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Some technical considerations on costs, projections and pension benefit statement

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EXECUTIVE SUMMARY

The provision of a pension benefit statement is one of the requirements imposed on fund managers across Europe when providing PEPP. The implementation of the pension benefit statement is intended to increase the understanding between the savings' parameters set and the expected value of pension savings at the end of the accumulation period.

An appropriately designed pension benefit statement can significantly assist savers to properly manage their savings parameters during the accumulation phase. It may also help them to understand the relationship between the amount of contributions, the choice of pension fund, and the expected pension accumulated.

The aim of the study is to propose, based on the knowledge of behavioral studies, an efficient pension benefit statement for private pension savings. The proposed model can be applied after the adoption of the implementing measures concerning the PEPP regime, and is already integrated in a pension benefit statement platform in Slovakia called „Orange Envelope". This functional model of the pension benefit statement uses modern features stimulating the learning process and significantly increases the understanding of savings and the decision-making ability for participants. However, an indispensable part of the pension benefit statement must be a tool by which the trustee expresses a recommendation on the participant's savings with an estimation of the achievement of the pension objective.

Assumptions for calculating the expected real value of pension savings should also be included in the pension benefit statement. The methods of data generation we have examined for the purposes of calculations point to the appropriateness of the multi-block bootstrap method, which is technically undemanding and allows the back-up of the calculation process. At the same time, we propose a centralized provision and maintenance of the database to ensure transparency of the calculation process for individual administrators based on the pension fund synthetic risk-reward profile.

Methodology and methods of simulating returns and estimating expected future value of savings

This first technical part of the paper focuses on the methods used to simulate future returns, techniques of incorporating fund fees, modeling life-cycle income of an individual for presenting the life-cycle contributions towards the PEPP tied to the one´s salary, and, finally, modeling life-cycle saving strategies tied to the age and remaining saving/investing horizon of an individual.

Modeling expected investment returns of PEPP vehicles

The following chapter contains a description of 3 approaches to modeling gross returns of pension funds. Ranked from the easiest to implement to the most sophisticated modeling:

1. Moving-block bootstrap (resampling) using empirical stock and bond returns and related macroeconomic indicators;
2. Monte Carlo simulations;
3. Application of linearized scenarios of financial market development (3 scenarios) - optimistic, pessimistic and neutral.

Subsequently, we evaluate the advantages and disadvantages of the modeling methods in the calculation of future pension fund performance with respect to the data used, predictive accuracy and taking into account the structure of pension fund portfolios. Practice shows that not all equity funds always hold a high (over 90%) share of equities in the portfolio. Therefore, we want to avoid a methodological error of counting the return achieved by the stock market into a fund that does not hold equity positions all times, but its return is determined by the return of equities and bonds. To account for this, we construct pension funds (vehicles) with different risk-reward profile by combining the two key asset classes (equities and bonds) and calculate respective SRRI using the UCITS methodology. For ease of simulation when presenting simple strategies for risk-mitigation techniques, we use the combination of 2 benchmark passively managed funds with SRRI 2 and 6 (typical full bond and equity funds). At the same time, in this subchapter we assess the difficulty and practical consequences of the application of individual methods.

Moving-block bootstrapping (resampling) using long-term empirical data and other macro-economic variables

The basic idea of the block bootstrap is closely related to the i.i.d. nonparametric bootstrap. Both procedures are based on drawing observations with replacement. In the block bootstrap, instead of relying on single observations, blocks of consecutive observations are drawn. This is done to capture the dependence structure of neighbored observations. This method allowed us to overcome the problem with capturing close relations among inflation, bond returns, and many other macroeconomic parameters influencing other parts of the model (life-cycle income) during the whole savings period. It has been shown that this approach works for a large class of stationary processes (Gilbert & Troitzsch, 2005). The blocks of consecutive observations are drawn with replacement from a set of blocks. By construction, the bootstrap time series has a nonstationary (conditional) distribution.

Moving blocks bootstrap is a simple resampling algorithm, which can replace the parametric time series models, avoiding model selection and only requiring an estimate of the moving block length (l). Let a saver have the option to allocate his contributions and savings either to an equity (SRRI class 6) or bond (SRRI class 2) pension fund. We consider an x-year saving/investment horizon.

At the same time, we want to use historical returns and other macroeconomic variables (inflation, labor productivity, unemployment) in order to maintain the relationship between macroeconomic variables throughout the simulation process. The number of simulated daily returns will depend on the remaining savings period expressed in trading days.

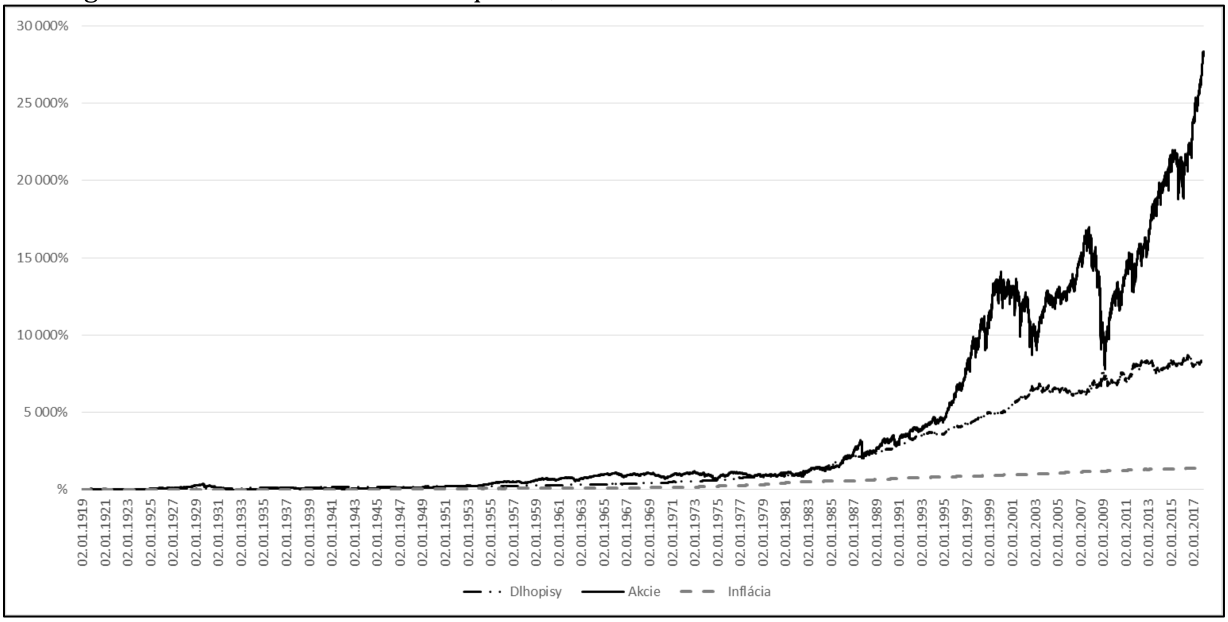
We work with the daily historical returns of the Dow Jones Industrial Average 30 (DJIA 30), the daily historical returns of 7-10 years US bonds and the monthly CPI inflation rate for the US from January 1, 1919 to December 31, 2001 (CPI to the present). Since January 1, 2002 to January 31, 2017 DJIA 30 will be replaced by DIA ETF, which follows the composition of DJIA 30, and for bond yields we use ETF IEF, which invests in US bonds with maturity of 7 to 10 years. The Equity and Bond Pension Funds will be considered passively managed and will consist only of these two financial instruments. In the case of inflation (τ), we work with a monthly (m) inflation rate. The inflation rate τ for each trading day d during each month m is calculated as:

