Lisbon School of Economics & Management
Universidade de Lisboa

MASTER IN ACTUARIAL SCIENCE

FINAL MASTER WORK

RISK MARGIN IN SOLVENCY II: SCR PROJECTION IN LIFE INSURANCE

SUPERVISOR: HUGO MIGUEL MOREIRA BORGINHO

GONÇALO NUNO HENRIQUES MENDES

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Resumo

Desde 1 de janeiro de 2016, as empresas de seguros estão sujeitas ao regime de Solvência II, que visa assegurar a estabilidade financeira das empresas de seguros, tornando-se essencial garantir que as Provisões Técnicas e o Requisito de Capital de Solvência (RCS) calculados correspondam corretamente às obrigações e riscos a que cada empresa está sujeita.

As Provisões Técnicas são o montante que uma seguradora necessita para cumprir as suas obrigações de seguro e liquidar todos os compromissos esperados para com os tomadores de seguros e outros beneficiários que surjam ao longo da vida da sua carteira de contratos, o que inclui a Melhor Estimativa e a Margem de Risco.

No que se refere à Margem de Risco, o seu cálculo inclui a projeção (em *run-off*) de um Requisito de Capital de Solvência específico, pois é calculado sob a perspetiva da entidade de referência que se assume que vai adquirir este portfolio, não sendo na legislação fornecida uma fórmula específica.

Conceptualmente este cálculo é bastante complexo e exigente, e na prática as empresas recorrem a simplificações. Este trabalho apresenta três metodologias distintas para projeção do RCS usado para o cálculo da margem de risco numa companhia de seguros do ramo vida.

Palavras-chave: Solvência II, Provisões Técnicas, Margem de Risco, Requisito de Capital de Solvência

Classificação JEL: G22

Abstract

Since 1 January 2016, insurance companies have been under the Solvency II regime, which aims to ensure the financial stability of insurance companies, making it essential to guarantee that the Technical Provisions and the Solvency Capital Requirement (SCR) are properly calculated and reflect the insurance company risks.

The Technical Provisions reflect the amount that an insurer needs to fulfil its insurance obligations and settle all expected commitments to policyholders and other beneficiaries arising over the lifetime of its portfolio contracts, which includes the Best Estimate and the Risk Margin.

Regarding the Risk Margin, its calculation includes the projection (in *run-off*) of a specific Solvency Capital Requirement for the risk margin as it is calculated from the perspective of the reference undertaking that is assumed to acquire this portfolio, and no specific formula is provided in the legislation.

Conceptually, this calculation is quite complex and demanding, and in practice companies use simplifications. This paper presents three different methodologies for projecting the SCR used to calculate the risk margin in a life insurance company.

Keywords: Solvency II, Technical Provisions, Risk Margin, Solvency Capital Requirement

JEL Classification: G22

Acknowledgements

The completion of this master's degree was only possible thanks to a happy combination of people along the way, whom I would like to thank here.

Firstly, a very special thank you to Filomena Santos, for always encouraging me to do this master's degree, and for all support throughout this time, which we both know has not been easy. To the other management team at GamaLife, thank you for all your support and constant motivation.

During these two years at ISEG, I was lucky enough to meet some young people on the very first day who welcomed me as one of their own, regardless of age, and who became more than colleagues: Daniel Machado, Diogo Rodrigues and Mariana Godinho, thank you all.

To all my colleagues at GamaLife, thanks for all your support during this time, and a special thanks to Ana Brito for suggesting the subject for this paper and for all your feedback.

To my family, especially my wife Tânia Viais, I don't have words to express my gratitude for all your love and support during these difficult times.

I dedicate this master's degree to my daughters Júlia and Carmo Viais, showing them that it's never too late to fight for your dreams.

Finally, I would like to say a huge thank you to my teacher and supervisor Hugo Borginho for accepting my invitation and for his always constructive remarks during the course of this work.

Abbreviations

BEL | Best Estimate Liabilities

BOF | Basic Own Funds

BSCR | Basic Solvency Capital Requirement

CEIOPS | Committee of European Insurance and Occupational Pensions Supervisors

EIOPA | European Insurance and Occupational Pensions Authority

EC | European Commission

EU | European Union

HRG | Homogeneous Risk Groups

LoB | Line of Business

MCR | Minimum Capital Requirement

ORSA | Own Risk and Solvency Assessment

PV | Present Value

RM | Risk Margin

SCR | Solvency Capital Requirement

SWAP | Swap Curve

SWAP_VA | Swap Curve with volatility adjustment

UL | Unit-Linked products

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1. Introduction

According to Solvency II, the technical provisions should be valued as the sum of a best estimate and a risk margin. The best estimate is the expected present value of insurance liabilities till *run-off*, using risk-free interest rate term structure to discount the relevant projected cash flows. These cash-flows should be projected using the best estimated assumptions (that should be previously studied and defined) with regard to economic and non-economic assumptions.

The risk margin is the additional amount required by a third party to accept the transfer of the insurance portfolio and is calculated using the cost of capital methodology. It should consider underwriting risk, reinsurer default risk, operational risk and ‘unavoidable’ market risk.

Risk Margin considers the cost of holding Solvency Capital Requirement (SCR) in each future year, so the SCR must be projected until the full *run-off* of the liability portfolio.

Considering the difficulties to compute the SCR in each future year, EIOPA allows insurers to consider some simplifications on the SCR *run-off* calculation.

The purpose of this document is to present three different ways (hereinafter called “models”) to estimate the future SCRs, just concerning life insurance portfolios.

The first model considers the projected SCR linked to Best Estimate Liabilities (BEL) run-off. The second model aims to project each sub-risk according with the most “suitable” driver and then calculates the SCR in each year. The last model comprises an extension of the second model where specific product features are considered.

Besides the introduction, this document encompasses five others chapters:

Chapter 2 contains an introduction to Solvency II focused on pilar I, namely related with technical provisions and SCR.

Chapter 3 describes the risk margin formula and the three models proposed for its calculation, namely for SCR projection. Here it is presented the first 2 models, and then the motivation to create model 3

Chapter 4 presents the results obtained through the application of the three models to a real life insurance portfolio composed by four different products.

It contains their projected cash-flows, and initial SCR. Next, the SCR is projected according to different models and, finally, the risk margin for each model is presented and the main differences are explained.

Chapter 5 makes reference to the Solvency II 2020 review that brings changes to risk margin calculation.

Finally, Chapter 6 presents the conclusions of the models presented.

2. Solvency II

Solvency II is the prudential regime for insurance and reinsurance undertakings in the European Union (EU), which has entered into force in January 2016[1].

Solvency II sets out requirements applicable to insurance and reinsurance companies with the aim to ensure the adequate protection of policyholders and beneficiaries, ensuring a uniform and strengthened level of policyholder protection across the EU. A stronger system will give policyholders greater confidence in insurers' products.

Solvency II has a risk-based approach that makes possible to assess the "overall solvency" of insurance and reinsurance companies through quantitative and qualitative measures, which contributes to a harmonisation of supervisory regimes, and increases the international competitiveness of EU insurers.

The implementation of Solvency II is based on a "Three Pillar" approach that allows to understand and to manage risks across the sector, as follows:

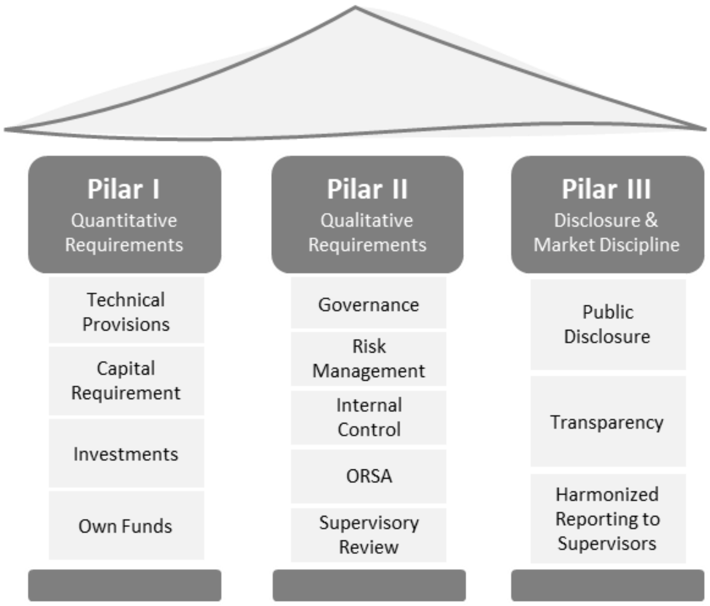

Figure 1: Solvency II, Three Pillar Approach

[1] (EIOPA, "Directive 2009/138/EC", 2009)

- Pillar I sets the quantitative requirements associated with the valuation of assets and liabilities, calculation of technical provisions, solvency capital requirements, minimum capital requirements (MCR) as well as estimation and classification of eligible own funds and investments.

- Pillar II sets the qualitative requirements, which includes the system of governance, risk management and internal control. Each firm is required to carry out an own risk and solvency assessment (ORSA), which aims to identify all the risks that the firm is exposed to, including those not covered under Pillar I.

- Pillar III establishes the supervisory reporting and public disclosure.

This document is focused on Pillar I, so it is worth to also mention that this Pillar also contains an integrated view of the Balance Sheet on an Economic View.

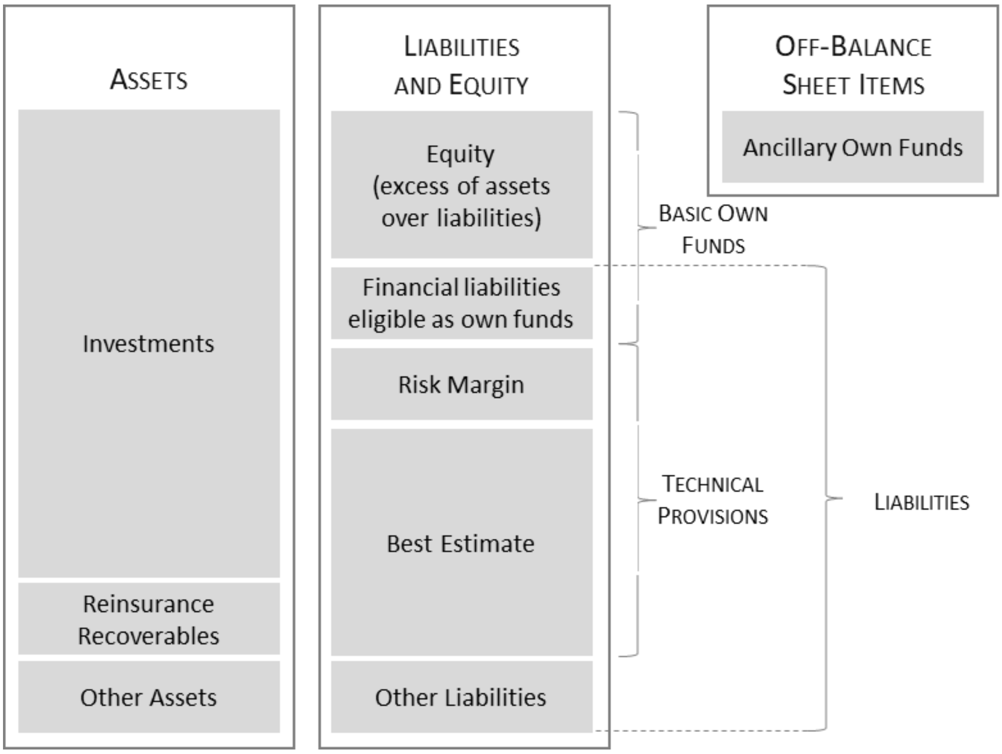

Figure 2: Solvency II Economic Balance Sheet

The assets are evaluated at current market value, *mark-to-market*, that is, at the amount for which they can be exchanged, transferred, or settled in the market.

