The Impact of Dynamic Surrender on Guarantees and Options in Life Insurance

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Abstract **– Early termination of an insurance contract (surrender) and sharing of the investment return are the two basic option features of traditional insurance products, such as term insurance and endowment insurance. Managing the process of insurance policies surrenders leads us to research the dynamic of surrender. All the examples use the methods for calculating the technical provisions and the profit set out in Solvency II and the international financial reporting standard IFRS 17, valid since 2023. The paper also presents examples of the valuation of surrender value options in the case of dynamic policyholder behaviour. The Monte Carlo approach through the use of stochastic models places a value on investment sharing and surrenders value options. Using a dynamic policyholder surrender behaviour technique leads to a more significant impact on the profit.**

Keywords **– Dynamic surrender, Solvency II, IFRS 17, financial options and guarantees.**

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1. Introduction

Options give the policyholder, but not the insurance company, the right to change one or more of the predefined parameters of the insurance contract, for example, the right to extend the contract term or increase the sum insured. Amongst the typical options are the options to receive a share of future investment returns, the option to cancel the contract before the end of the agreed term (henceforward "surrender option") either with payment of a surrender value or without, or the option to have the insured sum paid as an annuity. Guarantees can be divided into two types depending on whether they arise from an option or whether they do not. The financial effect of options and guarantees cannot be determined simply as their pricing leads to a nonlinear relationship between the premium, the reserves and the profit. This hypothesis will be demonstrated later. The introduction of the Solvency II valuation and regulation regime has led to a change in the evaluation of the financial condition of an insurance company in terms of its available financial resources, i.e., a balance sheet view of available financial resources at a particular moment in time. Among the most significant changes brought in by the Solvency II valuation regime are the methods for evaluating the technical provisions based on the market value principles. To calculate the technical provisions, all relevant, up-to-date information regarding the insurance company's portfolio and current best estimates of the parameters, such as interest rate, mortality, morbidity, are requested. Options and guarantees are to be valued in accordance with the same principles, i.e. using market parameters and probability-weighted possible outcomes [13].

The accounting standard IFRS 17 – Insurance contracts, issued by the IASB - International Accounting Standards Board, brought with it a change of approach, namely to recognise the market value of an insurance company's profit at the time it arises with the aim of providing a solution to the current valuation imbalance.

The technical provisions will be determined in accordance with new principles and rules arising from a market value approach to evaluating the technical provisions and a substantially different approach to technical insurance profit recognition and reporting. IFRS 17 is the first real international, exhaustive and complex accounting standard to cover the insurance contract valuation. This standard is valid from 1 January 2023 for all insurance companies that report in accordance with international accounting standards. IFRS 17 introduces a market-consistent valuation of the technical provisions but with several different approaches compared to Solvency II. These relate to using discount rates, segmenting the portfolio into homogeneous groups according to risk and applying contract boundaries. One must, however, realise that the true profit from selling insurance products is objectively independent of the accounting standard used for their presentation.

1.1. Literature Review

Traditional life insurance products usually contain the option of guaranteed surrender values if a contract is terminated early, and these values do not consider current market interest rates or the current market value of the technical life reserves. Therefore, it is not straightforward to mathematically define the value of such options, particularly in the case of regular premium-paid contracts. In the case of single premium paid contracts exists a method, which is unsuitable for regular premium contracts and uses a closed form for surrender option valuation [7].

In accordance with past standard IFRS 4, technical provisions consist of the time value of guarantees and options, the best estimate of the liabilities, and several margin levels. The IFRS 17 has abandoned the term "technical provisions" and instead used the term "future cash flows". The IFRS 17 is an interim standard that sets some minimum requirements on the accounting policies in different jurisdictions, but apart from this, it allows considerable variation in financial reporting practices [4]. The main objective of IFRS 17 is to make accounting practices more consistent over different jurisdictions and make the financial statements of insurance companies more informative and comparable for analysts.

The IFRS 17 defines several new terms related to the valuation of life insurance contracts, in particular, the Contractual Service Margin (hereafter CSM) and the Risk Adjustment (hereafter RA). The CSM is a component that reflects the unearned profit of a group of contracts. A very detailed description of the CSM is presented by Yousuf et al. [1].

The explanation of risk margin in accordance with Solvency II in the context of risk adjustment according to IFRS 17 is written in [5]. Sotona [10] deals with the analysis of mortality risk and the calculation of the RA by the requirements of IFRS 17 using the example of term insurance. He states the calculation of the RA at a 90% confidence level. The risk adjustment is necessary to represent correctly the uncertain nature of the insurance liabilities [2].