$$\tau_d(m) = (1 + \tau_m)^{\frac{1}{M}} - 1 \tag{1}$$

where M represents the total number of trading days within the month *m.*

Daily historical returns of DJIA 30, resp. DIA ETF, shall be defined as r_{s,t^*}, daily historical returns of bonds shall be defined as r_{b,t^*} and daily inflation as τ_{t^*}. Figure below presents the cumulative returns of equities, bonds and inflation since January 1st until March 2017.

Figure 1 Cumulative returns of equities, bonds and inflation in US from 1919 until 2017



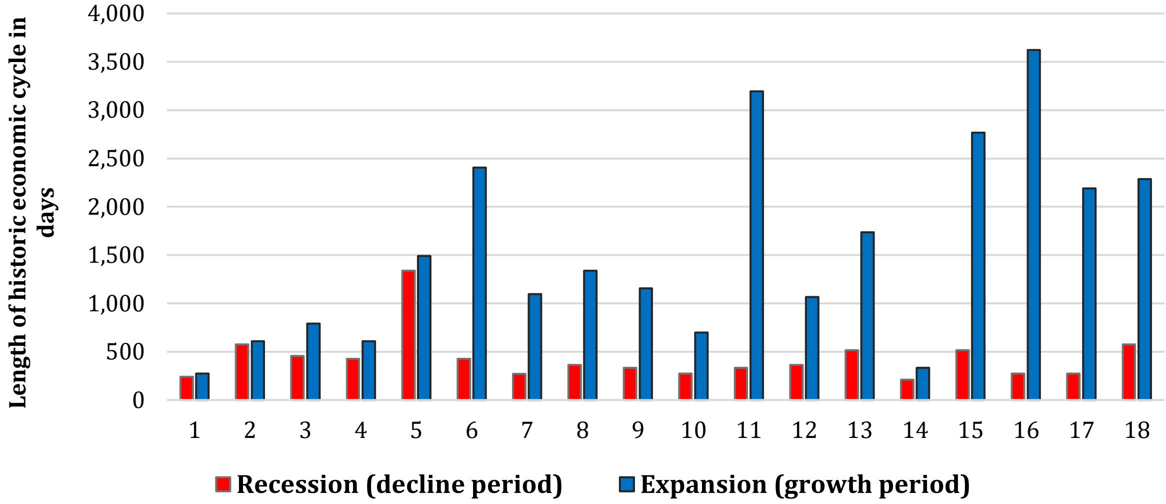
Source: Own elaboration using FRED data, 2019

Let $\boldsymbol{r}$ be the *3 x T* matrix consisting of daily returns of equities, bonds and daily inflation, where T is the number of daily returns (inflation) within the block of trading days starting 1.1.1919 until 14.3.2017. The initial matrix shall be called the block 0 (b_0) consisting of T^* = 25 882 daily historical returns, and thus $t^* \in \{1,2, \ldots T^*\}$.

In order to apply moving-block bootstrapping technique (resampling), daily historical data within the matrix $\boldsymbol{r}$ shall be divided into the blocks based on the economic cycle phases (up-trend/expansion and down-trend/recession). To divide the matrix into the blocks, we use the data on economic cycles from the *National Bureau of Economic Research (NBER)* under the section *US*

Business Cycle Expansions and Contractions[1]. During the analyzed timeframe, there was 36 economic cycle phases. Block b_0 could be divided into 36 phases (f): $b_0 = \{f_1, f_2, \dots, f_{36}\}$, which is characterized by the changing up and down phases. Both types of phases are present 18 times. The figure below presents the economic phases and their duration.

Figure 2 Up-trending and down-trending macroeconomic periods in the US (1919 – 2017)



Source: NBER (2018), available at: http://www.nber.org/cycles/cyclesmain.html

Each phase is defined by the respective number, where upward phase has even numbers and downward phase odd numbers. The table below contains the annualized returns of equities and bonds, inflation and their respective standard deviations for various timeframes.

Table 1 Annualized returns and standard deviations for equities, bonds and inflation

All phases						
	Equities		**Bonds**		**Inflation**	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***
1919 - 2017	6,31%	16,13%	5,17%	2,56%	2,83%	0,35%
1919 - 1975	7,16%	15,16%	4,23%	2,19%	2,78%	0,37%
1975 - 2017	3,33%	19,52%	8,44%	3,87%	3,01%	0,27%
Downward phases (recessions)						
	Equities		**Bonds**		**Inflation**	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***
1919 - 2017	-0,01%	18,04%	7,07%	2,75%	1,76%	0,38%
1919 - 1975	-0,02%	16,64%	5,18%	1,66%	0,43%	0,39%
1975 - 2017	0,00%	21,66%	12,00%	5,56%	5,23%	0,33%
Upward phases (expansions)						
	Equities		**Bonds**		**Inflation**	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***
1919 - 2017	12,63%	14,22%	3,26%	2,38%	3,90%	0,32%
1919 - 1975	13,46%	13,67%	2,92%	1,64%	3,81%	0,37%
1975 - 2017	10,45%	15,64%	4,14%	4,29%	4,12%	0,18%

Source: Own elaboration and calculations using NBER.org, FRED a Thomson Reuters EIKON database, 2019.