If there is no quoted market value, an attempt should be made to use an adjustment to quoted market value of similar assets and, as last option, to use *mark-to-model* techniques, in which the value is estimated using a model based, as much as possible, using market information.

The liabilities are evaluated as the amount for which they can be transferred to other entity in a rational transaction under normal market conditions.

2.1. Technical Provisions

Technical provisions are the most important liabilities for a Life insurance company, which are calculated as the sum of the best estimate liabilities (BEL) and a risk margin[2].

Technical provisions could be defined as the current amount that the undertakings will have to pay if they transfer their insurance obligations to another undertaking, so, this valuation must rely, as much as possible, on market information. When there is no market information, which is what happens in practice, these calculations should rely on the expectable cash-flows considering the time value of the money, using a risk-free interest rate term structure plus a Risk Margin (which is explained below).

Best Estimate Liabilities

The best estimate liabilities are calculated as being the present value of the expected future cash-flows, using the "*relevant risk-free interest rate term structure*"[3]. This should be based upon up-to-date and credible information and realistic assumptions and shall be performed using adequate, applicable, and relevant actuarial and statistical methods.

The cash-flow projection used in the calculation shall consider all the cash-in and out-flows required to settle the insurance and reinsurance obligations over their lifetime. These should be estimated without any deduction of the amounts recoverable from reinsurance contracts.

There are some specifications related to contract boundaries[4], that define which cash flows should be included or not in this calculation. All obligations that relate to existing contracts should be included. The scope of cashflows to project must end at the same moment that the company has the possibility of exercising

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[2] Article 77 (EIOPA, "Directive 2009/138/EC", 2009)
[3] Article 77 (EIOPA, "Directive 2009/138/EC", 2009)
[4] (EIOPA, "Guidelines on the Contract Boundaries", 2015)

unilateral rights that materially mitigate or avoid risks stemming from future policy coverage periods.

Technical provisions should be calculated by homogeneous risk groups (HRG) and must be reported at a minimal segmentation level called Line of Business (LoB).

Let us consider the notation $CF_{t,p}^{k}$ to represent a cash-flow from type k, on projection year t and related with product p (omitted if it is not at product level). From here on, let us consider the following cash-flows included in best estimate liabilities (these are an example, it could be added more cash-flows, depending on the insurance product):

$CF_{t,p}^{0}$: total amount of premiums at year t for product *p*,
$CF_{t,p}^{1}$: total amount of death benefits at year t for product *p*,
$CF_{t,p}^{2}$: total amount of Illness benefits at year t for product *p*,
$CF_{t,p}^{3}$: total amount of annuity benefits at year t for product *p*,
$CF_{t,p}^{4}$: total amount of surrender benefits at year t for product *p*,
$CF_{t,p}^{5}$: total amount of maturity benefits at year t for product *p*,
$CF_{t,p}^{6}$: total amount of expenses at year t for product *p*,
$CF_{t,p}^{7}$: total amount of commissions at year t for product *p*

Considering these cash-flows, the total cash-flow to be considered on BEL at time t for product p, $CF_{t,p}$ is obtained as:

$$CF_{t,p} = -CF_{t,p}^{0} + \sum_{k=1}^{7} CF_{t,p}^{k} \quad (1)$$

Note that just the first cash-flow is to be received, so it will have a negative sign which means that reduces the liabilities.

The best estimate liabilities for each product p are obtained as:

$$BEL_p = \sum_{i>0} \frac{CF_{i,p}}{\left(1 + r(0,i)\right)^{i}} \quad (2)$$

Where $r(0,i)$ denotes the risk-free interest rates (spot rates) for i years.

Risk Margin

The risk margin is the additional return that a third party would require to accept the insurance portfolio and consequently to meet the insurance and reinsurance obligations. It is the cost of holding sufficient SCR to ensure the full *run-off* of liabilities.

Therefore, market assumptions should be used, in which it is assumed that the asset portfolio that is transferred along with the liabilities has been substantially restructured to minimise the capital charge for market risk. In other words, it is as if all the assets were instantly sold, and at the same moment risk-free asset exposures were acquired (e.g., EU sovereign bonds) with perfect cash flow matching with the liabilities, which minimises or even cancels out interest rate risk.

The specific SCR should consider underwriting risk, reinsurer default risk, operational risk, and 'unavoidable' market risk, hereinafter called SCR^{RM}. To obtain the risk margin, the SCR^{RM} *run-off* is calculated and then applied the 6% cost of capital method, discounted at risk-free rate curve.

According with regulation[5], Risk Margin should be calculated using the formula:

$$RM = CoC \times \sum_{t \geq 0} \frac{SCR_t^{RM}}{\left(1 + r(0, t+1)\right)^{t+1}} \tag{3}$$

Where:

- CoC denotes the Cost-of-Capital rate, which is currently fixed at 6%[6]. This rate is the same for all insurers and it was calibrated to reflect the spread over the risk-free rate for a BBB entity looking for market funding[7].
- SCR_t^{RM} denotes the solvency capital requirement of the reference undertaking[8] after t years.
- Where $r(0, t+1)$ denotes the risk-free interest rate for $t+1$ years

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[5] Article 37 (EIOPA, "Delegate Regulation (EU) 2015/35", 2014)
[6] Article 39 (EIOPA, "Delegate Regulation (EU) 2015/35", 2014)
[7] (Borginho, 2022)
[8] Article 38 (EIOPA, "Delegate Regulation (EU) 2015/35", 2014)

2.2. SCR | Solvency Capital Requirement

Solvency Capital Requirement is one of the key Solvency II components, being the amount of capital that an insurance company must hold to ensure it has an adequate financial buffer to cover its risks both on assets and liabilities.

The SCR is the capital needed to sustain a shock on the basic own funds. This shock corresponds to the Value-at-Risk with a confidence level of 99.5% of the loss distribution, reflecting all risks to which the insurer is exposed, in a one-year period.

SCR also aims to ensure the availability of a level of eligible own funds that enables insurance and reinsurance undertakings to absorb significant losses and that gives reasonable assurance to policyholders and beneficiaries that payments will be made as they fall due.

The SCR can be calculated using the standard formula which includes some predefined shocks to be performed and the factors that relates each risk with each other, using correlation matrices.

The SCR for a life insurance undertaking contains the risks modules of “Life Underwriting”, “Market Risk”, “Counterparty Default”, “Intangible Assets” and “Operational”, that will be explained in more detail.

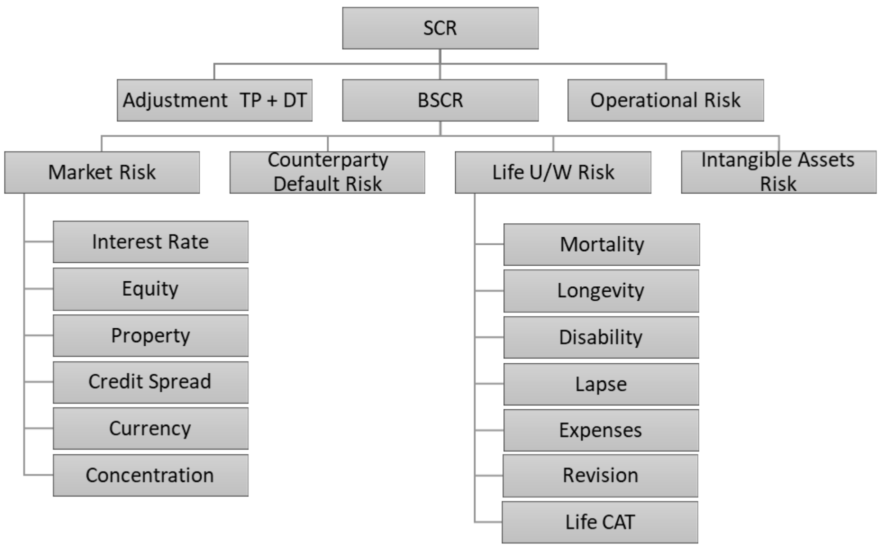

Figure 3: SCR standard formula structure for a Life Insurance Undertaking

SCR | Life Underwriting Risk

The Life Underwriting Risk combines the risks of mortality, longevity, disability, expenses, revision, and catastrophe.

The SCR for each individual risk is then calculated as the difference between the basic own funds (BOF) after and before each shock. It is worth mentioning that this difference is only considered when the shock leads to an increase on BEL (decrease on BOF).

The shock details are as follows:

- Mortality risk: increase of 15% on mortality rates;
- Longevity risk: decrease of 20% on mortality rates;
- Disability/morbidity risk: increase on disability/morbidity rates of 35% on the first projection year and 25% in the following years;
- Life-expense risk: increase of 10% on expenses, combined with 1pp of inflation increase;
- Revision risk: increase of 3% of benefits (only for annuities where the benefits can increase due to a change in the legal environment or in the health status of the insured person);
- Lapse risk- lapse risk is the worst case of three scenarios:
  - Mass Lapses: immediate discontinuance of 40% portfolio;
  - Lapse Up: increase of 50% on surrender rates;
  - Lapse Down: decrease of 50% on surrender rates;
- Life-catastrophe risk: adding 0.15 percentual points in the mortality rates in the next 12 months.

The life underwriting risk module is calculated as follows:

$$SCR_{life} = \sqrt{\sum_{i,j} Corr_{i,j} \times SCR_i \times SCR_j} \qquad (4)$$

Where i and j denotes all possible combinations between the risks, so each SCR is then replaced by:

$SCR_{mortality}$ refers to mortality sub-module risk,

$SCR_{longevity}$ refers to longevity sub-module risk,

$SCR_{disability}$ refers to disability sub-module risk,

$SCR_{expense}$ refers to expense sub-module risk,

$SCR_{revision}$ refers to revision sub-module risk,

SCR_{lapse} refers to lapse-risk sub-module risk,

$SCR_{catastrophe}$ refers to catastrophe sub-module risk,

$Corr_{i,j}$ denotes the correlation parameter for sub-modules (i,j) on the correlation matrix for Life Risk (in Appendix).

SCR | Market Risk

The Market Risk combines the risks of interest rates, equity, property, spread, concentration, and currency. In this document no further details are presented since it will not be used on the risk margin, as explained on risk margin assumptions.

The market risk module is calculated as follows:

$$SCR_{market} = \sqrt{\sum_{i,j} Corr_{i,j} \times SCR_i \times SCR_j} \tag{5}$$

Where i and j denotes all possible combinations between the risks, so each SCR is then replaced by:

$SCR_{interest}$ refers to interest rate sub-module risk,

SCR_{equity} refers to equity sub-module risk,

$SCR_{property}$ refers to property sub-module risk,

SCR_{spread} refers to spread sub-module risk,

$SCR_{concentration}$ refers to concentration sub-module risk,

$SCR_{currency}$ refers to currency sub-module risk,

$Corr_{i,j}$ denotes the correlation parameter for sub-modules (i, j) on the correlation matrix for Market Risk (in Appendix)

SCR | Counterparty Default Risk

The counterparty default risk occurs when in a financial transaction the counterpart could not fulfil its part of the deal and may default its obligations.

The insurance company must differentiate the counterparties between "exposures type 1", which may not be diversified and are likely to be rated (reinsurance, derivatives, cash at bank) and "exposures type 2" that usually are diversified and are unlikely to be rated exposures.

Different detailed approaches are specified for the determination of the SCR for each type of exposure, which are then combined using a given formula.[9]

SCR | Intangible Assets Risk

The intangible assets risk contains the inherent risk of holding intangible assets.

This could come from market, related to price or liquidity, and could also come from internal risks.

The SCR is given by:

$$SCR_{intangibles} = 80\% \cdot Value\ of\ Intangibles \tag{6}$$

[9] (EIOPA, "Delegate Regulation (EU) 2015/35", 2014)

Basic SCR

The Basic Solvency Capital Requirement (BSCR) is calculated by considering previous modules of risks: life underwriting, market, counterparty default and intangible assets.

