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MORTALITY RISK ASSESSMENT UNDER IFRS 17

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Abstract

The article focuses on the mortality risk assessment in the insurance industry for the Czech Republic. New accounting standard IFRS 17 requires to disclose confidence level at which the insurance company assessed insurance risks inherent in issued insurance contracts. This article analyzes mortality risk which can be further split into four subrisks: volatility, catastrophic risk, level uncertainty and trend uncertainty. On the practical example of insurance portfolio with term insurance product I present the application of various statistical methods to assess mortality risk and to estimate total risk adjustment (under IFRS 17) for mortality risk on 90% confidence level. Final results are analyzed and commented with conclusions.

Key words: *mortality risk, IFRS 17, life insurance*

JEL Codes: *C0, G22, J10, M4*

1. Introduction

In this article I aim to adopt produced mortality table from Sotona (2018) in the practical example from insurance industry. In May 2017 International Accounting Standards Board (IASB) released new standard IFRS 17 for insurance contracts that will be in force starting 1st January 2021. This new standard was being prepared for many years and already in time of the release of current standard for insurance contracts IFRS 4 it was announced that it is only temporary standard as it is not capturing all complex characteristics of insurance contracts.

The concept of IFRS 17 is very different from current accounting principles used for insurance contracts. IFRS 17 is more consistent with other accounting standards for other instruments and industries (such as IFRS 9 or IFRS 13) and at the same time this standard should increase transparency and consistency between insurance companies. It is beyond the scope of this article so I refer to Svoboda (2017) and Svoboda and Sotona (2017) for further information about IFRS 17.

Under the current accounting regimes such as Czech Accounting Standard (CAS) or IFRS 4 the insurance company is creating technical reserves for existing and future liabilities arising from insurance contracts held. The rules for technical reserves calculation are defined using standard actuarial formulas and these values are reviewed by an external auditor to confirm the correct value of these reserves. On the top of these reserve the insurance company has to perform liability adequacy testing (LAT) to verify that the amount of created reserves is sufficient to cover liabilities from corresponding insurance contracts. If the amount of reserves is not sufficient the insurance company has to create the additional reserve (so called LAT reserve) or to perform other steps to cover these liabilities.

In the Czech Republic the LAT calculation should follow the guideline issued by Czech Society of Actuaries (CSpA). This guideline is not mandatory but it is recommended by CSpA and it is market practice to follow the principles in this guideline. One of the principles for LAT calculation is the use of risk margins in LAT calculation to allow for the uncertainty in the best estimates of assumptions used in actuarial models. This guideline prescribes illustrative values of risk margins for particular risks. For mortality risk it is 10% increase in mortality rates (for term insurance) and 10% decrease in mortality rates (for predominant longevity risk), respectively.

The appropriateness of the risk margin and key characteristics of such definition of risk margin are further discussed and analyzed in Sotona (2009) and Sotona (2010).

Under upcoming IFRS 17 there will not be further any reason to calculate LAT because the technical reserves will not exist in the accounting anymore. In this new regulation there will be three main components creating the liability side of balance sheet :

- **Best Estimate of Liabilities (BEL)** - *An explicit, unbiased and probability-weighted estimate (i.e. expected value) of the present value of the future cash outflows minus the present value of the future cash inflows that will arise as the entity fulfils insurance contracts*[1], i.e. similar item to best estimate of liabilities concept in Solvency II regime;
- **Risk Adjustment (RA)** - *The compensation an entity requires for bearing the uncertainty about the amount and timing of the cash flows that arises from non-financial risk as the entity fulfils insurance contracts*[1], i.e. similar item to risk margin (RM) concept in Solvency II regime;
- **Contractual Service Margin (CSM)** - *A component of the carrying amount of the asset or liability for a group of insurance contracts representing the unearned profit the entity will recognise as it provides services under the insurance contracts in the group*[1].

In this article I focus on two of these items. Section **??** further focuses on best estimate of liabilities and section **??** covers risk adjustment for mortality risk. These two components together create so called fulfillment cash flows (FCF).