According to the International Actuarial Association's (hereafter IAA) the objective of the risk margin can be viewed from different perspectives. It can be either the reward for bearing the risk, measured in terms of the inherent uncertainty in the estimation of insurance liabilities and the future financial returns from the contract, or in a solvency adequacy context as the amount to cover adverse deviations that can be expected under normal circumstances, next to the solvency capital covering adverse deviations in more unusual circumstance [8].

2. Methodology

The actuarial assumptions are defined as the best estimate values needed to determine the cash flows and the probability that they arise. These assumptions shall be based on current market information and determined by the best estimate method with respect to each parameter:

- rate of mortality,
- rate of morbidity,
- risk-free interest rate structure,
- probability of surrender (early termination),
- estimated expenses (acquisition, maintenance, claim and investment expenses),
- estimated rate of inflation,
- investment return from the current asset portfolio for with-profit contracts,
- and others [3], [12], [6].

2.1. Solvency II Directive

The primary method to be used for the calculation of the market value of the technical provisions under Solvency II is the discounted cash-flow method, and for financial options and guarantees, a stochastic approach using a probability-weighted average of risk-neutral interest rates is to be used. The choice of method for calculating the best estimate of the technical provisions of insurance contracts should be appropriate to the nature, extent, and complexity of the risk the insurance company takes. The possible methods include simulation, deterministic, and analytic methods.

The most suitable method in the case of contracts participating in the insurance company profit and those containing financial options and guarantees may be a stochastic simulation. The same cash flows are used here as they were defined for testing the reserve adequacy [11]. In the case of an endowment contract, the following equation is formed:

$$Pr_t = income_t\,(P_t + I_t) - outgo_t\,(SA_t + M_t + B_t + SV_t + E_t + V_t - V_{t-1}) \quad (1)$$

$income_t$:
P_t expected premiums in year *t*,
I_t investment income from the reserves and profit shares in year *t*,
$outgo_t$:
SA_t expected payments on death in year *t*,
M_t expected payments on survival in year *t*,
B_t expected profit share paid out only on survival in year *t*,
SV_t expected amounts paid without share in profit on surrender in year *t* as a percentage of V_t,
E_t expected total expenses (e.g. administration, new business) in year *t*,
$(V_t - V_{t-1})$ expected change in reserves in year *t*.

The value of the technical provisions is the sum of their best estimate and the risk margin:

$$TR_t^{SII} = PV\ BE\ CF_t^{SII} + PV\ RM_t^{SII} \quad (2)$$

where TR_t^{SII} is the value of the technical provisions in year t according to Solvency II method,
$PV\ BE\ CF_t^{SII}$ is the best estimate of the technical provisions including the market value of options and guarantees in year t.

$$PV\ BECF_t^{SII} = PV\ CF_t^{det} + PV\ FOG_t \quad (3)$$

where
$PV\ CF_t^{det}$ is the present value of the cash-flows in year *t* as shown deterministically in (1) modified for Solvency II method,
$PV\ FOG_t$ is the present value of financial options and guarantees in year *t* calculated stochastically as the average value of *m* simulated cash-flows using the following equation:

$$PV\ FOG_t = \frac{\sum_{j=1}^{m}(PV\ CF_{j,t})}{m} - PV\ CF_t^{\,det} \quad (4)$$

and
$PV\ RM_t^{SII}$ is the risk margin in year *t*,

$$PV\ RM_t = CoC\ .\ PV\ SCR_t \quad (5)$$

where
CoC - *Cost of Capital* - 6% of the projected value of the *Solvency Capital Requirement* determined by European Union law as the average cost of risk of the invested capital in insurance industry,
$PV\ SCR_t$ is the present value of this projected capital discounted by using a risk-time structure of the free interest rates valued in year *t*.

The insurance company's profit is expressed as the difference in the insurance company's own available resources during the given period ignoring cash-flows relating to the shareholders (dividends or capital injections).

$$Pr_t^{SII} = \Delta TA_t - \Delta TL_t + CF_t \quad (6)$$

where
Pr_t^{SII} is the profit according to Solvency II determined as the change in its own financial resources in year *t*,
ΔTA_t is the change in the market value of the total assets in year *t*,
ΔTL_t is the change in the market value of the total liabilities in year *t*.

The expression of the present value of the profit *PV* Pr_t^{SII} as follows:

$$PV\ Pr^{SII} = \sum_{t=1}^{N} \frac{Pr_t^{SII}}{\prod_{k=1}^{t}(1+i_k)} \quad (7)$$

2.2. General Model Measurement Under IFRS 17

IFRS 17 reflects the view of the IASB that insurance contracts combine elements of financial instruments and service contracts.

For the initial recognition of an insurance contract, i.e. at the moment of sale, the insurance company shall determine the value of the reserve for the group of contracts as the sum of:

- the fulfilment cash-flows made up of the best estimate of the cash flows arising from the contract and risk adjustment and
- the contractual service margin (CSM).