When using the resampling technique, the use of long historical data on returns and inflation allows us to maintain the links (historically given correlation specific for each phase) between the development of stock returns, bonds, inflation and other macroeconomic data. Mathematical models often fail to maintain these constraints despite their efforts, and they are broken during

[1] http://www.nber.org/cycles.html

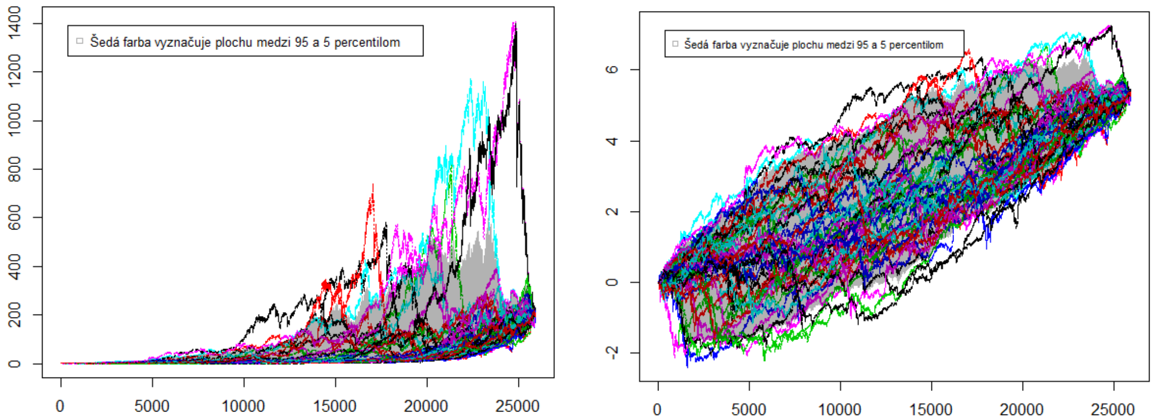
simulation. At the same time, our task is not to properly estimate the distribution of revenues and their subsequent simulation, but to provide reasonable scenarios on the various probable developments of two financial instruments or funds during the saving period of an individual.

We consider blocks b_x, where $x \in (0,1,2, \ldots 49)$, while the block b_0 is the original one where phases are ordered gradually. Limiting the number of blocks b to 50 ($b_0, b_1, \ldots, b_{49}$) is intended to limit the number of savings simulations that will be performed in the next section. Each block b_x consists of *25 882* historical daily returns classified into 36 blocks. The phases f_k are stacked into random blocks b_x, while respecting the rule of alternating growth and fall phases. Following this rule, we can maintain the alternation of growth and decline periods and the links between, r_s, r_b and τ v b_x.

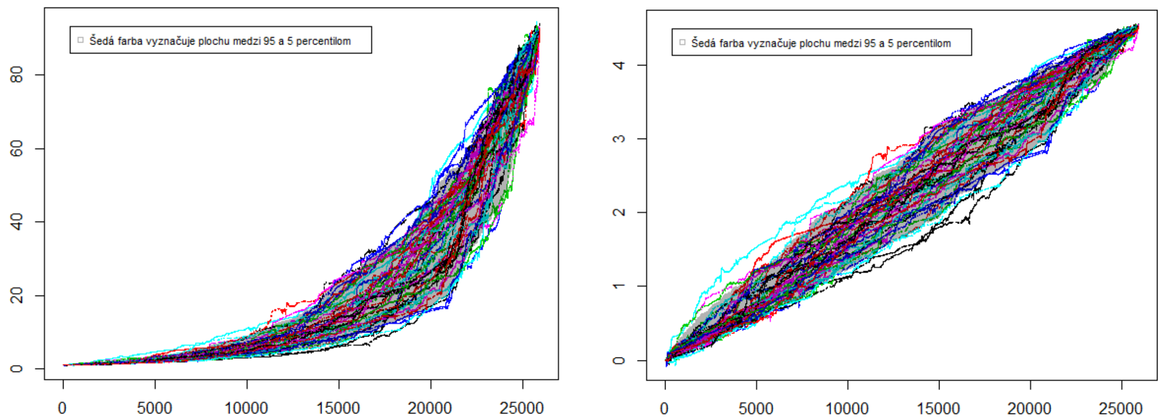
Price (or net asset value of one unit) at time t, where $t \epsilon \{1,2, \ldots, T\}$, is denoted P_t. P_1 has an initial value of 1 Eur. We calculate every other P_t for $t \epsilon \{2, \ldots, T\}$ as $P_t = P_{t-1} * (1 + r_t)$. To simulate the returns of r_t for the equity and bond fund, we use the returns $r_{s,t}$ a $r_{b,t}$ of blocks b for $t \in \{1, \ldots, T\}$. From each block b_x we gradually choose a block m with the length of the remaining days of the savings horizon, which consists of historical returns of equities, bonds and inflation, while the selection is gradually shifted by 250 trading days.

Figure 3 Prices and log-prices of 25 882 historical daily returns of equities, bonds and inflation using the resampling technique