2. Example Definition

Before I discuss BEL and RA in detail I define the example characteristics. Let's assume I have a portfolio of insurance contracts with the mortality risk. In the Czech Republic the traditional insurance products such as term insurance, pure endowment of endowment products are not often sold anymore. In recent years the market focus was on unit linked products with various mix of additional insurance coverages (riders). Nevertheless market environment with low interest rates led to lower interest in unit linked products and currently insurance companies return to pure risk insurance business without (or with limited part of) the investment component. Considering this development I consider term insurance product in this practical example, i.e. life insurance with coverage in case of death. I have excluded any additional riders to keep focus only on mortality risk.

Term insurance product considered in this illustrative example is till the age 100 years of insured person. Although such product (term insurance till age 100) is not currently offered on

[1]Definitions of all items are taken from IASB's standard IFRS 17 (2017).

the market I assume policy term till higher age than usually offered on market to capture also mortality risk in higher ages. Mortality rates projection is based on complete mortality table (series of mortality tables for future calendar years) which was produced in Sotona (2018). For simplicity mortality selection factors are not considered. There is no surrender benefit and annual maintenance costs per policy are assumed to be 400 CZK with the inflation rate 2% p.a. Annual lapse rate is equal to 8%, premium is paid monthly and to illustrate characteristics of insurance portfolio I assume that insurance contracts were sold 10 years ago. The same entry year for all contracts is on purpose to meet requirement for group of contracts under IFRS 17. Discount rate is set for simplicity equal to 2% p.a.

Portfolio consists of 500,000 contracts with sum assured in case of death equal to 3,000,000 CZK. Portfolio contains 50% males and 50% females. I consider an age at entry of insured person 30, 35, 40, 45 and 50 years, respectively. Each of these group contains 100,000 contracts and annual premium for these groups is 2,400, 2,600, 2,800, 3,000 and 3,200 CZK, respectively.

Complete mortality table was derived based on the Czech observed data from calendar years 1920 - 2011 containing number of deaths and exposures for males and females and for each age 0 - 100 years (provided by Czech Statistical Office). For derivation of mortality table I used the following mortality model:

$$\ln \frac{q(t,x)}{p(t,x)} = \alpha_x^{(1)} + \kappa_t^{(1)} + \kappa_t^{(2)} x \tag{1}$$

where $q(t,x)$ is probability of death at age x and in calendar year t, $p(t,x)$ is probability of survival at age x and in calendar year t and $\alpha_x^{(1)}$, $\kappa_t^{(1)}$ and $\kappa_t^{(2)}$ are parameters calibrated using maximum likelihood estimation implemented in VBA in MS Excel. This model is an extension of so called CBD model (introduced by Cairns, Blake and Dowd) which can be found for example in Cairns et al. (2011). This extension is introduced in Sotona (2018).

Future projection for calendar years 2012 - 2100 is based on the application of the random walk approach (for further reference see Pitacco et al. (2009)) with variable trend factor which combines three trends (short term, medium term and long term) from observable period. Projected mortality rates were further smoothed and extrapolated till the age of 110 to build complete mortality table till 2100. For further details about the derivation of this mortality table I refer to Sotona (2018).

Considered model was selected based on the comparison with some other known stochastic mortality models, for further information about those models I refer to Lee and Carter (1992), Currie (2006), Haberman and Renshaw (2011), Plat (2009), Renshaw and Haberman (2003), Renshaw and Haberman (2006) and Cairns et al. (2011).

3. Best Estimate of Liabilities

BEL represents an explicit, unbiased and probability-weighted estimate of the present value of the future cash outflows minus the present value of the future cash inflows that will arise as the entity fulfills insurance contracts.

For the calculation of future cash flows I use the actuarial software Prophet that is broadly used as an actuarial cash flow engine especially for life insurance portfolios. The calculation is performed as at 31st December 2017 and projection horizon used is 80 years.

Because I do not consider any profit sharing and defined product does not have any inherent options and guarantees (except of the surrender option) I do not use stochastic projections but only consider deterministic projection. This approach is commonly used for such products.