The general measurement model (GMM) is the basic model used in most cases. Similar methods are used to calculate the market value of the technical provisions under Solvency II, in particular, the discounted cash-flow method and the stochastic approach using risk-neutral interest rates to value financial options and guarantees embedded in insurance contracts.

There are, however differences in valuation for the purpose of Solvency II and IFRS 17:

- the determination of the parameters for modelling the time period of cash-flows within the contract boundaries,
- the definition of what is an insurance contract and its components,
- the segmentation of the contracts into portfolios and groups,
- the required principles for the presentation of the values of the technical provisions in the balance sheet and in the financial result for the given year.

The market value of the technical provisions is equal to the sum of the estimate value of the fulfilment cash flows and the risk margins:

$$MVL_t^{IFRS} = FCF_t^{IFRS} + RA_t^{IFRS} \qquad (8)$$

where

MVL_t^{IFRS} is the market value of the technical provisions (liabilities) under IFRS 17 valued in year t,

FCF_t^{IFRS} is the value of the fulfilment cash-flows under IFRS 17 in year *t*, defined as the best estimate of the cash-flows before reinsurance including the market value of options and guarantees discounted at the interest rate from the portfolio of assets or the relevant structure of risk-free interest rates i.e.,

$$FCF_t^{IFRS} = PV\ CF_t^{\det IFRS} + PV\ FOG_t \qquad (9)$$

RA_t^{IFRS} is the risk adjustment in year *t*,

$PV\ CF_t^{\det IFRS}$ is the current value of the cash-flows in year *t* similar to (1) calculated deterministically with differences for IFRS 17,

$PV\ FOG_t$ is the value of financial options and guarantees in year *t* calculated stochastically with differences for IFRS 17.

For the purpose of this paper the risk adjustment RM_t^{SII} is defined similarly as RA_t^{IFRS} with the aim of not bringing into the paper differences which do not relate to the topic considered.

The expected value of the profit under IFRS 17 is determined by releasing the contractual service margin CSM_0

$$CSM_0 = \begin{cases} -FCF_0 & \text{if } FCF_0 > 0 \\ 0 & \text{if } FCF_0 \le 0 \end{cases} \qquad (10)$$

Calculated value CSM_t so that their present value at a risk-free interest rate equals CSM_0^{IFRS}. Thus

$$CSM_0 = \sum_{t=1}^{n} \frac{CSM_t}{\prod_{k=1}^{t}(1+i_k)} \qquad (11)$$

where

CSM_t has a constant value on the basis of the method used for allocating the contractual service margin to each year,

i_k is the locked-in interest rate (curve).

2.3. Dynamic Policyholder Behaviour

If the policyholders were to act rationally, then there would be a higher probability they would exercise a surrender option at a time when they expect higher interest rates in the future than they are guaranteed currently in insurance contracts and vice versa. So they can realise the risk-free profit arbitrage, execute the surrender option now and invest the obtained means at a higher interest rate return than the guaranteed technical interest rate. In the current system, the policyholder needs to be informed of the market value of their contract if they have the option to surrender it. They can, however, receive information on its guaranteed value, i.e., the surrender value. For this reason, the policyholder's actions are not fully efficient as they cannot maximise their profit. Policyholder behaviour is therefore intuitive, and even then, only policyholders act in case they understand economic principles or receive sound advice from an intermediary. This means that policyholder behaviour, i.e., the probability of surrendering the contract, changes according to expectations about the future interest rates. Policyholder surrender behaviour, in reality, often depends also on other factors, for example, the need for cash, intermediary advice, change in the tax regime for a particular type of insurance contract, the level of interest rates, the value of similar products in the market, and so on. It discovers a change in the surrender behaviour of its policyholders after it happens. Therefore, the insurance company needs to monitor it on a regular basis and, if needed, consider the changes in the best estimate of actuarial assumptions. That is not, however, conventional practice. Often, insurance companies try to limit the policyholder's behaviour, which could cause them a loss. For example, they promise the policyholder a share in future investment profits.

A second often-used approach is to impose a surrender penalty deducted from the original net surrender value. Dynamic policyholder surrender behaviour is a means of valuation of the technical provisions required by Solvency II [9]. In practice, it is not used much as it is difficult to determine a reliable mathematical description of policyholders' behaviour and to parameterise it. In a simplified form, surrender rates can be expressed as an introductory rate adjusted by a dynamic factor based on a predetermined floor rate and a cap rate. There are a number of ways of setting these values.

The natural minimum value, i.e. floor, is 0%, and the maximum value, i.e. cap, is 100%. The relationship between the probability of surrender and changes in interest rates needs to be determined based on the insurance company's own data or other participants from the market.