It has the following closed formula:

$$BSCR = \sqrt{\sum_{i,j} Corr_{i,j} \times SCR_i \times SCR_j} \qquad (7)$$

Where i and j denotes all possible combinations between the presented modules risks, so each SCR is then replaced by:

SCR_{life} refers to life risk module,

SCR_{market} refers to market risk module,

$SCR_{default}$ refers to counterparty default risk module,

$SCR_{intangibles}$ refers to intangible risk module.

$Corr_{i,j}$ denotes the correlation parameter for risk modules (i, j) on the correlation matrix for BSCR (in Appendix).

SCR | Operational Risk

The operational risk is the risk of losses arising from inadequate or deficient internal processes, from personnel, systems, or external events.

The measures to capture this risk could be technical provisions, premiums earned during the previous twelve months and expenses incurred during the previous twelve months.

For life products, the formula is given by:

$$SCR_{Operational} = min(30\% \cdot BSCR, \text{Op}) + 25\% \cdot UL\ Expenses \qquad (8)$$

where,

$$Op = max(Op_{premiums}, Op_{provisions})$$

And both are not related with Unit-Linked (UL) products:

$Op_{premiums} = 4\%\ Premiums$ + add-on, if Δ premiums >20%

$$Op_{provisions} = 0.45\%\ BEL$$

And $UL\ Expenses$, are the expenses from Unit Linked products (excluding acquisition expenses).

SCR

Finally, the SCR is given by the sum:

$$SCR = BSCR + LAC_{TP} + LAC_{DT} + SCR_{Operational} \tag{9}$$

Where:

- LAC_{TP} is the "loss absorbing capacity of technical provisions", which represents the part of losses that can be passed to policyholders due to a reduction on discretionary benefits, included on technical provisions.

- LAC_{DT} is the "loss absorbing capacity of deferred taxes", which represents the part of losses that can be passed to future tax bills, via a change of the value of deferred tax assets and liabilities.

- Both LAC_{TP} and LAC_{DT} are negative values, so the final SCR would decrease with these quantities.

2.3. Risk Margin

The SCR used to calculate Risk Margin, SCR^{RM}, according with regulation[10], should capture all the following risks:

- Underwriting Risk,
- Market Risk, only if it is material and not related with interest rate risk,
- Counterparty Default Risk, just related with credit risk from Reinsurance contracts,
- Operational Risk[11],

In this paper, the Market Risk is assumed to be not material, so it will be excluded hereon after.

The SCR used to calculate Risk Margin, could be obtained as:

$$SCR^{RM} = \sqrt{{SCR_{life}}^2 + {SCR_{Def}^{RM}}^2 + 2 \cdot 0.25 \cdot SCR_{life} \cdot SCR_{Def}^{RM}} + SCR_{Op} \qquad (10)$$

Where:

- SCR_{life} refers to life underwriting risk module,
- SCR_{Def}^{RM} refers to counterparty default risk module just for reinsurance contracts,
- 0.25 is the correlation factor between the previous two risks (in Appendix),
- SCR_{Op} is the Operational Risk,

As defined in equation (3), to calculate the Risk Margin it is necessary to obtain the SCR^{RM} amount during all projection, that is, the SCR^{RM} should be projected for each year t, SCR_t^{RM}.

Obtaining a complete projection of all future Solvency Capital Requirements would be very hard to implement and time consuming. As such, the regulation allows, taking into consideration the nature, scale and complexity of the underlying risk, to

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[10] Article 37and 38 (EIOPA, "Delegate Regulation (EU) 2015/35", 2014)
[11] It could be different from the Operational coming for SCR, due to CAP of 30%SCR. In this paper we will consider no differences on both.

use alternative methods[12] to calculate the risk margin, ensuring that the method chosen is adequate to capture the risk profile of the undertaking.

EIOPA, issued a guideline[13] with four methods to calculate a simplified Risk Margin. These methods should be applied in a hierarchy way:

- **Method 1** consists of approximating the individual risks for each year t and then calculate the SCR_t^{RM}.

- **Method 2** consists of approximating the whole SCR_t^{RM} using the *run-off* ratio of the BEL. This is the ratio between the BEL in each future year and the BEL at valuation date. However, this method is not appropriate when the BEL is negative (example of some risk products, where the present value of outflows is lower than the present value of the future premiums).

- **Method 3** consists of approximating the discounted sum of future SCR_t^{RM} using a proportion of the modified duration of the insurance liabilities.

- **Method 4** that calculates all Risk Margin as a percentage of the BEL.

In this document, it will be presented, by order of complexity, three different models to compute the SCR_t^{RM}: Model 1 based on Method 2, and Models 2 and 3 based on Method 1.

[12] Article 58 (EIOPA, "Delegate Regulation (EU) 2015/35", 2014)
[13] (EIOPA, "Guidelines on the valuation of technical provisions", 2015)

3. Risk Margin | SCR *run-off*

To compute the Risk Margin, a specific SCR calculated at company level is required.

In the following it is presented three different models to estimate the SCR *run-off* and finally the Risk Margin.

The first model estimates each future SCR just linked with BEL *run-off*. This methodology is on legislation but should not be used when the insurer has negative BEL.

The second model aims to project each sub-risk according with the most “suitable” driver and then calculates the SCR in each year.

The last model comprises an extension of the second model where specific product features are considered.

3.1. Model 1 | "BEL *run-off*"

Following the simplification[14] suggested in method 2, future SCR is computed according with total BEL *run-off*.

We can set-up the following procedure:

- CF_t: the cash-flow considered in BEL calculations at year t, as previously defined.

- Calculate $r(t,i)$: the forward rate from year t to i, implicit on risk-free interest rate curve,

- Calculate BEL at each year t (BEL_0 is at valuation date):

$$BEL_t = \sum_{i\geq 1} \frac{CF_{t+i}}{\left(1 + r(t,i)\right)^i}, t \geq 0 \tag{11}$$

- Calculate BEL_{ratio} at each year t:

$$BEL_{ratio_t} = \frac{BEL_t}{BEL_0} \tag{12}$$

- Compute SCR^{RM}_{model1} at each year t (SCR^{RM}_0 is at valuation date):

$$SCR^{RM}_{model1_t} = BEL_{ratio_t} \times SCR^{RM}_0 \tag{13}$$

The Risk Margin under the model 1 is given by:

$$RM_{model1} = CoC \times \sum_{t\geq 0} \frac{SCR^{RM}_{model1_t}}{\left(1 + r(0,t+1)\right)^{t+1}} \tag{14}$$

[14] (EIOPA, "Guidelines on the valuation of technical provisions", 2015)

3.2. Model 2 | "Sub-Risk Models *run-off*"

Following the simplification[15] suggested in method 1, instead of projecting all the SCR at once, we will first estimate each risk and sub-risk model for the following years separately and then compute the SCR.

The idea here is to calculate a *run-off* for each single risk model using a different driver than BEL *run-off* and then compute the module risk SCR for each year.

Recall that SCR for Risk Margin needs the SCR_{life}, SCR_{Def}^{RM} and $SCR_{Operational}$.

It is essential to identify the best factor for each risk, so below it is indicated, although empirically, the ones that will be considered as being the best drivers and thus make the best estimate for the SCR projection and consequently for the risk margin, that is the main goal.

Life SCR

To calculate the Life SCR for each year t, we will consider the following drivers for each sub-risk module:

- Mortality Risk | Present value of death cash-flows
- Longevity Risk | Present value of all benefits cash-flows
- Disability-morbidity risk | Present value of illness cash-flows
- Lapse Risk | Present value of surrenders cash-flows
- Expense Risk | Present value of expenses and commissions cash-flows
- Catastrophe Risk | Present value of deaths cash-flows
- Revision Risk is assumed 0.

We can set-up the following procedure:

- Calculate $r(t,i)$: the forward rate from year t to i, implicit on risk-free interest rate curve,

[15] (EIOPA, "Guidelines on the valuation of technical provisions", 2015)

- Calculate Present Value (PV) at each year t, for each type of cash-flow k used on BEL, as follows:

$$PVCF_t^k = \sum_{i\geq 1} \frac{CF_{t+i}^k}{\left(1 + r(t,i)\right)^i}, t \geq 0, \qquad k \in [0,7] \tag{15}$$

Recall previous definitions:

CF_t^0: total amount of premiums at year t,
CF_t^1: total amount of death benefits at year t,
CF_t^2: total amount of Illness benefits at year t,
CF_t^3: total amount of annuity benefits at year t,
CF_t^4: total amount of surrender benefits at year t,
CF_t^5: total amount of maturity benefits at year t,
CF_t^6: total amount of expenses at year t,
CF_t^7: total amount of commissions at year t,

We will also consider the PV of the following aggregated cash-flows:

$CF_t^8 = CF_t^6 + CF_t^7$, total expenses and commissions,
$CF_t^9 = \sum_{i=1}^{5} CF_t^i$, the total of benefits (claims) to be paid.

- Calculate $ratio\_CF_t^k$ at each year t and for each type of cash-flow k:

$$ratio\_CF_t^k = \frac{PVCF_t^k}{PVCF_0^k} \tag{16}$$

- Compute individually sub-risk SCR at each year t using the present value *run-off* of specific driver:

$$SCR_{mortality_t} = SCR_{mortality_0} \times ratio\_CF_t^1 \tag{17}$$

$$SCR_{longevity_t} = SCR_{longevity_0} \times ratio\_CF_t^9 \tag{18}$$

$$SCR_{disability_t} = SCR_{disability_0} \times ratio\_CF_t^2 \tag{19}$$

$$SCR_{expense_t} = SCR_{expense_0} \times ratio\_CF_t^8 \tag{20}$$

$$SCR_{lapse_t} = SCR_{lapse_0} \times ratio\_CF_t^4 \quad (21)$$

$$SCR_{catastrophe_t} = SCR_{catastrophe_0} \times ratio\_CF_t^1 \quad (22)$$

- Compute each Life SCR at each year t using the standard formula:

$$SCR_t^{life} = \sqrt{\sum_{i,j} Corr_{i,j} \times SCR_t^i \times SCR_t^j} \quad (23)$$

Counterparty Default SCR

As previously referred, the SCR to be considered on risk margin calculation includes the counterparty risk just related with reinsurance contracts.

The simplification used here is to consider the previous driver for all benefits to this risk, so the counterparty default risk for risk margin in each year t, is given by:

$$SCR_{Def_t}^{RM} = SCR_{Def_0}^{RM} \times ratio\_CF_t^9 \quad (24)$$

Operational SCR

Without loss of generality, we can consider that the operational risk for the next years will come from provisions instead of premiums, since no new business is to be considered (both provisions and premiums related to non-unit-linked products). The remaining component, the UL expenses will be driven by the *run-off* of Unit Linked BEL, which is the most reasonable driver.

Then the operational SCR is computed, for each year t, as follows:

$$SCR_{Operational_t} = 0.45\%\ BEL\_nonUL_t + 25\% \cdot UL\ Expenses_t \quad (25)$$

Where:

BEL_nonUL_t is the amount of BEL for non-UL products in year, and

$$UL\ Expenses_t = UL\ Expenses_0 \times \frac{BEL\_UL_t}{BEL\_UL_0} \quad (26)$$

Risk Margin

Using the SCR projections above, we can compute the future SCRs using the standard formula, and finally the Risk Margin under the model 2 is given by:

$$RM_{model2} = CoC \times \sum_{t \geq 0} \frac{SCR^{RM}_{model2_t}}{\left(1 + r(0, t+1)\right)^{t+1}} \quad (27)$$

Where $SCR^{RM}_{model2_t}$ is the SCR calculated under model 2, for each year t.

3.3. Model 3 | "Best Estimate SCR"

The two models above mentioned calculate the SCR projection at the portfolio level.

Model 1 is easy to compute, but it cannot be used when we have products with negative BEL (according with legislation).

Model 2 seems more accurate, but even this one can have some strange behaviour, since it is not calculated at a product level.

In cases where the mortality SCR *run-off* is based on the evolution of PV of deaths cash-flows, if some products do not have mortality SCR (BEL after shock are lower than BEL before shock) and have death cash-flows, the SCR evolution could be biased.

