (1)

Even if the company intends to apply the standard formula, the model risk needs to be mitigated in the view of ORSA and risk management.

- Definition of the model governance
  It is important that the role and responsibilities are defined, incl. design and implementation of model changes (committees, etc..). Solvency II is a natural framework for this kind of governance.

- Limit the all types of model risk through review (or independent review), benchmarking and “used tests”

- Limit the “Incorrect implementation” risk
  It can be achieved through:
    - regular validation tests, simple mirror models, and internal control system.
    - improved model documentation,
    - benchmarking of the results
Can we mitigate the model risk? (2)

- Quantitative approaches are not always possible, especially regarding business, strategic, legal and emerging risks.

- Qualitative “top down” approaches based on simple probability-severity analysis might be useful.

- Besides the SII quantitative requirements, the models have to be embedded in the decision process in order to strengthen the company risk culture.
Risk culture and model risk

- The management should understand the limitations of the quantitative techniques.
- This actuary/modeler should ensure that the risk framework is the common language of the company.
- Technical skills are necessary, but pragmatism and communication skills are needed as well.
- In order to achieve this task:

  The sensitivity to the key parameters and drivers should be communicated to the top management. For example:

  - SAA
  - Economic conditions: interest rates, inflation, spreads, volatility
  - Use of available “buffers” (bonus fund, realization of URGL’s, etc.)
  - Discretionary bonus/served rates
  - Business mix, guarantees given to the policyholders (e.g., minimum guaranteed rates)
  - Risk avoidance/acceptance/mitigation/transfer policy (equity/IR hedging, reinsurance…)

- Key assumptions and limitations (e.g., “management rules” and PH’s behavior)
- Main levers in order to increase the value and to improve the risk-adjusted return
- Results based on extreme scenarios. For example: historical scenarios (e.g., 2008) or synthetic (deflation, sudden rise of interest rates, …)
Conclusion

- Model risk is a key issue in risk management.

- Model risk cannot be avoided, but it can be mitigated and reduced.

- It is crucial that the advantages, limitations and key assumptions are well understood not only by the actuaries and the modelers, but also by the top management. This represents a clear requirement for a successful enterprise-wide risk management framework.

- Risk management is not only about measurement/assessment but also about supporting the decision process in order to increase the risk-adjusted profitability through a holistic approach.

- Risk managers will have to demonstrate that the models create value.
Bibliography