Absolute change in the dynamic surrender rate ds_t: the probability of surrender changes by an amount z% if the interest rate changes by more than y% in year t as compared with year $(t-1)$.
It can be expressed as follows:

$$ds_t = \begin{cases} s_t + z & \text{if } i_t > i_{t-1} + y \\ s_t & \text{if } i_{t-1} - y \le i_t \le i_{t-1} + y \\ s_t - z & \text{if } i_t < i_{t-1} - y \end{cases} \quad (12)$$

where
ds_t is the dynamic probability that a policyholder surrenders its contract in year t,
s_t is the probability of surrender (early termination) in year t determined in a deterministic model as the best estimate (average),
i_t is the interest rate in year t,
z is the absolute level of dynamic policyholder change in the surrender probability expressed as a percentage,
y is the absolute change in the interest rate between year t and year $(t-1)$.

In the paper, $z = 1\%$ and $y = 0.5\%$ are set as an example.
Relative change r in the dynamic probability ds_t: the surrender probability changes by r% if the interest rate changes by more than y% in year t compared with year $(t-1)$.
It is expressed as follows:

$$ds_t = \begin{cases} s_t.(1+r) & \text{if } i_t > i_{t-1} + y \\ s_t & \text{if } i_{t-1} - y \le i_t \le i_{t-1} + y \\ s_t.(1-r) & \text{if } i_t < i_{t-1} - y \end{cases} \quad (13)$$

where
r is the relative change in the dynamic surrender probability.
In the paper is setting as example $r = 30\%$ and $y = 1\%$.

2.4. Profit Sharing Option

The cash flows relating to the participation are conditional, as they arise if the achieved investment return is sufficiently high to meet the requirement for their sharing with the policyholder, i.e., it exceeds the guaranteed interest rate. The relevant cash flows can be expressed as follows

$$PVS_t = \begin{cases} i_t - TIR & \text{if } i_t > TIR \\ 0 & \text{if } i_t \le TIR \end{cases} \quad (14)$$

The present value of the share in profit is expressed as follows

$$PV\ FOG\ PVS_t = \\ = \frac{\sum_{j=1}^{m} (PV\ CF\ PVS_{j,t})}{m} - PV\ CF\ PVS_t^{det} \quad (15)$$

where
$PV\ FOG\ PVS_t$ is the present value of the option to participate in profit in year *t*,
$PV\ CF\ PVS_{j,t}$ are the cash-flows relating to profit participation for the jth interest rate simulation in year *t*,
$PV\ CF\ PVS_t$ are the cash-flows relating to profit participation in year *t* based on the risk-free interest rate,
TIR is the technical interest rate,
PVS_t is the present value of surrender in year *t*.

3. Results

This part illustrates the use of actuarial models with respect to a particular product type, namely endowment assurances, including contracts participating in investment profit. The calculation of the reserves for the market value of the reserves is also presented, including the value of the technical interest rate guarantee, depending on the expected future market interest rate and sensitivity scenarios. Examples of the valuation of the surrender option and the effect of a surrender penalty on the market value of the insurance contract are also shown. The value of the profit participation option and the surrender option with dynamic policyholder behaviour are determined using a Monte Carlo simulation approach. Their effect on the insurance company's reserves is shown. Both approaches for the valuation of the profit participation option and the dynamic behaviour of policyholders on surrender value are requested for the market valuation of the insurance company's reserves under Solvency II and IFRS 17. The calculations are performed using MS Excel for deterministic and stochastic models. The model endowment assurance product might contain the following guarantees and options.
Guarantees:

- mortality rates, as used to calculate the premium for a given sum assured,
- interest rate, the premium is calculated using a guaranteed technical interest rate.

Options:

- participation in the investment return on the reserves,

- surrender of the contract by the policyholder,
- cessation of payment of premiums and conversion of the contract to a so-called "paid-up" state,
- possibility of paying an additional single premium with a predetermined corresponding increase in the benefit on maturity,
- possibility of increasing the sum assured to allow for inflation on predetermined terms without the need to re-underwrite the policyholder,
- possibility of increasing or reducing the sum assured whilst maintaining the guarantees valid at the start of the contract,
- possibility of increasing or reducing the term of the contract,
- possibility of paying the sum assured at maturity as an annuity on guaranteed terms regarding mortality and interest rates.