Model 2 also considers the PV of surrenders amount as a driver of surrender shock. This will work for products where after a surrender there is a cash-out flow (typically financial products), but in case of products without any cash-out flow (typically risk products) this will not have a driver.

The purpose of model 3 is to extend the model 2 at product level, using the available cash-flows considered to calculate BEL (which are also available at product level).

Just the Life SCR is changed here, the remaining stills as defined in model 2.

Life SCR

We can set-up the following procedure:

- Calculate $r(t,i)$: the forward rate from year t to i, implicit on risk-free interest rate curve,

- Consider the previous definitions of $CF_t^k, k = 0, \dots, 9$ presented in model 2, which now are considered analogous by product p: $CF_{t,p}^k$

  $CF_{t,p}^0$: total amount of premiums at year t, for product p,
  $CF_{t,p}^1$: total amount of death benefits at year t, for product p,
  $CF_{t,p}^2$: total amount of Illness benefits at year t, for product p,
  $CF_{t,p}^3$: total amount of annuity benefits at year t, for product p,
  $CF_{t,p}^4$: total amount of surrender benefits at year t, for product p,
  $CF_{t,p}^5$: total amount of maturity benefits at year t, for product p,
  $CF_{t,p}^6$: total amount of expenses at year t, for product p,
  $CF_{t,p}^7$: total amount of commissions at year t, for product p,

  And additionally,
  $CF_{t,p}^8 = CF_{t,p}^6 + CF_{t,p}^7$, total expenses and commissions, for product p

  $CF_{t,p}^9 = \sum_{i=1}^{5} CF_{t,p}^i$, the total of benefits (claims) to be paid, for product p

- For each type of cash-flow k, calculate present value at each year t and for each single product p:

$$PVCF_{t,p}^k = \sum_{i \geq 1} \frac{CF_{t+i,p}^k}{\left(1 + r(t,i)\right)^i}, t \geq 0 \qquad (28)$$

- Calculate $ratio\_CF_{t,p}^k$ at each year t and for each single product p:

$$ratio\_CF_{t,p}^k = \frac{PVCF_{t,p}^k}{PVCF_{0,p}^k} \qquad (29)$$

- Estimate each sub-risk module for SCR Life at year t, using the same drivers as seen before on model 2 for the sub-risks. Please note that doing in this way, we are no longer using cash-flows to driver some risks, when the product does not have the risk itself (as happened in model 2).

$$SCR_{mortality_t} = \sum_p SCR_{mortality_{0,p}} \times ratio\_CF^1_{t,p} \tag{30}$$

$$SCR_{longevity_t} = \sum_p SCR_{longevity_{0,p}} \times ratio\_CF^9_{t,p} \tag{31}$$

$$SCR_{disability_t} = \sum_p SCR_{disability_{0,p}} \times ratio\_CF^2_{t,p} \tag{32}$$

$$SCR_{expense_t} = \sum_p SCR_{expense_{0,p}} \times ratio\_CF^8_{t,p} \tag{33}$$

$$SCR_{catastrophe_t} = \sum_p SCR_{catastrophe_{0,p}} \times ratio\_CF^1_{t,p} \tag{34}$$

- For SCR lapses, the driver will now be different depending on whether the product has a cash-out flow after lapse. For the products with surrender amount, we will keep the surrenders cash-flows as a driver, whilst for the other products we will use the premium cash-flows.

  Consider the new ratio, as follows:

$$ratio\_Lapses_{t,p} = \begin{cases} ratio\_CF^0_{t,p}, \text{if product } p \text{ has no surrender amount} \\ ratio\_CF^4_{t,p}, \text{if product } p \text{ has surrender amount,} \end{cases}$$

  And then,

$$SCR_{lapse_t} = \sum_p SCR_{lapse_{0,p}} \times ratio\_Lapses_{t,p} \tag{35}$$

  Besides estimation of lapse risk is done by product, it should be highlighted that the shock considered for each product is always the same shock: “mass lapse", "up", or "down" that was derived for the real SCR (at a company level).

- Compute each Life SCR at each year t using the standard formula:

$$SCR_t^{life} = \sqrt{\sum_{i,j} Corr_{i,j} \times SCR_t^i \times SCR_t^j} \quad (36)$$

Risk Margin

Using the SCR projections above, we can compute the future SCRs using the standard formula, and finally the Risk Margin under the model 3 is given by:

$$RM_{model3} = CoC \times \sum_{t \geq 0} \frac{SCR^{RM}_{model3_t}}{\left(1 + r(0, t+1)\right)^{t+1}} \quad (37)$$

Where $SCR^{RM}_{model3_t}$ is the SCR calculate under model 3, for each year t.

It should be noticed that with this model, since it is computed at a product level, it would be easy to group by LoB as required for the regulatory report.

4. Examples

To illustrate the three models mentioned in Section 3, four products from a Portuguese life insurance company were considered. Each product has specific characteristics that were chosen to allow to understand the impacts obtained depending on the methodology followed.

We will consider the following life insurance products:

P1: Guaranteed financial product with fixed and high interest rate.
P2: Unit linked financial product.
P3: Term assurance.
P4: Whole Life Annuity.

The first two products are financial products. P1 is a non-profit product due to its high interest rate, so the main risk here comes from longevity or lapse down (more time giving a high interest rate and making financial losses).

P2 is a profitable product since the company receives a management fee on it and so, the main underwriting risks is to end the product earlier, that could be due to death/catastrophe shock or surrender shock (mass or lapse up).

The term assurance P3 is a profitable product, as the premiums are higher than the claims, so the main risk comes also from death, disability and catastrophe, where the company must pay the sum assured in the contract, and from lapse risk, where the policy stops.

It was also included a whole life annuity, P4, where the main risk is longevity. There is assumed no revision risk on this annuity.

The cash flows presented below were obtained using actuarial software, with real data and approved assumptions, and were projected for 30 years. The total projected CFs can be found in the appendix.

The above products features can easily be observed on Table 1, with the SCR life for each product, and for the entire portfolio.

					(EUR millions)
SCR Life (net LAC TP)	**P1**	**P2**	**P3**	**P4**	**Portfolio**
Mortality risk	-	0.2	2.2	-	2.3
Longevity risk	0.2	-	-	0.5	0.7
Disability-morbidity risk	-	-	1.3	-	1.3
Lapse risk "mass"	-	3.6	10.8	-	14.3
Life expense risk	0.1	0.6	0.4	0.0	1.1
Revision risk	-	-	-	-	-
Life catastrophe risk	-	0.0	1.7	-	1.7
diversification effect	*- 0.1*	*- 0.4*	*- 4.4*	*- 0.0*	*- 5.4*
SCR Life (Net LAC TP)	**0.3**	**3.9**	**12.1**	**0.5**	**16.1**

Table 1: SCR Life by product

In this example, counterparty risk was considered immaterial, so it is not presented here.

Table 2 presents the first 10 years of projected cash-flows.

										(EUR millions)
P1 | Cash-Flows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Premiums	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2
Benefits	19.8	15.5	15.5	14.0	12.0	11.8	11.9	10.1	8.3	8.3
Death	2.4	2.2	2.1	1.9	1.8	1.7	1.5	1.4	1.3	1.2
Illness	-	-	-	-	-	-	-	-	-	-
Annuity	-	-	-	-	-	-	-	-	-	-
Surrender	3.5	3.2	3.0	2.7	2.5	2.3	2.1	1.9	1.8	1.6
Maturity	13.9	10.1	10.4	9.4	7.7	7.8	8.3	6.8	5.2	5.4
Expenses and Comm.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CF	**19.5**	**15.2**	**15.2**	**13.8**	**11.7**	**11.6**	**11.7**	**9.9**	**8.1**	**8.1**

P2 | Cash-Flows	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Premiums	-	-	-	-	-	-	-	-	-	-
Benefits	38.0	31.6	37.9	32.5	24.6	23.2	27.8	23.8	20.8	18.8
Death	5.9	5.9	5.8	5.6	5.6	5.6	5.5	5.2	5.0	4.8
Illness	-	-	-	-	-	-	-	-	-	-
Annuity	-	-	-	-	-	-	-	-	-	-
Surrender	25.0	23.4	21.5	19.6	17.6	15.9	14.6	13.3	12.3	11.4
Maturity	7.1	2.3	10.5	7.3	1.4	1.7	7.6	5.2	3.5	2.6
Expenses and Comm.	2.5	2.3	2.1	2.0	1.8	1.7	1.6	1.4	1.3	1.2
CF	**40.5**	**33.9**	**40.0**	**34.5**	**26.4**	**25.0**	**29.4**	**25.2**	**22.1**	**20.0**

P3 | Cash-Flows	1	2	3	4	5	6	7	8	9	10
Premiums	5.4	5.1	4.8	4.6	4.4	4.2	4.1	3.9	3.8	3.6
Benefits	1.7	1.6	1.6	1.5	1.4	1.4	1.3	1.2	1.2	1.1
Death	1.3	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.8
Illness	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Annuity	-	-	-	-	-	-	-	-	-	-
Surrender	-	-	-	-	-	-	-	-	-	-
Maturity	-	-	-	-	-	-	-	-	-	-
Expenses and Comm.	1.3	1.3	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.8
CF	**- 2.3**	**- 2.2**	**- 2.1**	**- 2.0**	**- 1.9**	**- 1.9**	**- 1.8**	**- 1.8**	**- 1.7**	**- 1.7**

P4 | Cash-Flows	1	2	3	4	5	6	7	8	9	10
Premiums	-	-	-	-	-	-	-	-	-	-
Benefits	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Death	-	-	-	-	-	-	-	-	-	-
Illness	-	-	-	-	-	-	-	-	-	-
Annuity	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Surrender	-	-	-	-	-	-	-	-	-	-
Maturity	-	-	-	-	-	-	-	-	-	-
Expenses and Comm.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CF	**0.4**	**0.4**	**0.4**	**0.4**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**

Table 2: Cash-flows by each product

In all the examples listed below, it was considered the risk-free interest rate used for BEL calculation as being the EIOPA curves with volatility adjustment (SWAP_VA) curve whilst for Risk Margin discount was used same curve but without volatility adjustment (SWAP).

4.1. Examples | Model 1

Under Model 1, the estimate SCR life is calculated according with BEL *run-off.* Table 3 presents the entire portfolio cash-flows projection for the first 10 years.

(EUR millions)

Portfolio | Cash-Flows	1	2	3	4	5	6	7	8	9	10
Premiums	5.9	5.6	5.3	5.0	4.8	4.6	4.4	4.2	4.1	3.9
Benefits	60.0	49.1	55.2	48.4	38.4	36.7	41.3	35.4	30.5	28.5
Death	9.6	9.3	9.0	8.6	8.4	8.3	8.0	7.5	7.2	6.9
Illness	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Annuity	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Surrender	28.5	26.6	24.5	22.3	20.1	18.3	16.8	15.2	14.1	13.0
Maturity	21.0	12.4	20.9	16.6	9.1	9.5	15.9	12.0	8.7	8.0
Expenses and Comm.	4.0	3.7	3.4	3.2	3.0	2.8	2.6	2.4	2.3	2.1
CF	**58.1**	**47.3**	**53.4**	**46.6**	**36.6**	**35.0**	**39.6**	**33.6**	**28.8**	**26.7**

Table 3: Cash-flows for the entire portfolio.

Table 4 shows the present value of each cash-flow calculated for the first 10 years of projection. At the end it has the BEL calculation and the respective *run-off* ratio to be applied on SCR projection.