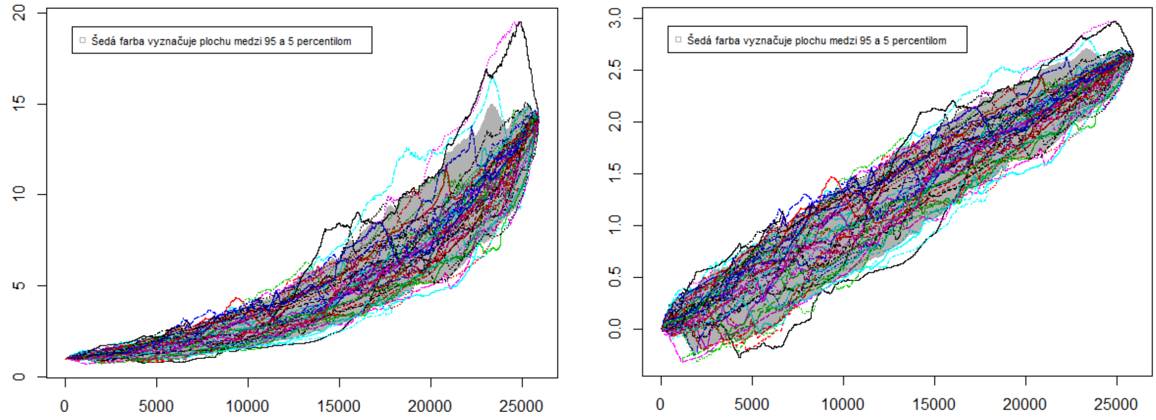
Equities



Bonds



Inflation

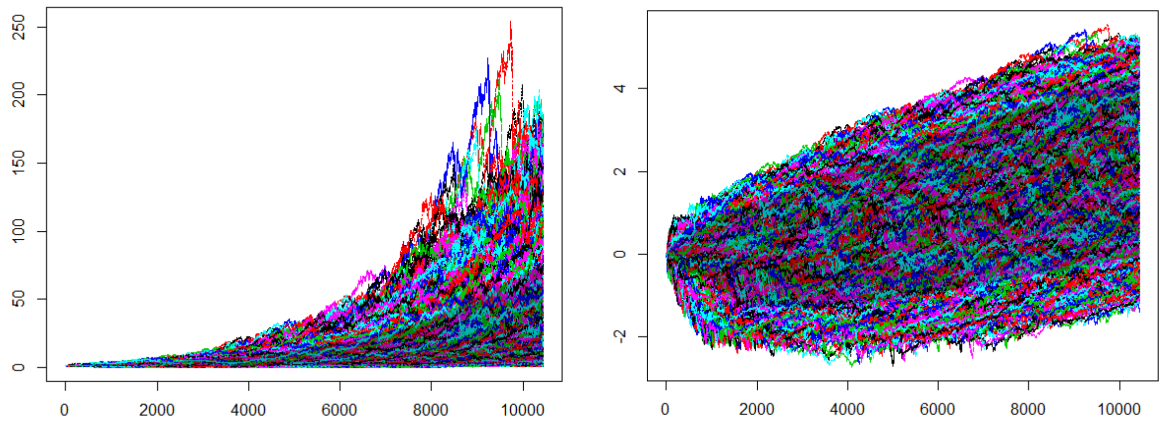


Source: Own elaboration based on FRED and NBER data, processed by R, 2019.

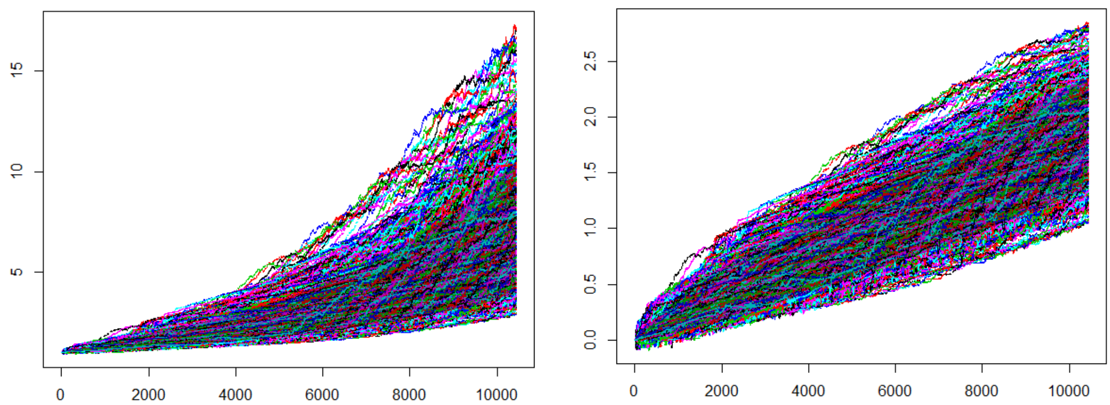
Explanation: “x-axis” – number of trading days; “y-axis” – price (left side) – log-price (right side).

Figure 4 Prices (left-side) and log-prices (right-side) of 40-years saving horizon consisting of 10 438 daily historical returns of equities, bonds and inflation

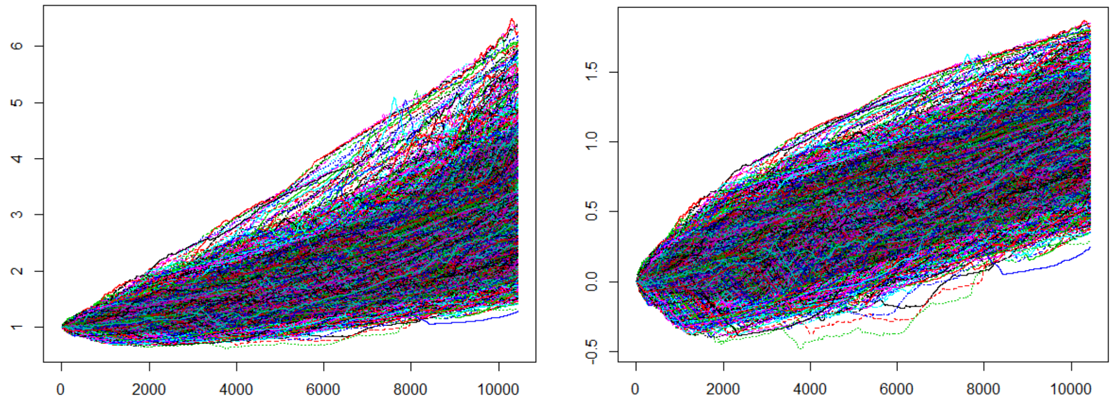
Equities



Bonds



Inflation

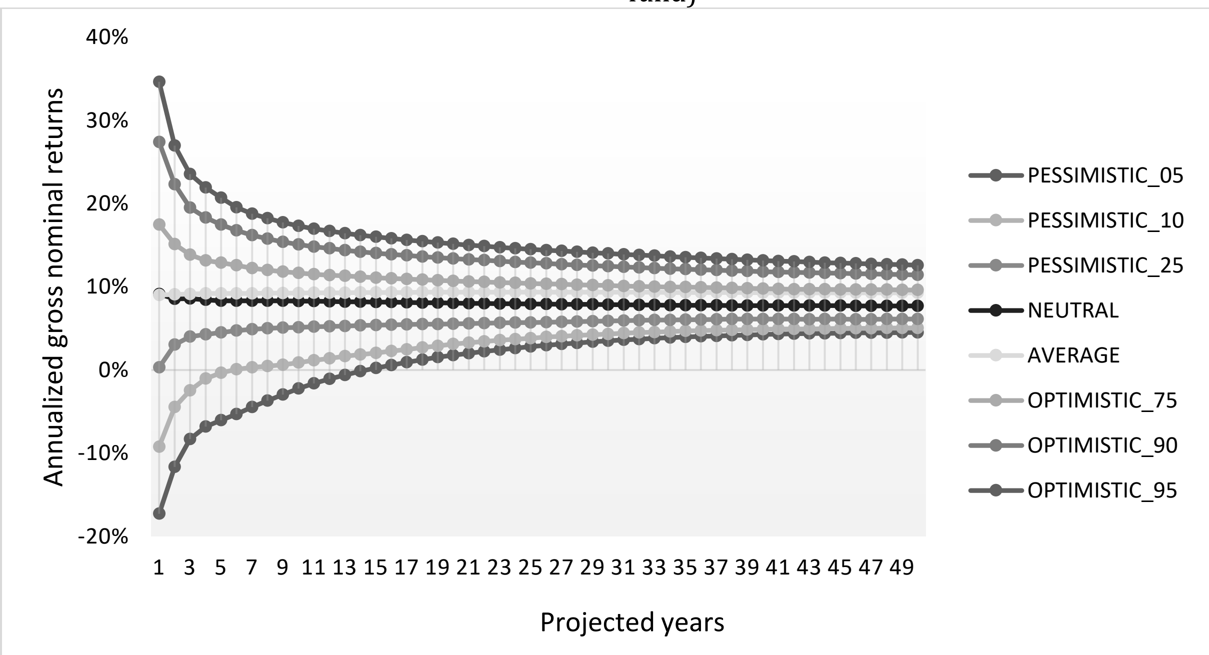


Source: Own elaboration based on FRED and NBER data, processed by R, 2019.