This paper deals with the interest rate guarantee, surrender, and participation in investment return options. The model assumptions used for this contract are determined deterministically and are, to a large extent, consistent. In practice, they represent the best estimate for a given portfolio and are determined using various methods. An average value is often used as the result of regression analysis depending on the time of the insurance contract being in force or the policyholder's age. Our model contract is a 10-year endowment assurance for a 45-year-old life for a benefit on death or at maturity of €10,000 and an annual premium of €1,000. The initial expenses are €1,000, and the administrative expenses are €25 yearly. The mortality rates used are those for the Slovakian population in 2016. The probability of surrender depends on the insurance contract time, as shown in Table 1. Investment return is 1.0% p.a., 2.0% p.a., and 3.5% p.a., and discount rate is 1.0% p.a., 2.0% p.a. and 3.5% p.a.

Table 1. Probability of surrender

Insurance year	1	2	3	4	5-10
Surrender rate	10%	8%	7%	6%	5%

The interest rate curves used are simulated using a Monte Carlo method based on the risk-free interest rates published by EIOPA with the help of the ESG company UNIQA. The study used 0% and 90% of the return above 3% for the participation in investment returns. The surrender penalty is 0%, 10% and 45% of the value of the net reserve. For the dynamic surrender rates, the values z = 1% (see equation 12) and r = 30% (see equation 13) are used.

Figure 1 shows the dynamic surrender probabilities for the seventh simulation of the interest rates, the values of which are also shown.

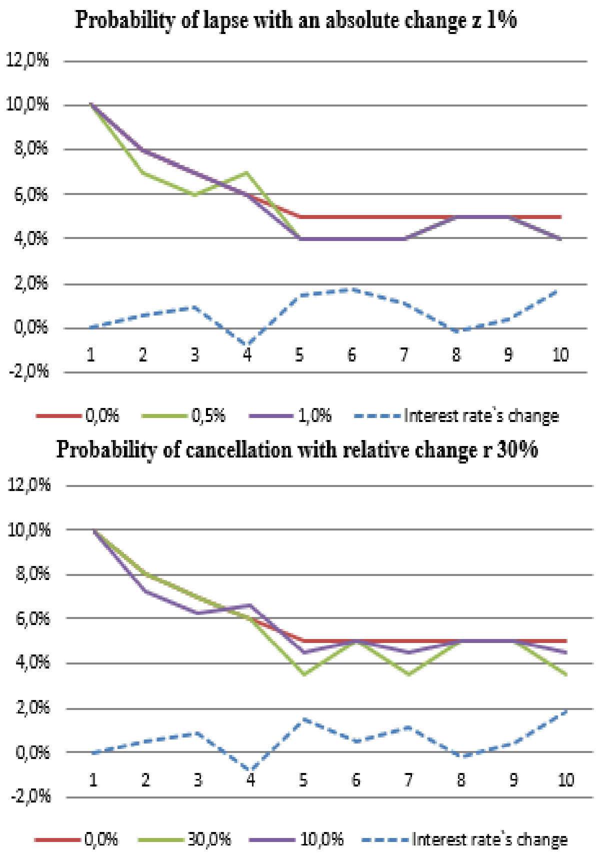

Figure 1. Dynamic surrender rates for the 7th simulation of the interest rate

The cash flows are dominated by the benefits paid at maturity. If the expenses are left aside, then the cash flows representing the premiums and the maturity benefits resemble those of a bond, with the difference that they are not fixed as they depend on the probability of surviving. The introduction of the surrender penalty has remained the same profit vector and the cash flows. The reason for the negative financial result is the interest rate guarantee in a low-interest-rate environment. Figure 2 shows the effect of the interest rate guarantee on the financial result and compares the guaranteed interest rate burden, taken as the reserve multiplied by the technical interest rate, with the actual investment income. This example shows that the guaranteed technical interest rate, under the expected interest rates, is valuable for the policyholder.

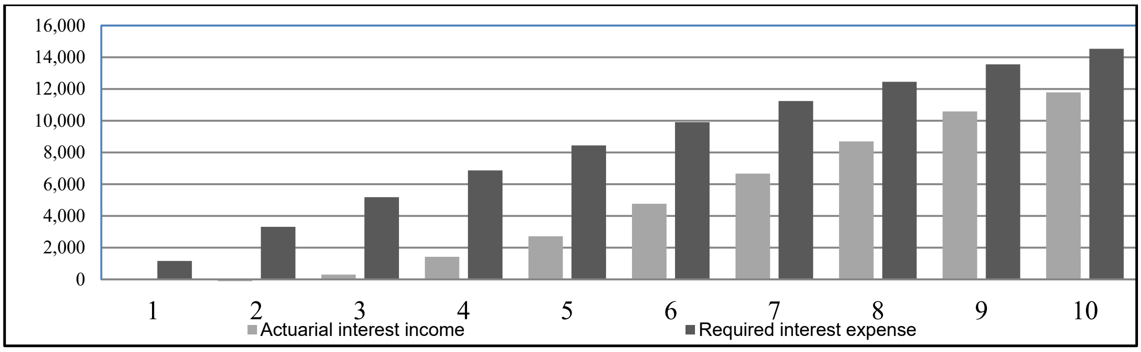

Figure 2. Comparison of actual investment income with the guaranteed interest rate burden