(EUR millions)

Portfolio | PV Cash-Flows	0	1	2	3	4	5	6	7	8	9	10
Premiums	65.8	62.0	58.6	55.1	51.8	48.6	45.6	42.5	39.6	36.8	34.1
Benefits	547.8	505.3	473.5	432.6	397.2	371.1	345.6	314.6	288.8	267.3	247.2
Death	111.2	105.2	99.5	93.5	87.7	82.0	76.2	70.5	65.2	60.0	55.0
Illness	4.9	4.6	4.3	4.0	3.7	3.4	3.2	2.9	2.7	2.4	2.2
Annuity	4.5	4.2	4.0	3.8	3.5	3.3	3.1	2.8	2.6	2.4	2.2
Surrender	235.8	214.8	195.4	176.8	159.8	144.5	130.5	117.6	106.0	95.2	85.1
Maturity	191.4	176.5	170.3	154.5	142.5	137.9	132.7	120.7	112.4	107.3	102.7
Expenses and Comm.	37.3	34.5	32.0	29.5	27.2	25.0	23.0	21.0	19.2	17.5	15.9
CF	**519.4**	**477.8**	**446.9**	**406.9**	**372.6**	**347.5**	**323.1**	**293.1**	**268.5**	**248.1**	**229.1**
BEL Run-off ratio	*100%*	*92%*	*86%*	*78%*	*72%*	*67%*	*62%*	*56%*	*52%*	*48%*	*44%*

Table 4: Portfolio's PV Cash-Flows and BEL *run-off* ratio

Table 5 shows the SCR at starting point and the projected components using BEL *run-off* ratio. At the end of the table, it is shown both ratios to highlight that it was used the same ratio in this model.

(EUR millions)

Portfolio | SCR Life (net LAC TP)	0	1	2	3	4	5	6	7	8	9	10
Mortality risk	2.3	2.1	2.0	1.8	1.7	1.6	1.4	1.3	1.2	1.1	1.0
Longevity risk	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3
Disability-morbidity risk	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.6
Lapse risk	14.3	13.2	12.3	11.2	10.3	9.6	8.9	8.1	7.4	6.8	6.3
Life expense risk	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5
Revision risk	-	-	-	-	-	-	-	-	-	-	-
Life catastrophe risk	1.7	1.6	1.5	1.4	1.2	1.2	1.1	1.0	0.9	0.8	0.8
diversification effect	*- 5.4*	*- 5.0*	*- 4.7*	*- 4.3*	*- 3.9*	*- 3.6*	*- 3.4*	*- 3.1*	*- 2.8*	*- 2.6*	*- 2.4*
SCR Life (Net LAC T)	**16.1**	**14.8**	**13.8**	**12.6**	**11.5**	**10.8**	**10.0**	**9.1**	**8.3**	**7.7**	**7.1**
BEL Run-off ratio	*100%*	*92%*	*86%*	*78%*	*72%*	*67%*	*62%*	*56%*	*52%*	*48%*	*44%*
SCR life Run-off ratio	*100%*	*92%*	*86%*	*78%*	*72%*	*67%*	*62%*	*56%*	*52%*	*48%*	*44%*

Table 5: SCR Life Projection under Model 1

After including the Operational risk, also being projected with same ratio, the following SCR^{RM} projection and the Risk Margin is obtained:

(EUR millions)

SCR Risk Margin | Method 1	0	1	2	3	4	5	6	7	8	9	10
BSCR (net LAC TP)	**16.1**	**14.8**	**13.8**	**12.6**	**11.5**	**10.8**	**10.0**	**9.1**	**8.3**	**7.7**	**7.1**
Market Risk	-	-	-	-	-	-	-	-	-	-	-
Counterparty Risk	-	-	-	-	-	-	-	-	-	-	-
Life Underwrting Risk	16.1	14.8	13.8	12.6	11.5	10.8	10.0	9.1	8.3	7.7	7.1
SCR Operational	**1.2**	**1.1**	**1.1**	**1.0**	**0.9**	**0.8**	**0.8**	**0.7**	**0.6**	**0.6**	**0.5**
SCR Risk Margin	**17.3**	**15.9**	**14.9**	**13.6**	**12.4**	**11.6**	**10.8**	**9.8**	**8.9**	**8.3**	**7.6**
CoC	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5
discounted CoC	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.3
Risk Margin	**8.8**										
BEL run-off ratio	*100%*	*92%*	*86%*	*78%*	*72%*	*67%*	*62%*	*56%*	*52%*	*48%*	*44%*
SCR Risk Margin run-off ratio	*100%*	*92%*	*86%*	*78%*	*72%*	*67%*	*62%*	*56%*	*52%*	*48%*	*44%*

Table 6: Risk Margin results under Model 1

4.2. Examples | Model 2

We will start to present the *run-off* path of the main cash-flows that are used as a driver for each sub-risk of life underwriting, as previously explained for this model.

Table 7 sets for each life sub-risk which cash-flows are used as a driver and presents the cash-flows for the next ten years.

(EUR millions)

Risk	Driver	Cash-Flows										
		0	1	2	3	4	5	6	7	8	9	10
Mortality	Deaths		9.6	9.3	9.0	8.6	8.4	8.3	8.0	7.5	7.2	6.9
Longevity	all Benefits		60.0	49.1	55.2	48.4	38.4	36.7	41.3	35.4	30.5	28.5
Disability	Illness		0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Lapse	Surrenders		28.5	26.6	24.5	22.3	20.1	18.3	16.8	15.2	14.1	13.0
Expense	Exp. + Comm.		4.0	3.7	3.4	3.2	3.0	2.8	2.6	2.4	2.3	2.1
Catastrophe	Deaths		9.6	9.3	9.0	8.6	8.4	8.3	8.0	7.5	7.2	6.9

Table 7: The cash-flow drivers by risk under Model 2

Table 8 presents the PV of cash-flows at each future projection year, as well the *run-off* ratio to be considered.

(EUR millions)

Risk	Driver	Present Value of Cash-Flows										
		0	1	2	3	4	5	6	7	8	9	10
Mortality	Deaths	111	105	99	94	88	82	76	71	65	60	55
Longevity	all Benefits	548	505	473	433	397	371	346	315	289	267	247
Disability	Illness	5	5	4	4	4	3	3	3	3	2	2
Lapse	Surrenders	236	215	195	177	160	144	131	118	106	95	85
Expense	Exp. + Comm.	37	35	32	29	27	25	23	21	19	18	16
Catastrophe	Deaths	111	105	99	94	88	82	76	71	65	60	55

Risk	Driver	Run-Off Ratio										
		0	1	2	3	4	5	6	7	8	9	10
Mortality	Deaths	100%	95%	89%	84%	79%	74%	69%	63%	59%	54%	49%
Longevity	all Benefits	100%	92%	86%	79%	73%	68%	63%	57%	53%	49%	45%
Disability	Illness	100%	93%	87%	81%	76%	70%	65%	60%	55%	50%	45%
Lapse	Surrenders	100%	91%	83%	75%	68%	61%	55%	50%	45%	40%	36%
Expense	Exp. + Comm.	100%	92%	86%	79%	73%	67%	62%	56%	52%	47%	43%
Catastrophe	Deaths	100%	95%	89%	84%	79%	74%	69%	63%	59%	54%	49%
BEL run-off ratio		*100%*	*92%*	*86%*	*78%*	*72%*	*67%*	*62%*	*56%*	*52%*	*48%*	*44%*

Table 8: Driver's PV *run-off* for each risk under Model 2

At the end of previous table is also shown the BEL *run-off*, where it is showed that each sub-risk *run-off* are quite similar but not the same as BEL *run-off*, which leads to a different risk margin.

The next step is to project SCR Life according with these previous ratios.

(EUR millions)

Portfolio | SCR Life (net LAC TP)	0	1	2	3	4	5	6	7	8	9	10
Mortality risk	2.3	2.2	2.1	2.0	1.8	1.7	1.6	1.5	1.4	1.3	1.2
Longevity risk	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3
Disability-morbidity risk	1.3	1.2	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6
Lapse risk	14.3	13.1	11.9	10.7	9.7	8.8	7.9	7.1	6.4	5.8	5.2
Life expense risk	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.5
Revision risk	-	-	-	-	-	-	-	-	-	-	-
Life catastrophe risk	1.7	1.6	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.9
diversification effect	*- 5.4*	*- 5.1*	*- 4.8*	*- 4.4*	*- 4.1*	*- 3.8*	*- 3.5*	*- 3.3*	*- 3.0*	*- 2.7*	*- 2.5*
SCR Life (Net LAC T)	**16.1**	**14.7**	**13.4**	**12.2**	**11.1**	**10.1**	**9.1**	**8.3**	**7.5**	**6.8**	**6.1**
BEL Run-off ratio	100%	92%	86%	78%	72%	67%	62%	56%	52%	48%	44%
SCR life Run-off ratio	100%	91%	84%	76%	69%	63%	57%	51%	47%	42%	38%

Table 9: SCR Life Projection under Model 2

Operational risk is also projected using the standard formula, as explained before, which is summarized in Table 10.

(EUR millions)

SCR Operational Projection	0	1	2	3	4	5	6	7	8	9	10
SCROp_TPs	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2
Non UL TPs	133.8	120.5	111.2	101.1	92.0	84.7	77.3	69.4	63.1	58.4	53.5
SCROp_Prm	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Non UL prm (last 12m)	5.9	5.9	5.6	5.3	5.0	4.8	4.6	4.4	4.2	4.1	3.9
Non UL prm (last 12m) prior 12months	5.9	5.9	5.9	5.6	5.3	5.0	4.8	4.6	4.4	4.2	4.1
UL expenses	2.5	2.3	2.2	2.0	1.8	1.7	1.6	1.5	1.3	1.2	1.1
SCR Operational	**1.23**	**1.12**	**1.04**	**0.95**	**0.87**	**0.81**	**0.75**	**0.67**	**0.62**	**0.57**	**0.53**

Table 10: SCR Operational Projection under Model 2 and 3.

Finally, Table 11 presents the SCR^{RM} projection and the Risk Margin.

(EUR millions)

SCR Risk Margin | Method 2	0	1	2	3	4	5	6	7	8	9	10
BSCR (net LAC TP)	**16.1**	**14.7**	**13.4**	**12.2**	**11.1**	**10.1**	**9.1**	**8.3**	**7.5**	**6.8**	**6.1**
Market Risk	-	-	-	-	-	-	-	-	-	-	-
Counterparty Risk	-	-	-	-	-	-	-	-	-	-	-
Life Underwrting Risk	16.1	14.7	13.4	12.2	11.1	10.1	9.1	8.3	7.5	6.8	6.1
SCR Operational	**1.2**	**1.1**	**1.0**	**1.0**	**0.9**	**0.8**	**0.7**	**0.7**	**0.6**	**0.6**	**0.5**
SCR Risk Margin	**17.3**	**15.8**	**14.5**	**13.2**	**12.0**	**10.9**	**9.9**	**9.0**	**8.1**	**7.3**	**6.6**
CoC	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4
discounted CoC	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3
Risk Margin	**8.0**										

Table 11: Risk Margin results under Model 2

It is worth highlighting that under this model the risk margin decreased 0.8M€, which represents 9% of previous risk margin.

4.3. Examples | Model 3

Model 3 is calculated at product level, considering some drivers specificities as the surrender ratio, that could be given by surrenders cash-flows or by premiums cash-flows, if the product doesn't have any cash-out flow when the product is lapsed.

It was done the same as for model 2, but at product level, with the following results for SCR Life.

(EUR millions)

Portfolio | SCR Life (net LAC TP)	0	1	2	3	4	5	6	7	8	9	10
Mortality risk	2.3	2.2	2.1	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2
Longevity risk	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3
Disability-morbidity risk	1.3	1.2	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6
Lapse risk	14.3	13.4	12.6	11.7	11.0	10.2	9.5	8.9	8.2	7.6	7.0
Life expense risk	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5
Revision risk	-	-	-	-	-	-	-	-	-	-	-
Life catastrophe risk	1.7	1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.0	1.0	0.9
diversification effect	*- 5.4*	*- 5.1*	*- 4.8*	*- 4.5*	*- 4.2*	*- 3.9*	*- 3.6*	*- 3.4*	*- 3.1*	*- 2.9*	*- 2.6*
SCR Life (Net LAC T)	**16.1**	**15.1**	**14.1**	**13.2**	**12.3**	**11.5**	**10.7**	**9.9**	**9.2**	**8.5**	**7.8**
BEL Run-off ratio	100%	92%	86%	78%	72%	67%	62%	56%	52%	48%	44%
SCR life Run-off ratio	100%	94%	88%	82%	76%	71%	66%	62%	57%	53%	49%

Table 12: SCR Life Projection under Model 3

Finally, Table 13 presents the SCR^{RM} projection and the Risk Margin.