Explanation: “x-axis” – number of trading days; “y-axis” – price (left side) – log-price (right side)

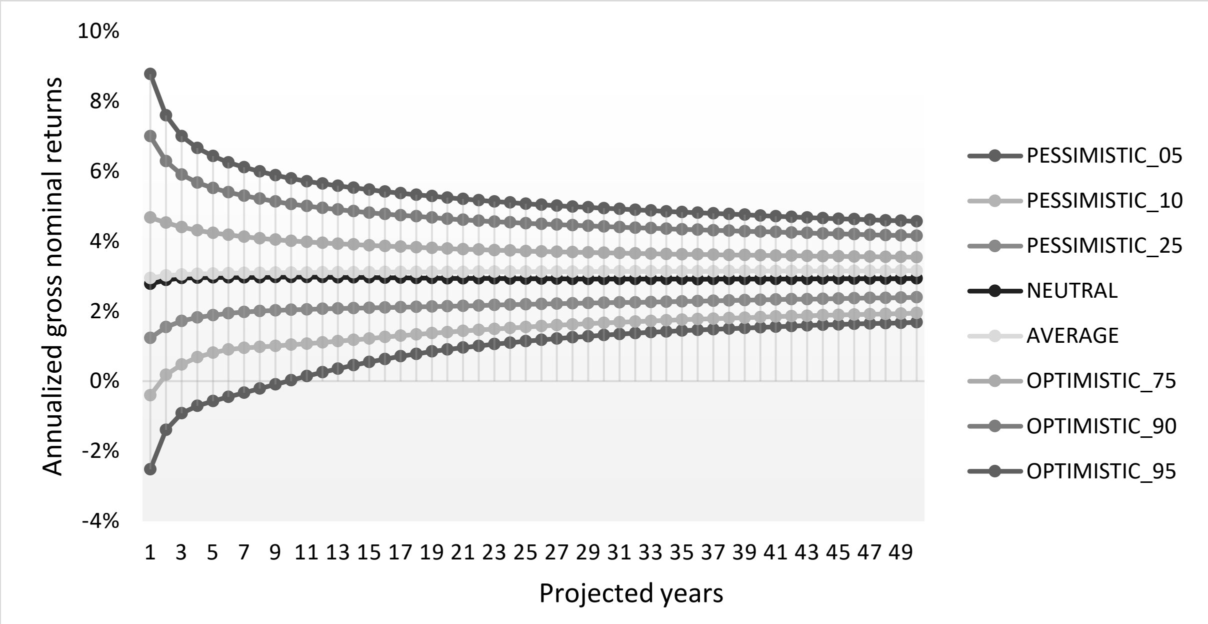
An advantage of resampling method is the possibility to generate correlated data-cubes containing various variables and scenarios, where the percentiles (scenarios) are ordered based on one variable. If we choose the historical equity returns that are often used as a proxy for the macroeconomic development, then we can create simplified data-cubes containing annualized data for equity, bond returns, inflation, unemployment, GDP growth, labor productivity, etc.

Figure 5 Projected gross nominal returns (total return) for fund with SRRI 5 (typical equity fund)



Source: Own elaboration (Orange Envelope simulation model), 2019

Figure 6 Projected gross nominal returns for fund with SRRI 2 (typical bond fund)



Source: Own elaboration (Orange Envelope simulation model), 2019

This resampling technique and generated data-cubes of variables opens new possibilities to simulate individualized life-cycle income of a saver in real-time, which gives more respectful outcomes of projected value of savings under the salary-tied contributions and opens the technological doors to create advanced online simulators and/or applications that can simulate expected value of savings/investments taking into account fee structure of financial instruments (vehicles) as well as individualized parameters of investment/saving scheme.

Method of linearized projections scenarios performance projections using PRIIPs KID methodology

Projection method based on linearized assumption on expected future returns is quite trivial method. This approach is based on the very simple principle that the future (on a certain time horizon) will bring the same average returns as it was in the previous periods. However, considering empirical evidence, financial markets developments and returns are not strictly linear, thus assuming a fixed rate of returns in each of the further periods is a massive simplification that might lead to the misleading results. The method based on the linearized returns for 3 scenarios uses empirical returns of equities and bonds over the 97 years. This method is used, for example, in the development of key investor information (KID) for Packaged Retail Investment and Insurance Products (PRIIPs) according to Regulation (EU) No 1286/2014. In view of the PRIIPs KID methodology, the Market Risk Measurement (Market Risk) approach is used to define the standard deviation, which calculates the optimistic and a pessimistic scenario. At the same time, other approaches, such as VaR (Value-at-Risk), can be used. Also, in the case of credit risk involvement for the bond part of the portfolio, a Synthetic Risk-Reward Indicator (SRRI) is created, which defines the risk categories for the investment and defines the risk-return profile of a financial instrument. Restrictions on the PRIIPs of KID methodology from an individual perspective are based on the non-disclosure of the overall portfolio structure.

In our case, we use PRIIPs KID methodology for category 2 funds. For a chosen scenario, first we calculate monthly empirical returns $r(I,s(b))_n$, than average monthly empirical return $\bar{r}(I,s(b))$ and a monthly standard deviation $SD(I,s(b))$ for equities and bonds from January 1919 until

December 2017 ($n \in \{1,2, \dots ,1178\}$). Average return and Standard deviation will be calculated as follows:

$$r\big(I, s(b)\big)_n = \frac{P_n}{P_{n-1}} \tag{2}$$

$$\bar{r}\big(I, s(b)\big) = \frac{\sum_{n=1}^{N=1178} r\big(I,s(b)\big)n}{N} \tag{3}$$

$$\sigma\big(I, s(b)\big) = \sqrt{\frac{1}{N}\sum_{n=1}^{N=1178}\big(r\big(I, s(b)\big)_n - \bar{r}(I, s(b))\big)^2} \tag{4}$$

Expected returns for unfavorable (10th percentile), moderate (50th percentile) and favorable (90th percentile) scenarios are calculated as follows:

- Neutral scenario – expected monthly returns will therefore equal:

$$r\big(I, s(b)\big)_t^{Neutral} = \sqrt[N]{e^{M_1 \times N - \delta \times {}^{\mu_1}/_6 - 0{,}5 \times \delta^2 \times N}} - 1 \tag{5}$$