3.1. Impact of the Dynamic Surrender

The stochastic method is based on the simulations of possible future interest rates, whereby it considers a random element in this assumption. It is used 1,000 scenarios for the modelling of the future development of the interest rate curve in order to determine the present value of the profit or loss. For each scenario it is determined the expected profit and thus obtain its probability distribution, which can describe as a random variable and get its characteristics. A sample of the results for the first ten simulations is shown in Table 2 for our endowment assurance without surrender penalty and without participation in investment profit up to a variation with both a surrender penalty and participation in investment profit.

It is used the same models as in the earlier parts of this paper with alterations of input parameters only for various risk-free interest rates.

The results of endowment with surrender penalty and participation in investment profit shows that only the fifth and sixth simulations have interest rates which are sufficiently high to produce an expected profit from this contract for each of the valuation methods. Introducing a surrender penalty changes the expected present value of the profit in each scenario. These two simulations show the effect of the investment profit-sharing option on the expected profit (emphasised figures). In the case of the variation of the endowment where there is participation in investment profit (80% of the income above the technical interest rate), the expected positive profit is lower.

Table 2. Sample of the profits for the first 10 simulations for an endowment assurance

Profit	**Endowment without surrender penalty and participation in investment profit**	**Endowment with surrender penalty and without participation in investment profit**	**Endowment with surrender penalty and participation in investment profit**
Simulation			
1	-27,045	-16,463	-16,463
2	-32,572	-21,864	-21,864
3	-41,384	-30,132	-30,132
4	-122,302	-109,935	-109,935
5	**19,735**	**29,744**	**8,101**
6	**-6,013**	**4,261**	**2,217**
7	-1,120	9,443	-1,250
8	-39,238	-28,360	-28,360
9	-53,563	-42,149	-42,149
10	-51,377	-40,371	-40,371

Table 2 shows the minimum and maximum values of the profit for various variations of interest rates of our endowment contract and discussed valuation methods for determining the profit. It is clear from the results that the spreads of the stochastic value results for the profit, in this case, expected loss, are significant compared with their average values. Comparing the average profit values for our different contract alterations, it is seen the same pattern as for the deterministic results. The average profit values with a surrender penalty are approximately €11,000 higher than where there is no penalty. The introduction of investment profit sharing increases the value of the liabilities, and the results for IFRS 17 and Solvency II are the same, but only so in the valuation time zero, later over insurance contract time duration; these results would be different also here. It is clear from the above results that having an investment profit participation option significantly affects the average expected profit as well as a result for a particular interest rate simulation, particularly in the case where the achieved investment return is higher than the guaranteed interest rate, and the excess has to be shared with the policyholder.

This result is also achieved at a time of low-interest rates when the basic risk-free rate is negative during the early years. The next step is the calculation of the value of financial guarantees and options by equations (4) and (15). The value of the investment profit participation option is the difference between the two results sets, including a surrender penalty. Table 3 also shows the time value of the financial option and guarantee, -€12,656 for Solvency II and IFRS 17, representing a reduction in the expected profit value (increase in the reserve) of 32% and 30%, respectively. This is a material change and significantly affects the expected profit.

The values for each guarantee and option are calculated as follows:

- the time value of the investment rate guarantee, -€8 017 for Solvency II and IFRS 17, is calculated using equation (14) and the minus sign means that it is a value which increases the liabilities,
- the time value of the surrender option, -€92 for Solvency II and IFRS 17, is taken as the difference between the values for the variants without penalty and with penalty but without profit participation,
- the time value of the investment profit participation option, €4,731 for Solvency II and IFRS 17, is taken as the difference in the results for the variant with the option and the variant without, i.e., the cash flow is separated out, and the value of the option is determined analogously.

The results show that it is important to value the investment income participation option and the value of the guarantee stochastically, as it takes into account the future uncertainty inherent in financial options. If a deterministic method is used, the results are optimistic and do not represent the expected market value of the insurance contract reserve.