(EUR millions)

SCR Risk Margin | Method 3	0	1	2	3	4	5	6	7	8	9	10
BSCR (net LAC TP)	**16.1**	**15.1**	**14.1**	**13.2**	**12.3**	**11.5**	**10.7**	**9.9**	**9.2**	**8.5**	**7.8**
Market Risk	-	-	-	-	-	-	-	-	-	-	-
Counterparty Risk	-	-	-	-	-	-	-	-	-	-	-
Life Underwrting Risk	16.1	15.1	14.1	13.2	12.3	11.5	10.7	9.9	9.2	8.5	7.8
SCR Operational	**1.2**	**1.1**	**1.0**	**1.0**	**0.9**	**0.8**	**0.7**	**0.7**	**0.6**	**0.6**	**0.5**
SCR Risk Margin	**17.3**	**16.2**	**15.2**	**14.1**	**13.2**	**12.3**	**11.4**	**10.6**	**9.8**	**9.1**	**8.4**
CoC	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5
discounted CoC	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.4	0.4	0.4
Risk Margin	**9.3**										
BEL run-off ratio	*100%*	*92%*	*86%*	*78%*	*72%*	*67%*	*62%*	*56%*	*52%*	*48%*	*44%*
SCR Risk Margin run-off ratio	*100%*	*93%*	*88%*	*82%*	*76%*	*71%*	*66%*	*61%*	*57%*	*52%*	*48%*

Table 13: Risk Margin results under Model 3

Under this model the risk margin increased 0.5M€ (+6%) from Model 1, and 1.3M€ (+17%) from Model 2.

4.4. Examples | Conclusion

In fact, the speed at which the projection is made until the SCR is cancelled varies, greatly, depending on the model chosen.

In the examples considered in this document, and as the graph below illustrates, model 2 is the one whose SCR decreases fastest, followed by model 1, while model 3 is the one with the slowest decreasing SCR.

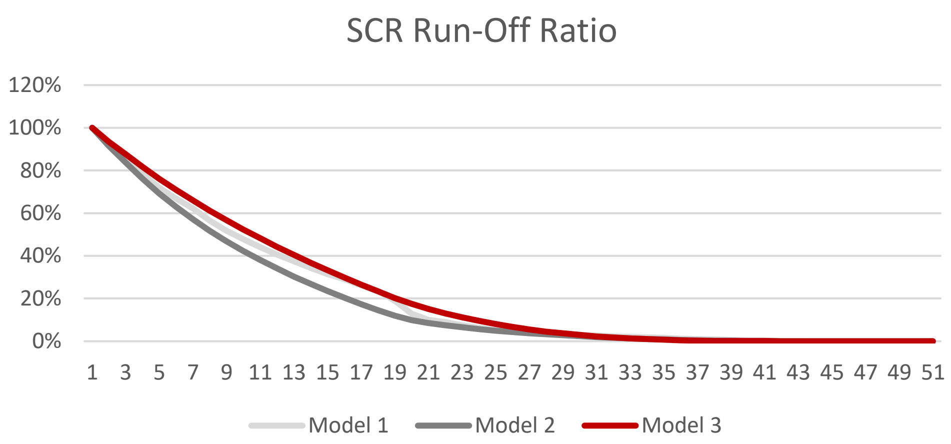

Figure 4: SCR *run-off* by three proposed model

Changing the speed at which the SCR decreases has an immediate effect on the value of the risk margin, which can change significantly.

Figure 5 shows the amounts of the risk margin for each of the models tested. Once again, model 2 has the lowest risk margin, followed by model 1 and finally model 3 that has the highest risk margin.

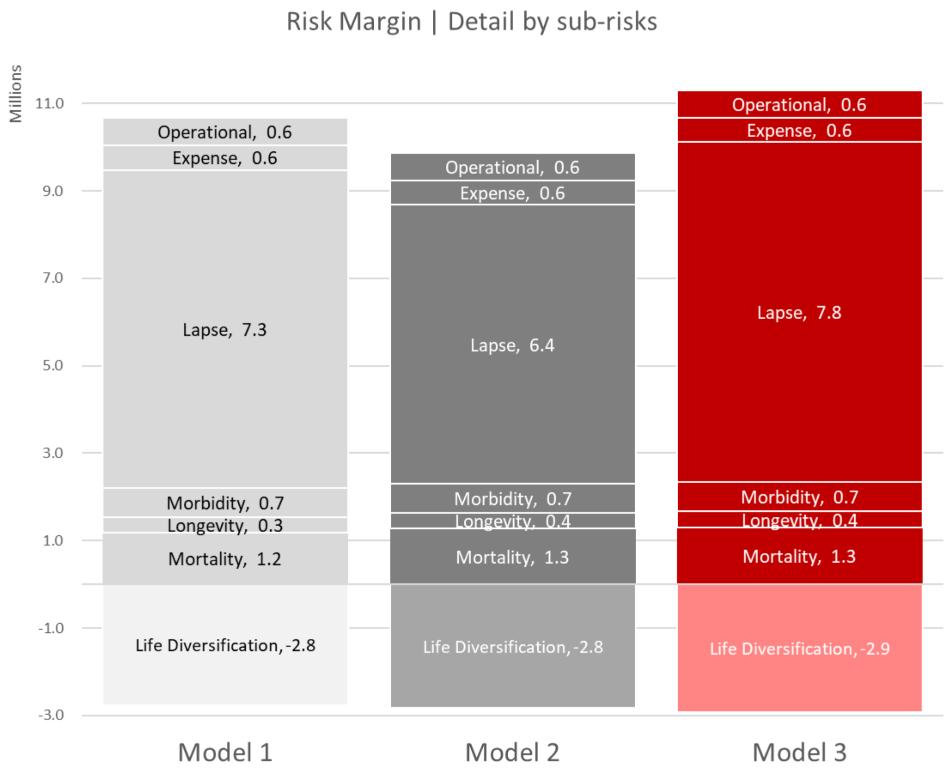

Figure 5: Risk Margin detail by the three proposed models

In this example the lapse risk, is the one that differs most between models, which at first look makes sense, since this is indeed the highest risk on this portfolio (over 80% of total SCR), however, looking for relative changes between models, the lapse risk is also the risk with more variability as Table 14 shows.

	Model 1	Model 2	Δ	Model 2	Model 3	Δ
Mortality risk	1.2	1.3	7%	1.3	1.3	2%
Longevity risk	0.3	0.4	1%	0.4	0.4	5%
Disability-morbidity risk	0.7	0.7	0%	0.7	0.7	0%
Lapse risk	7.3	6.4	-12%	6.4	7.8	22%
Life expense risk	0.6	0.6	-2%	0.6	0.6	-1%
Life catastrophe risk	0.9	1.0	7%	1.0	1.0	2%
Life diversification	- 2.8	- 2.8	2%	- 2.8	- 2.9	4%

Table 14: Risk margin between 3 models split by risk (all portfolio)

Analysing lapse risk in even more detail, Table 15 shows the contribution for risk margin by each product and model.

Lapse Risk	Model 1	Model 2	Model 3
P1 | Financial | Guaranteed	-	-	-
P2 | Financial | Unit-Linked	1.8	1.6	1.6
P3 | Term Assurance	5.5	4.8	6.2
P4 | Whole Life Annuity	-	-	-
Total	7.3	6.4	7.8

Table 15: Lapse Risk contribution for risk margin by product.

Just P2 and P3 products have lapse risk as it was initial shown on Table 1. Comparing model 2 to model 3, the only product that changes is P3, the term assurance product. Recall that for this product the driver considered in model 3 is the PV of premiums since there is no cash-out flow, while in model 2 the *run-off* ratio considered was the ratio resulting from PV of Surrenders for all portfolio (no matter if the product has lapse risk).

For P3 the BEL is negative, and that is why there is a lapse risk (since the company will lose future profits in case of increasing lapses. Table 16 shows the ratios used for both products in both models, and for P3, it can be observed that the *run-off* of Premiums are very aligned with the BEL *run-off*, which is very different from the PV of Surrenders, as used in model 2.

Model 2	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
PV Surrenders	100%	91%	83%	75%	68%	61%	55%	50%	45%	40%	36%
Model 3	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
P3 | Term Assurance											
PV BEL	100%	95%	90%	86%	81%	77%	73%	68%	64%	60%	56%
PV Premiums	100%	94%	89%	84%	79%	75%	70%	66%	61%	57%	53%
PV Total Claims	100%	94%	88%	83%	78%	73%	68%	63%	58%	54%	49%
PV Exp and Comm	100%	94%	89%	83%	78%	73%	68%	64%	60%	55%	51%
P2 | Finantial | Unit-Linked											
PV Surrenders	100%	91%	83%	75%	68%	61%	55%	50%	45%	41%	36%

Table 16: Ratios considered for lapse risk evolution.

5. Solvency II 2020 Review

In February 2019, the European Commission (EC) issued a formal call for advice to EIOPA on the review of Solvency II directive[16], where EIOPA was invited to provide technical information on several topics, including a dedicated section for risk margin.

EIOPA was challenged to assess the adequacy of the risk margin design, without challenging the approach based on the cost of capital, namely: the design of risk margin as being the transfer value of liabilities; the assumptions related to asset mix of the receiving undertaking, that are assumed to be risk-free; the use of a fixed cost-of-capital rate for all entities, as well the assumptions to derive that rate.

In December 2020[17], EIOPA published its opinion on the Solvency II 2020 review. This follows several consultation papers produced by EIOPA in 2019 and impact assessments carried out during 2020.

In the context of technical provisions, EIOPA has identify a number of issues and proposals related to best estimate liability and risk margin calculations.

"*Revision of the risk margin can be introduced in order to recognize diversification over time thereby reducing size and volatility of the margin, especially for long-term liabilities. But the calibration should remain prudent, indeed a too high decrease of the Risk Margin value would be unjustified and harming policyholder protection*."[18]

A change is proposed to the calculation of the risk margin to take account of the time dependence of risks, thereby reducing the sensitivity of the margin to interest rate variations. This change will reduce the amount of the risk margin, especially for long-term liabilities.

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[16] (Commission, "Request to EIOPA for technical advice on the review of the solvency II directive", 2019)
[17] (EIOPA, "Opinion on the 2020 review of Solvency II", 2020)
[18] (EIOPA, "Solvency II Review", 2022)

To implement such an adjustment, EIOPA proposes to change the risk margin calculation formula to introduce a floored, exponential and time dependent element λ such that:

$$RM = CoC \times \sum_{t \geq 0} \frac{SCR_t^{RM} \times max(\lambda^t, floor)}{\left(1 + r(0, t+1)\right)^{t+1}} \tag{38}$$

Where, $\lambda = 0.975$ and $floor = 50\%$, which means that after 30 years the SCR considered will be 50% of previous SCR (the floor is reached).

In 2021, European Commission[19] communicated that will take into consideration the time dependent parameter *lambda* as suggested by EIOPA, but without the floor, to allow for more effective mitigation of volatility. It will also consider reducing the cost-of-capital rate used in the risk margin calculation from 6% to 5%, in line with the reduction in capital cost for insurance and reinsurance companies over the past years.

[19] (Commission, "Communication from the Commission to the European Parliament and Council", 2021)

5.1. Examples | Impact

Applying the formula (38) on the portfolio shown in this paper, the SCR *run-off* ratio decreases faster, leading to a decrease in risk margin.

Figure 6 shows, for each model, the SCR *run-off* ratio after applying the adjustment provided on revision, including the floor of 50%.