The use of complete mortality tables in actuarial projections is not yet always applied in the Czech Republic and in Central and Eastern Europe. Therefore the first analysis shows the impact of the use of this complete mortality table, as produced in Sotona (2018), on BEL instead of the use of the basic mortality table based on the latest observation of mortality rates without consideration of future mortality trend. This comparison is presented in the following table **??**.

Table 1: Best Estimate of Liabilities with basic and complete mortality table

BEL	Mortality table		Difference	
(CZK)	Basic	Generation	(CZK)	(%)
Males	78,779,327,548	63,136,093,834	15,643,233,714	24.8%
Females	46,658,865,074	35,393,670,597	11,265,194,477	31.8%
Total	125,438,192,622	98,529,764,431	26,908,428 ,91	27.3%

Source: own elaboration

The impact on BEL is significant as expected and therefore the allowance for mortality trend is necessary to be compliant with the accounting principles under IFRS 17. Under current accounting principles it is not forbidden to have prudent reserves which in this case of term insurance is valid. In case of annuity business (or other business with longevity risk) it would probably lead to necessity to create additional LAT reserve.

Let's define the best estimate of liabilities based on complete mortality tables as BEL_{Base} so I can refer to this value in the next section **??**.

4. Risk Adjustment for Mortality Risk

Under current accounting regimes there is no requirement for explicit calculation and disclosure of risk adjustment. It is common practice that risk margin for mortality risk in pricing of life insurance products is based on simple percentage adjustment to observed mortality rates. Under IFRS 17 it will be mandatory to calculate this risk margin (called risk adjustment under IFRS 17) explicitly and present this item separately in mandatory disclosures.

There are several methods how to calculate risk margin for particular risk. This contains cost of capital method, quantile methods, discount rate methods and other explicit calculation methods. For further reading about risk margins and calculation methods I refer to Sotona (2009). In case of mortality risk there are four subrisks that create overall mortality risk. These are volatility, catastrophe, level and trend risk. Further information about these risks and their estimation is presented for example in Sotona (2009) and Sotona (2010).

Risk arising from volatility of observed data related to mortality risk (i.e. probability of death) is actually the principle of insurance business. Law of large numbers leads to the elimination of this risk if the exposure to this risk is large. Portfolio of insurance contracts therefore mitigates this risk and therefore I do not explicitly estimate risk adjustment for this subrisk similarly to approach in Sotona (2009).

Catastrophic risk is not typically captured in the mortality models and therefore explicit risk adjustment is necessary. It is a risk arising from extreme events that significantly and immediately impact mortality rates. There are only few extreme events observed in past that had significant impact on mortality rates and therefore it is very difficult to estimate this risk.

I mention here the existing definition of stress scenario under Solvency II regime for mortality catastrophic risk. This stress scenario is defined as an absolute increase of mortality rates by 0.15% in the first projection year and it represents 99.5% confidence level over one year horizon (for further information I refer to Solvency II Delegated regulation, 2015). Similarly to Sotona (2009) I use 200% of mortality rates in the first projection year, i.e. in 2018, and assume that it represents 90% confidence level on run off basis. International Actuarial Association (IAA) commented the problem with the allowance for this mortality subrisk in IAA (2004) and also suggested to apply 200% of estimated mortality rates in one year of projection as a sufficient allowance.

Applying the stress scenario I derive BEL_{Cat} and risk adjustment for mortality catastrophic risk RA_{Cat} is defined as a difference between BEL_{Cat} and BEL_{Base}. Table **??** shows these results for mortality catastrophic risk.

Table 2: BEL and RA for mortality catastrophic risk

(CZK)	BEL_{Base}	BEL_{Cat}	RA_{Cat}	(%)
Males	63,136,093,834	66,109,845,224	2,973,751,389	4.7%
Females	35,393,670,597	36,660,683,100	1,267,012,503	3.6%
Total	98,529,764,431	102,770,528,324	4,240,763,893	4.3%

Source: own elaboration

Another subrisk is mortality level risk. This risk reflects the fact that observed data are results of random variable and therefore estimated mortality level may be wrong. This risk can be reduced with the increasing number of observations.