- Pessimistic scenario – future expected monthly returns are calculated as:

$$r\big(I, s(b)\big)_t^{Pes} = \sqrt[N]{e^{M_1 \times N + \delta \times \sqrt{N} \times \left(-1{,}28 + 0{,}107 \times {}^{\mu_1}/_{\sqrt{N}} + 0{,}0724 \times {}^{\mu_2}/_N - 0{,}0611 \times {}^{\mu_1^2}/_N\right) - 0{,}5 \times \delta^2 \times N}} - 1 \tag{6}$$

- Optimistic scenario – future expected monthly returns are calculated as:

$$r\big(I, s(b)\big)_t^{Opt} = \sqrt[N]{e^{M_1 \times N + \delta \times \sqrt{N} \times \left(1{,}28 + 0{,}107 \times {}^{\mu_1}/_{\sqrt{N}} - 0{,}0724 \times {}^{\mu_2}/_N + 0{,}0611 \times {}^{\mu_1^2}/_N\right) - 0{,}5 \times \delta^2 \times N}} - 1 \tag{7}$$

where:

N – number of projected periods (months);

Exp - the exponential of;

M_1 - the mean of the distribution of all the observed returns in the historical period;

δ - standard deviation or volatility of the distribution;

μ_1 -skew of the distribution;

μ_2 - the excess kurtosis of the distribution.

In order to present projections in real terms, we use target annualized inflation rate according to ECB at level $\tau(I)_t$ = 2 %. Table 2 below provides historical monthly average returns and standard deviations for US price value for equity and bond indices with projected monthly returns to be used for modelled scenarios using PRIIPs KID methodology.

Table 2 Historical monthly (annual) average returns, standard deviations and scenarios´ projected returns for the period of 600 months (50 years)

	Equities monthly (*annually*)	**Bonds** monthly (*annually*)
Historical average monthly returns $\left(\bar{\mathrm{r}}(\mathrm{I}, \mathrm{s}(\mathrm{b}))\right)$	0,58627% *(6,02864%)*	0,37381% *(4,07331%)*
Historical monthly standard deviation $\left(\sigma(\mathrm{I}, \mathrm{s}(\mathrm{b}))\right)$	4,40328% *(17,22997%)*	1,14409% *(4,70833%)*
Pessimistic scenario projection $\left(\mathrm{r}(\mathrm{I}, \mathrm{s}(\mathrm{b}))_{\mathrm{t}}^{\mathrm{Pessimistic}}\right)$	0,26036% *(1,41434%)*	0,30812% *(3,17466%)*
Neutral scenario projection $r(I, s(b))_{t}^{Neutral}$	0,48988% *(4,62596%)*	0,36777% *(3,97343%)*
Optimistic scenario projection $\left(\mathrm{r}(\mathrm{I}, \mathrm{s}(\mathrm{b}))_{\mathrm{t}}^{\mathrm{Optimistic}}\right)$	0,72203% *(7,94116%)*	0,42803% *(4,94250%)*

Source: Own calculations using FRED data, 2019.

Clearly, if we model the monthly returns, we can expect to get higher expected returns compared to the modelled annual returns.

Monte Carlo simulation technique

One of the most used methods for estimating future returns of financial assets is the Monte Carlo method. This is a stochastic method using random or pseudo-random numbers. According to Wiersem (2008), Vajargah and Shoghi (2015) and Rubinstein and Kroese, (2017), Monte Carlo simulations are used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It is a technique used to understand the impact of risk and uncertainty in prediction and forecasting models. For this article, we will use the geometric Brownian motion (GBM), which is technically a Markov process. This means that the stock price follows a random walk and is consistent with (at the very least) the weak form of the efficient market hypothesis (EMH) – past price information is already incorporated, and the next price movement is "conditionally independent" of past price movements. The formula for GBM can be found below, where P is the fund price, $\bar{r}(I, s(b))$ is the expected return, $SD(I, s(b))$ is the standard deviation of returns, t is time, and ε is the random variable of Wiener´s process, where:

$$r(B., s(b)) = \frac{P_{\Delta}}{P} = \bar{r}(I, s(b))\Delta\mathrm{t} + \sigma(II, s(b))\varepsilon\sqrt{\Delta\mathrm{t}} \tag{8}$$

For formula (8) we need to fit the best distribution of equities and bonds returns. We try to find the best distribution from following distribution:

[1] Normal Gaussian distribution with parameters μ and σ ,

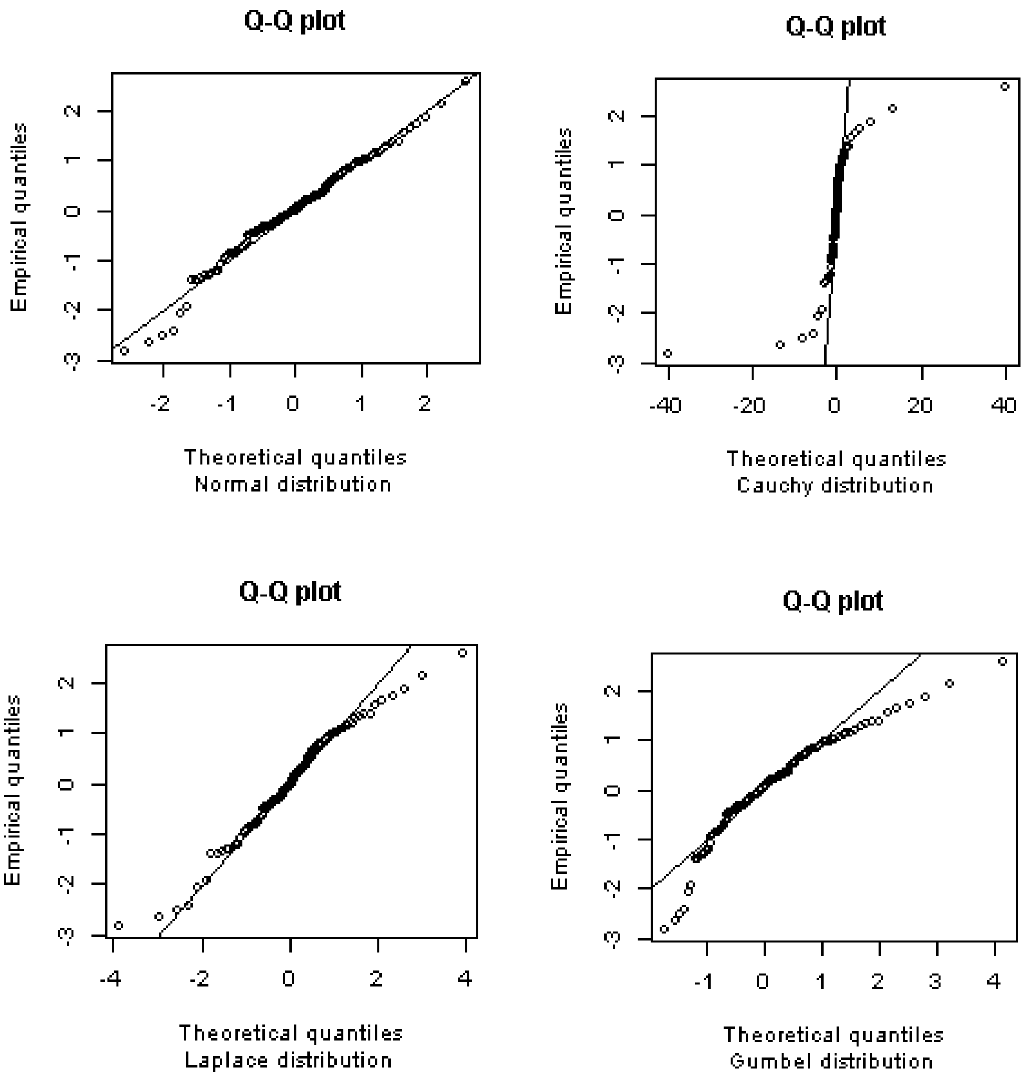
[2] Cauchy distribution witch location parameter x_0 and scale parameter γ,