Table 3. Value of the interest rate guarantee and investment income participating option

Without dynamic surrenders	**Endowment without surrender penalty and participation in investment profit**	**Endowment with surrender penalty and without participation in investment profit**	**Endowment with surrender penalty and participation in investment profit**
Value of the option and the guarantee	**Profit**		
Deterministic valuation	-53,371	-42,158	-42,158
FOG value	**-8,017**	**-7,925**	**-12,656**
Stochastic valuation	-61,388	-50,083	-54,814
Minimum value	-178,307	-165,378	-165,378
Maximum value	33,599	43,454	-8,773
Spread	211,907	208,832	156,605
Surrender option with 10% penalty			
Deterministic valuation		11,213	
FOG value		**92**	
Stochastic valuation		11,305	
Investment income participation option			
Deterministic valuation			0
FOG value			**-4,731**
Stochastic valuation			-4,731

Table 4. Value of the interest rate guarantee and investment income participating option with dynamic surrenders for z = 1% and y = 0.5%

Dynamic surrenders for z = =1% and y = 0.5%	**Endowment without surrender penalty and participation in investment profit**	**Endowment with surrender penalty and without participation in investment profit**	**Endowment with surrender penalty and participation in investment profit**
Value of the option and the guarantee	**Profit**		
Deterministic valuation	-53,371	-42,158	-42,158
FOG value	**-8,247**	**-8,529**	**-13,431**
Stochastic valuation	-61,618	-50,687	-55,589
Minimum value	-175,631	-162,391	-162,391
Maximum value	37,294	46,424	-7,692
Spread	212,924	208,816	154,700
Surrender option with 10% penalty			
Deterministic valuation		11,213	
FOG value		**-282**	
Stochastic valuation		10,931	
Investment income participation option			
Deterministic valuation			0
FOG value			**-4,902**
Stochastic valuation			-4,902

It is used the dynamic policyholder surrender behaviour equation, where a change of 0.5% in the interest rate leads to a 1% change in surrenders, for a stochastic simulation of the interest rate. The results are shown in Table 4.

The results show increased values for the financial options, guarantees, and all variations of our model contract. Table 4 gives the following values for the time-value of the options and guarantees -€13,431 for Solvency II and IFRS 17, which implies a reduction in the expected value of the insurance company's profit (increase in the value of the technical provisions) of 34% and 32% respectively. The values for the separate options and guarantees are as follows (for Solvency II and IFRS 17):

- the time value of the investment rate guarantee is -€8,247,
- the time value of the surrender option is -€282, which is a significant increase compared with the deterministic values,
- the time value of the investment profit participation option is -€4,902.

Table 5. Value of the interest rate guarantee and investment income participating option with dynamic surrenders for r = 30% and y = 1%

Dynamic surrenders for r = 30% and y = 1%	**Endowment without surrender penalty and participation in investment profit**	**Endowment with surrender penalty and without participation in investment profit**	**Endowment with surrender penalty and participation in investment profit**
Value of the option and the guarantee	**Profit**	**Profit**	**Profit**
Deterministic valuation	-53,371	-42,158	-42,158
FOG value	**-8,095**	**-8,290**	**-13,195**
Stochastic valuation	-61,467	-50,448	-55,353
Minimum value	-173,001	-160,190	-160,190
Maximum value	38,898	48,269	-8,387
Spread	211,898	208,459	151,803
Surrender option with 10% penalty			
Deterministic valuation		11,213	
FOG value		**-194**	
Stochastic valuation		11,019	
Investment income participation option			
Deterministic valuation			0
FOG value			**-4,905**
Stochastic valuation			-4,905

Equation for the dynamic policyholder behaviour is used in the case of a relative change in surrenders of 30 % in connection with a change in the interest rate of 1 % for a stochastic simulation of the interest rate. The results, as shown in Table 5, are very similar. However, this conclusion might be caused by the selection of the parameters and might be further explored.

Table 5 shows the following time values of the options and guarantees: -€13,195 for Solvency II and IFRS 17. These represent a reduction in the expected profit value (increase in the value of the reserves) of 34% and 31%, respectively. The difference in results between the absolute and relative change in surrenders is not material.

The values of the options and guarantees for a relative change in surrenders are as follows (for Solvency II and IFRS 17):

- the time value of the investment rate guarantee is -€8,095,
- the time value of the surrender option is -€194, which are significant increases compared with the deterministic values,
- the time value of the investment profit participation option is -€4,905.

4. Conclusion

The cash flows objectively represent the financial flows that arise between the policyholder and insurance company from the contract's inception. The valuation rules and methods for determining the technical provisions influence the profit timing of a life insurance company, cause differences as to when profits or losses are recognized, and produce accounting items not based on cash flows. In the paper is used a typical contract for life insurance companies: endowment assurance. The cash flows arising from the contract are the same whether consider the current IFRS 17 standard or the Solvency II regime. Differences arise when profits are recognized during the contract's life. It is described how, for Solvency II, a life insurance company recognizes the financial profit or loss from the sale of a contract immediately in its balance sheet in the year in which the contract is written. Thus, they immediately create their own capital, which is available for the shareholders to cover the required regulatory capital.