To model risk adjustment allowing for mortality level uncertainty I assume that total loss (paid mortality benefits) has compound Poisson distribution based on Poisson distribution assumption for number of deaths. The whole process is in detail described in Sotona (2009) and therefore I will not present here all technical details. I reach 90% confidence level using NP2 approximation which is further described for example in Mandl and Mazurová (1999). Further I assume that real mortality rates $q(t,x)_{Level}$ can be expressed as a product of observed (estimated) mortality rates $q(t,x)$ and factor f. Using Gram-Charlier series (described in detail in Mandl and Mazurová (1999)) I get quadratic equation with variable f. Solving this quadratic equation I derive real mortality rates $q(t,x)_{Level}$ for all ages and all future years. Final risk adjustment for mortality trend risk RA_{Level} is the difference between BEL_{Level} and BEL_{Base} based on mortality rates $q(t,x)_{Level}$. These results are summarized in table **??** below. Further details of this approach can be found in Sotona (2009).

Table 3: BEL and RA for mortality level uncertainty

(CZK)	BEL_{Base}	BEL_{Level}	RA_{Level}	(%)
Males	63,136,093,834	64,803,101,544	1,667,007,710	2.6%
Females	35,393,670,597	36,376,036,867	982,366,270	2.8%
Total	98,529,764,431	101,179,138,411	2,649,373,980	2.7%

Source: own elaboration

The results for mortality level uncertainty show less than 3% of best estimate of liabilities necessary to cover this risk.

Last subrisk is mortality trend risk. Uncertainty in mortality trend can be captured through the whole value of liabilities, in this case BEL. The reason is that it is simple way how to deal with the problem of dependencies between various ages when modelling mortality trend uncertainty. I consider data (number of deaths and exposure) in the observation period 1920 - 2011 (excluding years 1939 - 1945 affected by 2nd World War) and derive various observable trends. In particular I have identified 8 trends based on the following observation periods: 1920 - 1928, 1929 - 1938, 1946 - 1956, 1957 - 1967, 1968 - 1978, 1979 - 1989, 1990 - 2000, 2001 - 2011. For each trend I produce complete mortality tables (for males and females), calculate BEL^i_{Trend} for $i = 1, \ldots, 8$ and from these values I calculate sample variance σ^2_{Trend}.

Risk adjustment for mortality trend uncertainty is based on Student's t-distribution as proposed in Broekhoven (2002). Quantile of Student's t-distribution with seven degrees of freedom on confidence level 90% is equal to 1.41 and risk adjustment for mortality trend risk RA_{Trend} is a product of this quantile and sample standard deviation σ_{Trend}. More detailed description of this approach can be found in Sotona(2009). Key results are summarized in table **??** below.