[3] Laplace distribution with location parameter μ and scale parameter σ and,

[4] Gumbel distribution with location parameter μ and scale parameter $\beta; \beta > 0$.

For selection/evaluation of best fitting distribution we use Maximum-likelihood method. For this calculation we use R Cran package called "MASS" and function "fitdistr" for fitting the best distribution for equity and bond fund returns.

Figure 7 Q-Q plot of empirical and theoretical quantiles of selected distribution for equity pension fund returns



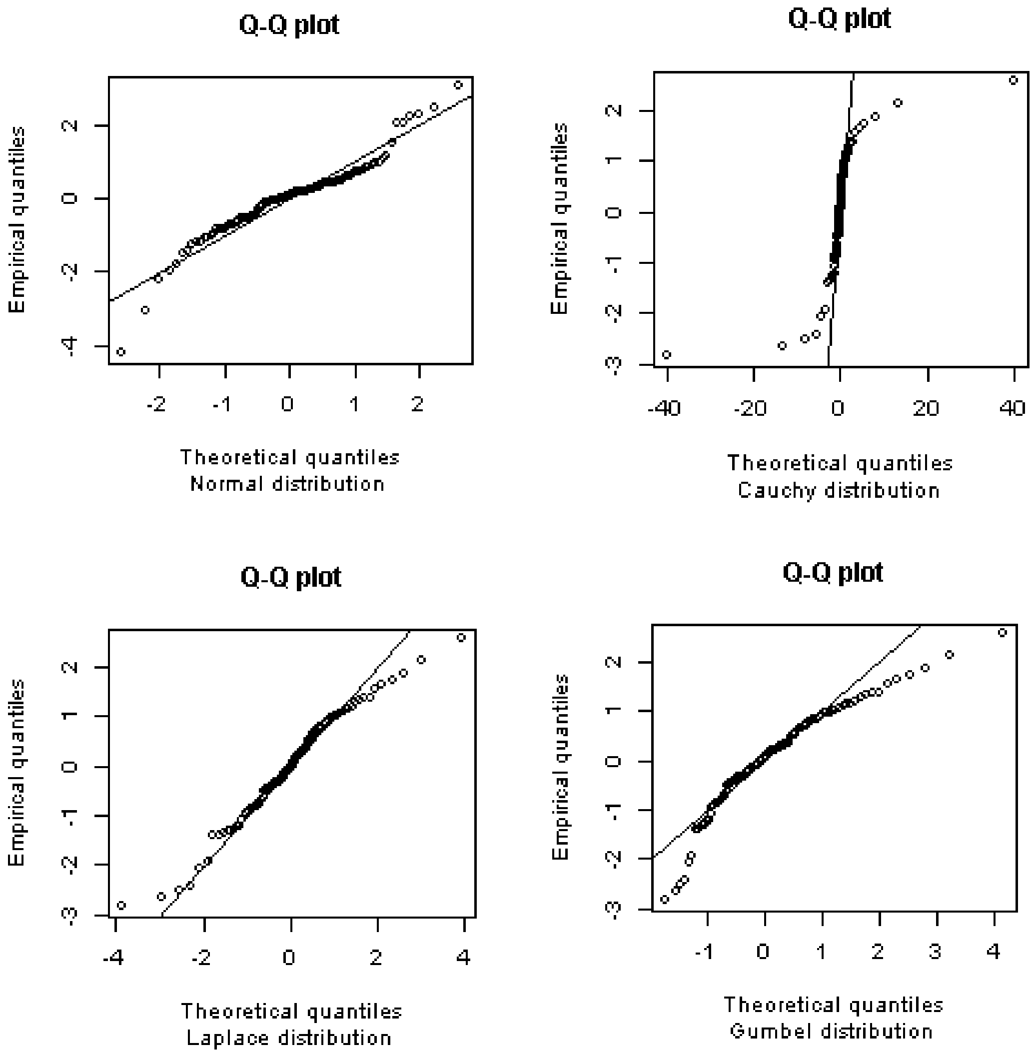
Source: Mešťan et al., 2018.

Table 3 Fit distribution results for Equity pension fund

Equity pension fund				
	Normal	Cauchy	Laplace	Gumbel
AIC	320,8377	351,1647	325,2244	393,4714
Location parameter	-1,05E-17	0,025294	0,025019	-0,34423
Scale parameter	0,995526	0,561196	0,8292	0,835127

Source: Mešťan et al., 2018.

Figure 8 Q-Q plot of empirical and theoretical quantiles of selected distribution for bond pension fund returns



Source: Mešťan et al., 2018.