Under IFRS 17, the life insurance company recognises the financial profit immediately in the year the contract is written, with a neutral impact on the own capital when a profitable contract. So, the expected profit is not immediately available to the shareholders but will be released during the life of the contract according to the insurance service provided. In the case of a loss-making portfolio, this is not the case as the market value of the loss is recognized immediately in the profit calculation as the setting up of an insurance reserve, and it will immediately reduce the insurance company's available capital. The recognized loss amount is the same in the same risk margin case of Solvency II and risk adjustment for IFSR 17. The risk margin will also be released over the contract's lifetime according to the insurance service provided. For IFSR 17, profit recognition was demonstrated as the transparent result between the insurance and investment results of the insurance contract.

In the study is pointed out the effect on the insurance company's valuation profit of an interest rate guarantee and options to surrender the contract and participate in investment income profit. Particularly at a time of low market interest rates, the interest rate guarantee in endowment contracts with a higher technical interest rate significantly impacts the financial results. However, the option's value is recognized in the case of IFRS 17 valuation. The option to participate in investment income profit also significantly affects the insurance company's results.

The value added of the research presented in this paper is the definition of a stochastic actuarial method possible to be used for the valuation of financial options and guarantees in regularly paid life insurance contracts that have been enlarged to allow for the testing of surrender options by simulating various dynamic policyholder surrender behaviors. It was demonstrated that using these methods has a significant effect on the financial results of life insurance companies, depending on the parameter values chosen for the interest rates and surrender rates. Therefore, the valuation of the financial option and guarantees shall not be omitted in Solvency II or IFRS 17 insurance contract reserves valuations. This is the case, particularly for an interest rate guarantee and an investment income profit-participating option. It is also shown that using a dynamic policyholder surrender behavior technique leads to a more significant impact on the profit and is therefore requested to be considered, which is not often used in practice as the parameters have yet to be known. The values to be used for the parameters for this technique have to be determined in the current economic climate from empirical data by using, for example, regression models.

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References:

[1]. Yousuf, W. et al. (2021). The IFRS 17 contractual service margin: a life insurance perspective. *British Actuarial Journal*, *26*. Doi: 10.1017/S1357321721000015

[2]. Chevallier, F., Dal Moro, E., Krvavych, Y., & Rudenko, I. (2018). Probability of sufficiency of the risk margin for life companies under IFRS 17. In *International Congress of Actuaries*.

[3]. Dickson, D. C., Hardy, M. R., & Waters, H. R. (2019). *Actuarial mathematics for life contingent risks*. Cambridge University Press. Doi: 10.1017/9781108784184

[4]. Palmborg, L., Lindholm, M., & Lindskog, F. (2021). Financial position and performance in IFRS 17. *Scandinavian Actuarial Journal*, *2021*(3), 171-197. Doi: 10.1080/03461238.2020.1823464

[5]. England, P. D., Verrall, R. J., & Wüthrich, M. V. (2019). On the lifetime and one-year views of reserve risk, with application to IFRS 17 and Solvency II risk margins. *Insurance: Mathematics and Economics*, *85*, 74-88. Doi: 10.1016/j.insmatheco.2018.12.002

[6]. Sakálová, K., & Krčová, I. O. (2016). Measures of profitability in life insurance product management. *Strategic Management-International Journal of Strategic Management and Decision Support Systems in Strategic Management*, *21*(1). [accessed: 12 March 2024].

[7]. Furrer, H. (2020). Valuing Options Embedded in Life Insurance Contracts. *Review of Financial Studies*, *14*(1), 113-147.

[8]. IAA. (2009). *Measurement of Liabilities for Insurance Contracts: Current Estimates and Risk Margins*. IAA.

[9]. IAA (2013). *Discount Rates in Financial Reporting. A practical Guide.* Ontario Canada: International Actuarial Association.

[10]. Sotona, P. (2018). Mortality risk assessment under IFRS 17. In *21th International Scientific Conference AMSE: Applications of Mathematics and Statistics in Economics, Czech Republic. Praha: VŠE v Praze. Roč*, *21*, 281-289.

[11]. Costabile, M., & Viviano, F. (2021). Modeling the Future Value Distribution of a Life Insurance Portfolio. *Risks*, *9*(10), 177. Doi: 10.3390/risks9100177

[12]. Kamenárová, M. (2019). *Niektoré garancie a opcie v životnom poistení a ich vplyv na hospodárenie životnej poisťovne.* [Dissertation].

[13]. Kronborg, M. T., & Steffensen, M. (2015). Optimal consumption, investment and life insurance with surrender option guarantee. *Scandinavian Actuarial Journal*, *2015*(1), 59-87. Doi: 10.1080/03461238.2013.775964