Table 4: BEL and RA for mortality trend uncertainty

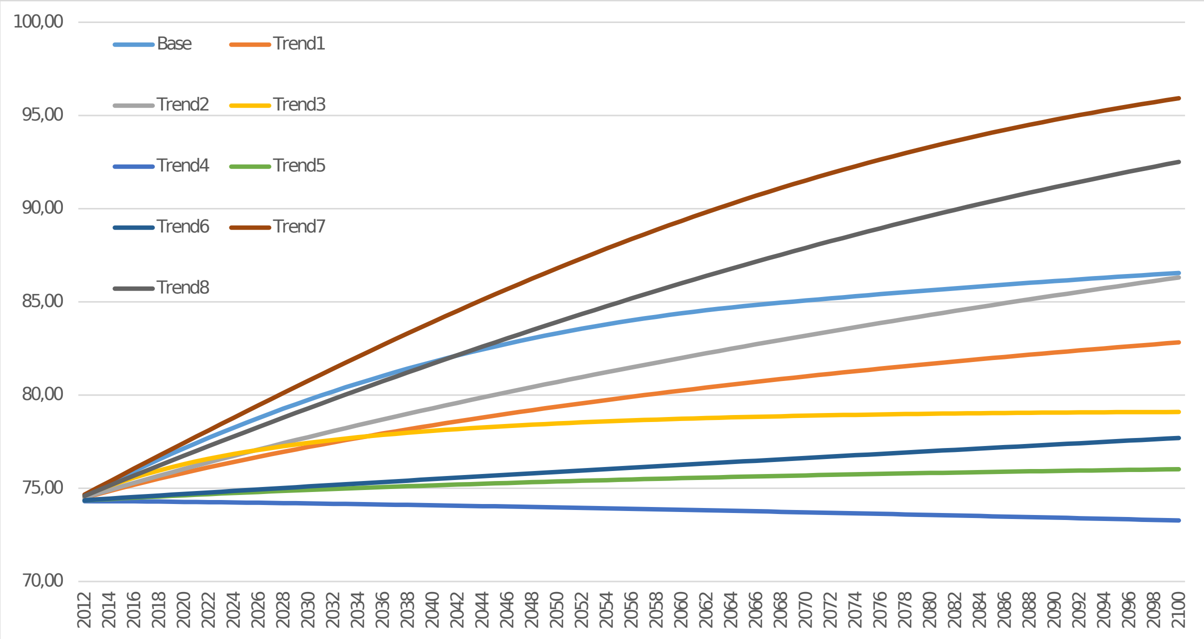
(CZK)	BEL_{Base}	RA_{Trend}	(%)
Males	63,136,093,834	26,737,550,028	42.3%
Females	35,393,670,597	11,677,077,665	33.0%
Total	98,529,764,431	34,275,150,359	34.8%

Source: own elaboration

The risk adjustment for trend uncertainty is significantly higher than for other mortality subrisks. Nevertheless this result is consistent with the result of analysis performed by IAA in IAA (2004) where the risk margin for mortality trend risk for term insurance product is assessed to 30% of BEL.

It is obvious that this subrisk is the most severe mortality risk which I illustrate on the following figure **??**. It shows the projection of life expectancy based various observed trends for males.

Figure 1: Projected life expectancy of males based on various observed trends



Source: own elaboration

If I assume that all these subrisks are independent then the total risk adjustment for mortality risk is the sum of the riask adjustments for each subrisk. The table **??** summarized the overall results for mortality risk.

Table 5: Summary of BEL and RA for mortality risk

Item	(CZK)	(%)
BEL_{Base}	98,529,764,431	-
RA_{Cat}	4,240,763,893	4.3%
RA_{Level}	2,649,373,980	2.7%
RA_{Trend}	34,275,150,359	34.8%
RA_{Total}	41,165,288,231	41.8%

Source: own elaboration

5. Conclusion

Under new accounting standard IFRS 17 mortality risk, as well as other insurance risks, will be much more transparently presented in the financial statements and disclosures. Therefore it is important to prepare for this huge change in actuarial and accounting practices and adjust current actuarial models for pricing, development, monitoring and accounting to more faithfully capture each of those risks.

Table **??** summarizes the results of presented worked example on the assessment of mortality risk for term insurance portfolio. This example shows how the insurance companies can assess mortality risk under IFRS 17 requirements. Of course other methods may be applied based on available and observed data. Results on the 90% confidence level for mortality risk can differ a lot for other life insurance products or for different product parameters and therefore it is not possible to conclude what percentage of BEL is appropriate level for risk adjustment estimation for particular confidence level. Nevertheless presented results are consistent with other analyses of mortality risk assessment.

The most important mortality risk component is the uncertainty related to mortality trend which confirms the importance of appropriate projection mortality models and allowance for future development of mortality rates.

It should be noted that each portfolio will have different mortality risk exposure and the natural hedging of this risk will partially reduce the risk presented on simple portfolio with one product type. Moreover I considered the 90% confidence level for risk adjustment which may in reality significantly differ between insurance companies reflecting various risk appetite and aversion.

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