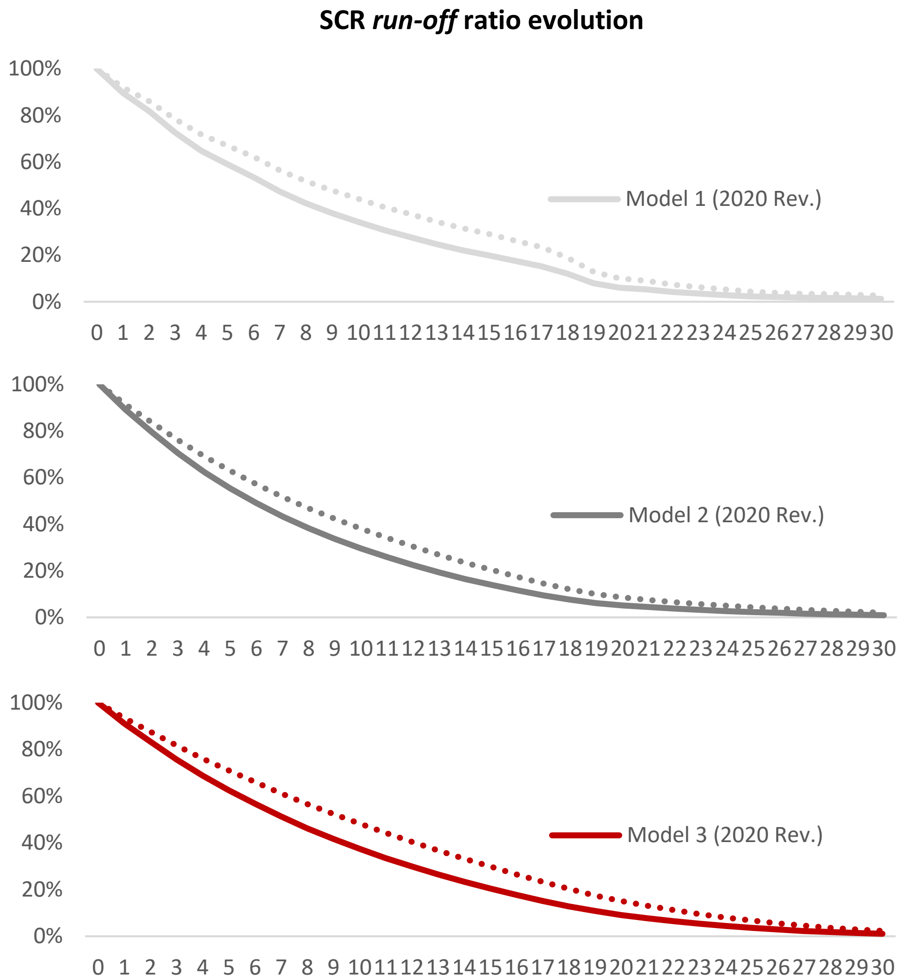

Figure 6: SCR *run-off* ratio after SII 2020 Review for 3 models

In terms of risk margin amount it decreases roughly 15% after including the lambda parameter and 16% due to change on CoC rate. This decreased is verified in all models, as shown in Figure 7 and Figure 8.

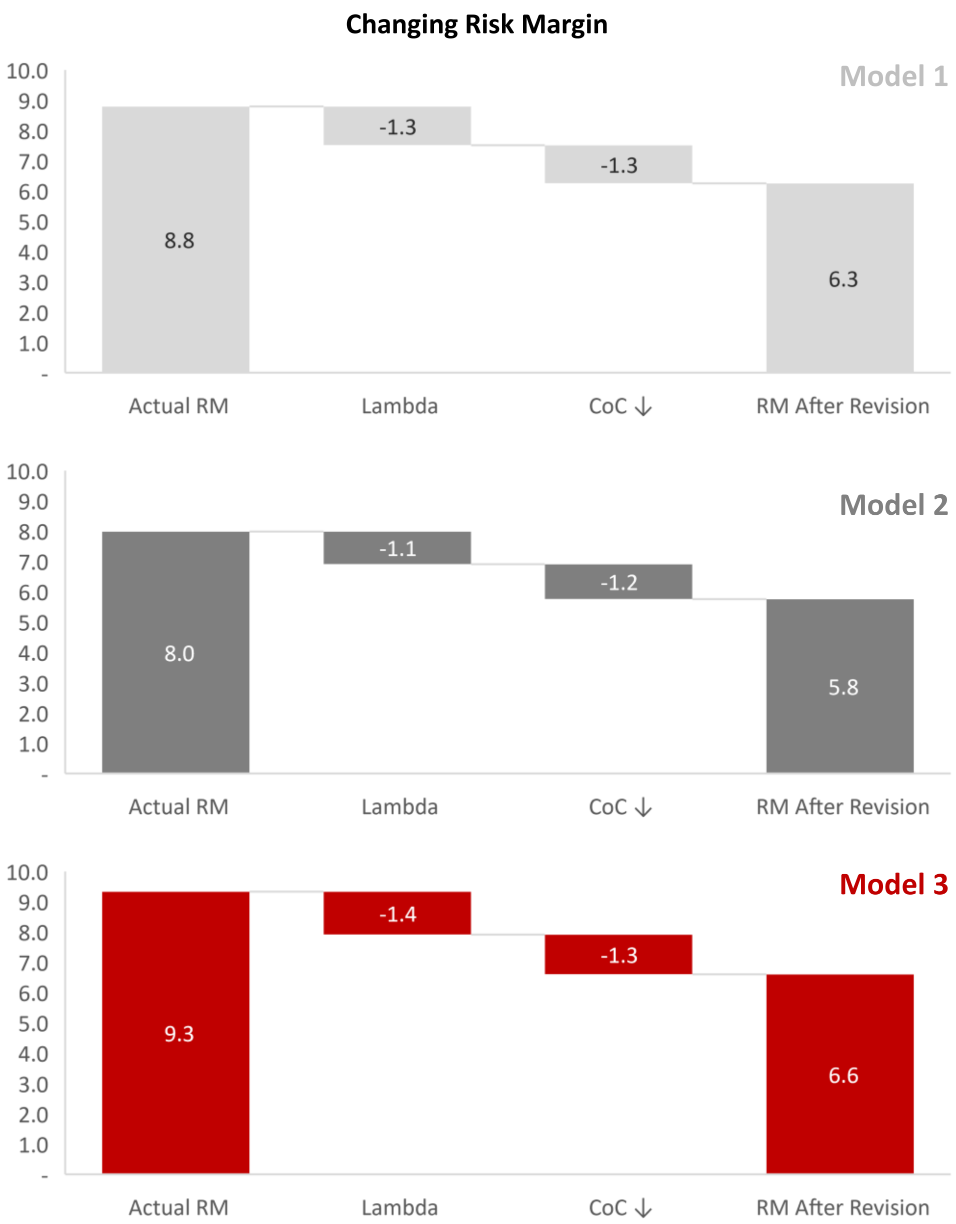

Figure 7: Risk margin after SII Review break down (by Model)

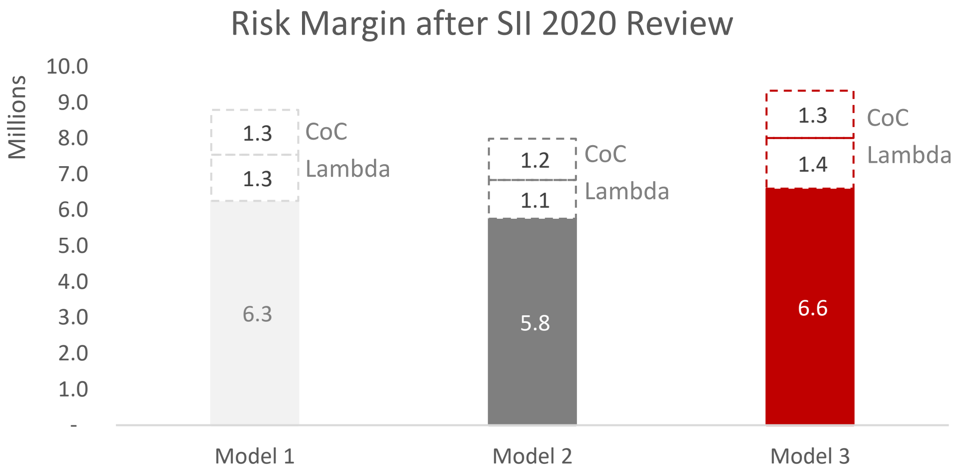

Figure 8: Risk margin before and after SII Review

6. Conclusions

The risk margin is part of the value of insurance liabilities that seeks to ensure that their valuation is in line with what another entity would require to accept those liabilities, in a rational transaction under normal market conditions. Its calculation implies projecting a specific SCR until full *run-off* of liabilities, which could be done using simplifications.

The way that its *run-off* is made could lead to a very different risk margin amount. In this paper it is presented 3 models, being the last one the most complete that aims to project each sub-risk according with the most "suitable" driver (for each product) and then calculates the SCR in each year.

Being calculated at a product level, it could be easily aggregated by LoB (mandatory), instead of having to recalculate all risk margin for each portfolio, as it would happen for other models.

For the portfolio tested in this paper, this method leads to the highest risk margin, but it cannot be concluded that this will always happen, since it would depend on product features and portfolio.

Although the formula is expected to be changed so that the SCR decreases more quickly, with a lambda factor, which reduces the cost associated with long-term liabilities, it will still be necessary to calculate the *run-off* SCR.

As future work, I would suggest developing a program in R that would simply read the CFs by year and product type, and the EIOPA curve. Defining procedures to calculate all the steps to get the total risk margin, as well, the split, at least by LoB, without forgetting that when separating by LoB, the diversification effect must be included, so that the sum of all LoB's totalizes the value of the Risk Margin.

7. Appendix

Correlation Matrix (from delegated acts)

BSCR	Market	Default	Life	Health	Non-Life
Market	100%	25%	25%	25%	25%
Default	25%	100%	25%	25%	50%
Life	25%	25%	100%	25%	0%
Health	25%	25%	25%	100%	0%
Non-Life	25%	50%	0%	0%	100%

SCR Life	Mortality	Longevity	Disability	Lapses	Expenses	Revisão	CAT
Mortality	100%	-25%	25%	0%	25%	0%	25%
Longevity	-25%	100%	0%	25%	25%	25%	0%
Disability	25%	0%	100%	0%	50%	0%	25%
Lapses	0%	25%	0%	100%	50%	0%	25%
Expenses	25%	25%	50%	50%	100%	50%	25%
Revisão	0%	25%	0%	0%	50%	100%	0%
CAT	25%	0%	25%	25%	25%	0%	100%

SCR Market	Interest	Equity	Property	Spread	Currency	Conc.
Interest	100%	0%	0%	0%	25%	0%
Equity	0% or 50%	100%	75%	75%	25%	0%
Property	0%	75%	100%	50%	25%	0%
Spread	0%	75%	50%	100%	25%	0%
Currency	25%	25%	25%	25%	100%	0%
Concentration	0%	0%	0%	0%	0%	100%

Table 17: Correlation matrices for SCR calculations

Interest Rate Term Structure

t	R(0 ; t)	R(1 ; t+1)	R(2 ; t+2)	R(3 ; t+3)	R(4 ; t+4)	R(5 ; t+5)	R(6 ; t+6)	R(7 ; t+7)	R(8 ; t+8)	R(9 ; t+9)	R(10 ; t+10)
1	3.37%	3.60%	3.21%	3.19%	3.24%	3.20%	3.17%	3.24%	3.29%	3.32%	3.37%
2	3.49%	3.41%	3.20%	3.21%	3.22%	3.18%	3.20%	3.27%	3.31%	3.34%	3.24%
3	3.39%	3.33%	3.21%	3.21%	3.20%	3.20%	3.23%	3.28%	3.33%	3.27%	3.19%
4	3.34%	3.31%	3.21%	3.20%	3.21%	3.22%	3.26%	3.31%	3.27%	3.22%	3.15%
5	3.32%	3.29%	3.20%	3.21%	3.23%	3.24%	3.28%	3.27%	3.24%	3.18%	3.07%
6	3.30%	3.27%	3.21%	3.22%	3.24%	3.26%	3.25%	3.24%	3.20%	3.11%	2.97%
7	3.28%	3.26%	3.22%	3.23%	3.26%	3.24%	3.23%	3.21%	3.14%	3.02%	2.86%
8	3.28%	3.27%	3.23%	3.25%	3.24%	3.22%	3.20%	3.15%	3.05%	2.91%	2.76%
9	3.28%	3.27%	3.25%	3.24%	3.23%	3.20%	3.15%	3.07%	2.96%	2.82%	2.68%
10	3.28%	3.28%	3.23%	3.22%	3.20%	3.16%	3.08%	2.98%	2.87%	2.74%	2.63%
11	3.29%	3.27%	3.22%	3.20%	3.16%	3.09%	3.00%	2.90%	2.79%	2.69%	2.60%
12	3.27%	3.25%	3.20%	3.17%	3.10%	3.02%	2.92%	2.83%	2.74%	2.66%	2.58%
13	3.26%	3.23%	3.17%	3.11%	3.03%	2.94%	2.86%	2.78%	2.71%	2.64%	2.58%
14	3.24%	3.20%	3.12%	3.04%	2.97%	2.88%	2.81%	2.74%	2.69%	2.63%	2.59%
15	3.21%	3.15%	3.06%	2.98%	2.91%	2.83%	2.77%	2.72%	2.68%	2.64%	2.60%
16	3.16%	3.09%	2.99%	2.92%	2.86%	2.80%	2.75%	2.71%	2.68%	2.64%	2.61%
17	3.11%	3.03%	2.94%	2.88%	2.82%	2.78%	2.74%	2.71%	2.68%	2.66%	2.63%
18	3.05%	2.98%	2.90%	2.84%	2.80%	2.77%	2.74%	2.71%	2.69%	2.67%	2.65%
19	3.00%	2.93%	2.86%	2.82%	2.79%	2.76%	2.74%	2.72%	2.70%	2.68%	2.67%
20	2.95%	2.90%	2.84%	2.81%	2.78%	2.76%	2.74%	2.73%	2.72%	2.70%	2.69%
21	2.92%	2.88%	2.83%	2.80%	2.78%	2.76%	2.75%	2.74%	2.73%	2.72%	2.71%
22	2.90%	2.86%	2.82%	2.80%	2.79%	2.77%	2.76%	2.75%	2.75%	2.74%	2.73%
23	2.89%	2.86%	2.82%	2.80%	2.79%	2.78%	2.77%	2.77%	2.76%	2.76%	2.75%
24	2.88%	2.85%	2.82%	2.81%	2.80%	2.79%	2.78%	2.78%	2.78%	2.77%	2.77%
25	2.87%	2.85%	2.82%	2.81%	2.81%	2.80%	2.80%	2.80%	2.79%	2.79%	2.79%

Table 18: Spot rates and forward rates from SWAP_VA at 31/12/2022.

t	R(0 ; t)	R(1 ; t+1)	R(2 ; t+2)	R(3 ; t+3)	R(4 ; t+4)	R(5 ; t+5)	R(6 ; t+6)	R(7 ; t+7)	R(8 ; t+8)	R(9 ; t+9)	R(10 ; t+10)
1	3.18%	3.41%	3.02%	3.00%	3.05%	3.01%	2.98%	3.05%	3.10%	3.13%	3.18%
2	3.30%	3.22%	3.01%	3.02%	3.03%	2.99%	3.01%	3.08%	3.12%	3.15%	3.05%
3	3.20%	3.14%	3.02%	3.02%	3.01%	3.01%	3.04%	3.09%	3.14%	3.08%	3.00%
4	3.15%	3.12%	3.02%	3.01%	3.02%	3.03%	3.07%	3.12%	3.08%	3.03%	2.96%
5	3.13%	3.10%	3.01%	3.02%	3.04%	3.05%	3.09%	3.08%	3.05%	2.99%	2.88%
6	3.11%	3.08%	3.02%	3.03%	3.05%	3.07%	3.06%	3.05%	3.01%	2.92%	2.78%
7	3.09%	3.07%	3.03%	3.04%	3.07%	3.05%	3.04%	3.02%	2.95%	2.83%	2.67%
8	3.09%	3.08%	3.04%	3.06%	3.05%	3.03%	3.01%	2.96%	2.86%	2.72%	2.57%
9	3.09%	3.08%	3.06%	3.05%	3.04%	3.01%	2.96%	2.88%	2.77%	2.63%	2.49%
10	3.09%	3.09%	3.04%	3.03%	3.01%	2.97%	2.89%	2.79%	2.68%	2.55%	2.44%
11	3.10%	3.08%	3.03%	3.01%	2.97%	2.90%	2.81%	2.71%	2.60%	2.50%	2.41%
12	3.09%	3.06%	3.01%	2.98%	2.91%	2.83%	2.73%	2.64%	2.55%	2.47%	2.40%
13	3.07%	3.04%	2.98%	2.92%	2.84%	2.75%	2.67%	2.59%	2.52%	2.46%	2.40%
14	3.05%	3.01%	2.93%	2.85%	2.78%	2.69%	2.62%	2.56%	2.50%	2.46%	2.42%
15	3.02%	2.96%	2.87%	2.79%	2.72%	2.64%	2.59%	2.54%	2.50%	2.46%	2.43%
16	2.97%	2.90%	2.80%	2.73%	2.67%	2.61%	2.57%	2.53%	2.50%	2.47%	2.45%
17	2.92%	2.84%	2.75%	2.69%	2.64%	2.59%	2.56%	2.54%	2.51%	2.49%	2.47%
18	2.86%	2.79%	2.71%	2.66%	2.62%	2.58%	2.56%	2.54%	2.53%	2.51%	2.50%
19	2.81%	2.74%	2.68%	2.64%	2.61%	2.58%	2.56%	2.55%	2.54%	2.53%	2.52%
20	2.77%	2.71%	2.66%	2.63%	2.61%	2.59%	2.57%	2.57%	2.56%	2.55%	2.55%
21	2.74%	2.69%	2.65%	2.62%	2.61%	2.60%	2.59%	2.58%	2.58%	2.58%	2.58%
22	2.72%	2.68%	2.64%	2.63%	2.62%	2.61%	2.60%	2.60%	2.60%	2.60%	2.60%
23	2.70%	2.68%	2.64%	2.63%	2.63%	2.62%	2.62%	2.62%	2.62%	2.62%	2.62%
24	2.70%	2.68%	2.65%	2.64%	2.64%	2.63%	2.64%	2.64%	2.64%	2.65%	2.65%
25	2.70%	2.68%	2.66%	2.65%	2.65%	2.65%	2.65%	2.66%	2.66%	2.67%	2.67%

Table 19: Spot rates and forward rates from SWAP at 31/12/2022.

Cash Flows Projection (30 years)

(EUR millions)

P1 | Cash-Flows	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Premiums	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-	-	-	-
Benefits	19.8	15.5	15.5	14.0	12.0	11.8	11.9	10.1	8.3	8.3	8.7	6.5	7.5	5.4	4.9	5.6	5.5	5.9	5.8	4.9	3.4	5.9	3.7	3.2	2.9	1.1	0.0	-	-	-
Death	2.4	2.2	2.1	1.9	1.8	1.7	1.5	1.4	1.3	1.2	1.1	1.1	1.0	0.9	0.9	0.9	0.8	0.7	0.7	0.6	0.5	0.4	0.2	0.2	0.1	0.0	0.0	-	-	-
Illness	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Annuity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surrender	3.5	3.2	3.0	2.7	2.5	2.3	2.1	1.9	1.8	1.6	1.5	1.4	1.2	1.1	1.0	1.0	0.9	0.7	0.6	0.5	0.4	0.4	0.2	0.2	0.1	0.0	0.0	-	-	-
Maturity	13.9	10.1	10.4	9.4	7.7	7.8	8.3	6.8	5.2	5.4	6.1	4.0	5.2	3.4	2.9	3.8	3.8	4.4	4.5	3.8	2.5	5.2	3.3	2.9	2.8	1.1	0.0	-	-	-
Exp and Com	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
CF	**19.5**	**15.2**	**15.2**	**13.8**	**11.7**	**11.6**	**11.7**	**9.9**	**8.1**	**8.1**	**8.6**	**6.3**	**7.4**	**5.3**	**4.8**	**5.5**	**5.4**	**5.8**	**5.8**	**4.8**	**3.4**	**5.9**	**3.7**	**3.2**	**2.9**	**1.1**	**0.0**	-	-	-

P2 | Cash-Flows	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Premiums	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benefits	38.0	31.6	37.9	32.5	24.6	23.2	27.8	23.8	20.8	18.8	17.1	16.2	15.3	14.5	12.6	13.2	11.9	20.3	28.4	11.3	3.9	3.7	3.8	2.8	2.8	2.7	2.9	2.1	2.1	2.0
Death	5.9	5.9	5.8	5.6	5.6	5.6	5.5	5.2	5.0	4.8	4.6	4.5	4.3	4.1	3.8	3.6	3.4	2.9	2.1	1.3	1.2	1.1	1.0	1.0	1.0	0.9	0.8	0.8	0.8	0.7
Illness	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Annuity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surrender	25.0	23.4	21.5	19.6	17.6	15.9	14.6	13.3	12.3	11.4	10.5	9.7	9.0	8.3	7.6	6.9	6.2	5.3	3.9	2.6	2.3	2.1	1.9	1.7	1.6	1.4	1.3	1.1	1.0	0.9
Maturity	7.1	2.3	10.5	7.3	1.4	1.7	7.6	5.2	3.5	2.6	1.9	2.0	2.1	2.2	1.2	2.7	2.3	12.0	22.5	7.4	0.5	0.5	0.9	0.1	0.2	0.3	0.8	0.2	0.3	0.4
Exp and Com	2.5	2.3	2.1	2.0	1.8	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.6	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
CF	**40.5**	**33.9**	**40.0**	**34.5**	**26.4**	**25.0**	**29.4**	**25.2**	**22.1**	**20.0**	**18.2**	**17.3**	**16.3**	**15.4**	**13.4**	**14.0**	**12.6**	**20.8**	**28.8**	**11.6**	**4.2**	**3.9**	**4.0**	**3.0**	**2.9**	**2.8**	**3.0**	**2.2**	**2.2**	**2.1**

P3 | Cash-Flows	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Premiums	5.4	5.1	4.8	4.6	4.4	4.2	4.1	3.9	3.8	3.6	3.5	3.3	3.2	3.0	2.8	2.7	2.5	2.3	2.1	2.0	1.8	1.6	1.5	1.3	1.2	1.0	0.9	0.7	0.6	0.5
Benefits	1.7	1.6	1.6	1.5	1.4	1.4	1.3	1.2	1.2	1.1	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Death	1.3	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1
Illness	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Annuity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surrender	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maturity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exp and Com	1.3	1.3	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1
CF	**- 2.3**	**- 2.2**	**- 2.1**	**- 2.0**	**- 1.9**	**- 1.9**	**- 1.8**	**- 1.8**	**- 1.7**	**- 1.7**	**- 1.6**	**- 1.5**	**- 1.5**	**- 1.4**	**- 1.3**	**- 1.3**	**- 1.2**	**- 1.1**	**- 1.1**	**- 1.0**	**-0.9**	**-0.8**	**-0.8**	**-0.7**	**-0.6**	**-0.5**	**-0.5**	**-0.4**	**-0.3**	**-0.3**

P4 | Cash-Flows	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Premiums	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benefits	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Death	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Illness	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Annuity	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Surrender	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maturity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exp and Com	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CF	**0.4**	**0.4**	**0.4**	**0.4**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**

Table 20: Cash-Flows complete projection (30 years).

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