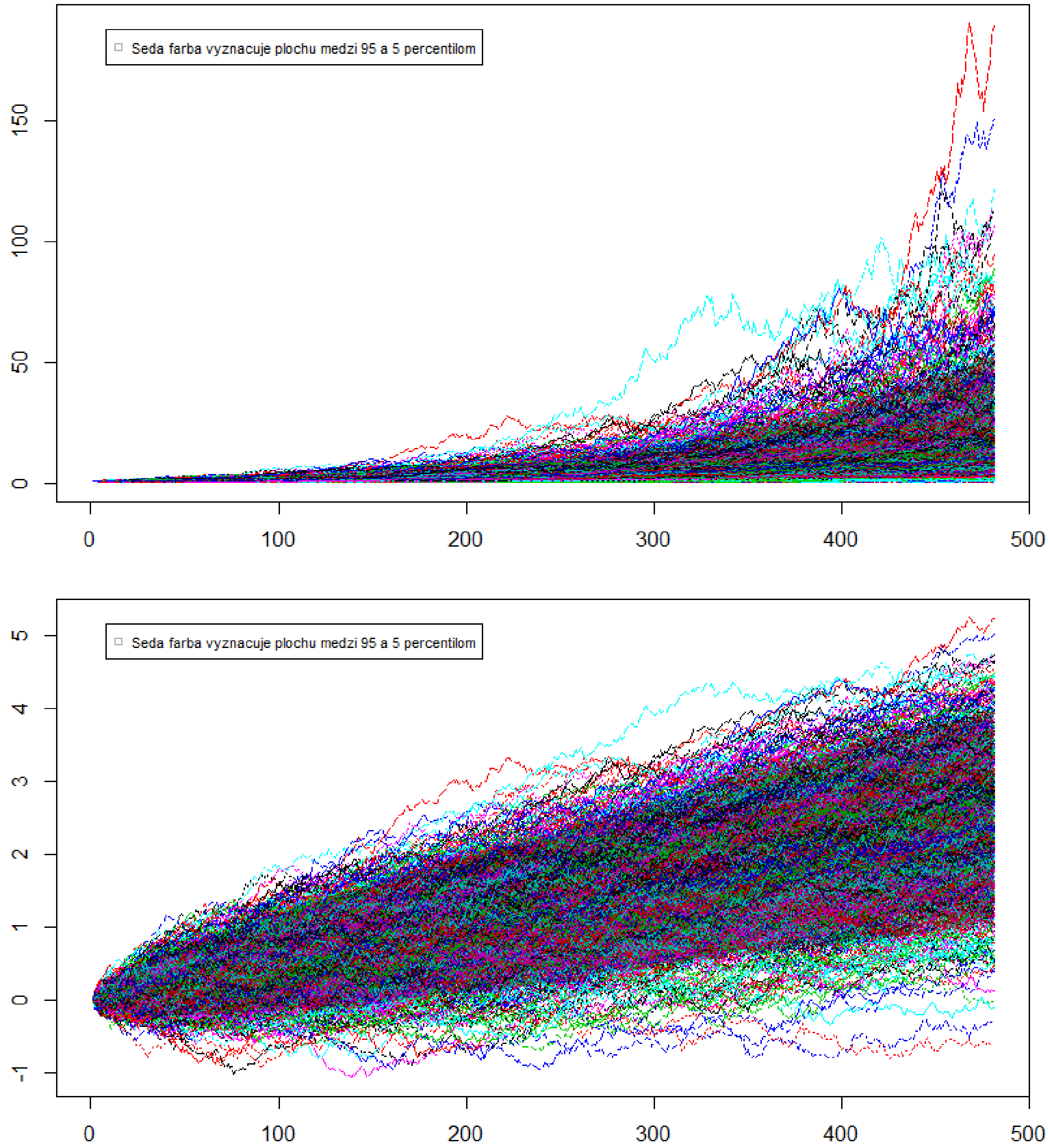
Table 4 Fit distribution results for Bond pension fund

Bond pension fund				
	Normal	Cauchy	Laplace	Gumbel
AIC	219,4354000	280,6903000	240,6032000	335,3200000
Location parameter	-3,98057E-18	0,0195243	0,0118746	-0,2489965
Scale parameter	0,521554534	0,3215522	0,7318795	0,6189742

Source: Mešťan et al., 2018.

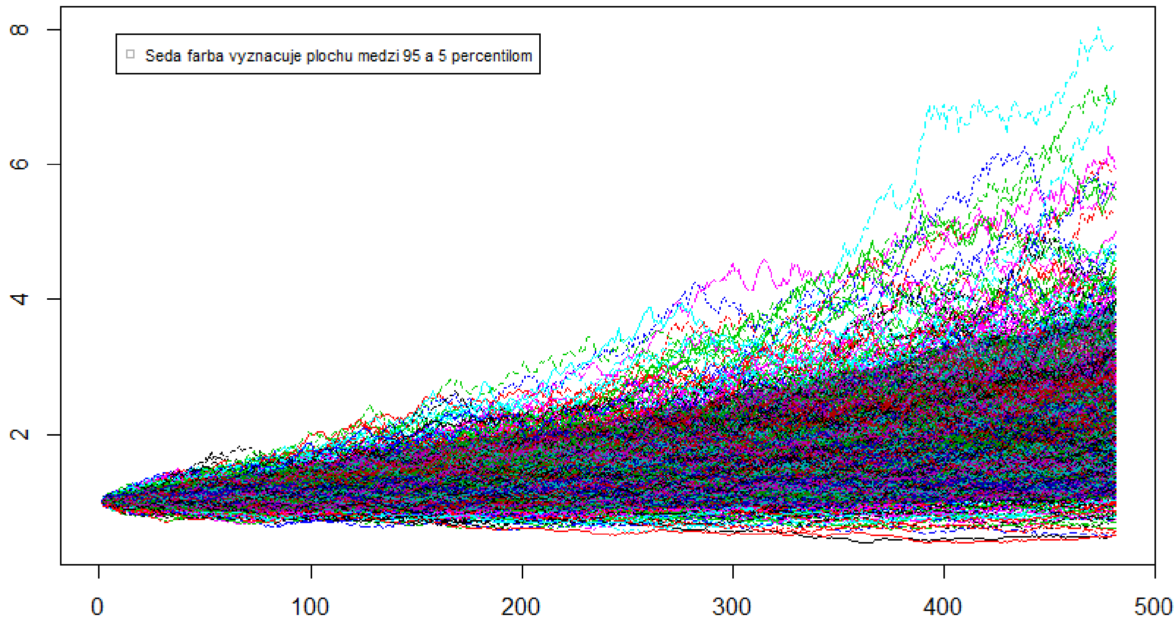
According to AIC criteria presented in tables above, we consider as a best fit distribution for equity and bond pension funds returns a Gaussian Normal Distribution. According to results, we suppose that $\varepsilon \sim N(0; 0{,}995526)$ for Equity pension fund and $\varepsilon \sim N(0; 0{,}521554534)$ for Bond pension fund. With the estimated normal distribution parameters, we ran 10.000 simulations of monthly returns for equities and bonds. The results of 480 months (40 years) long simulations of pension fund returns that invests passively into equities or bonds are presented in the figures below. Grey area represents 95th and 5th percentile, respectively.

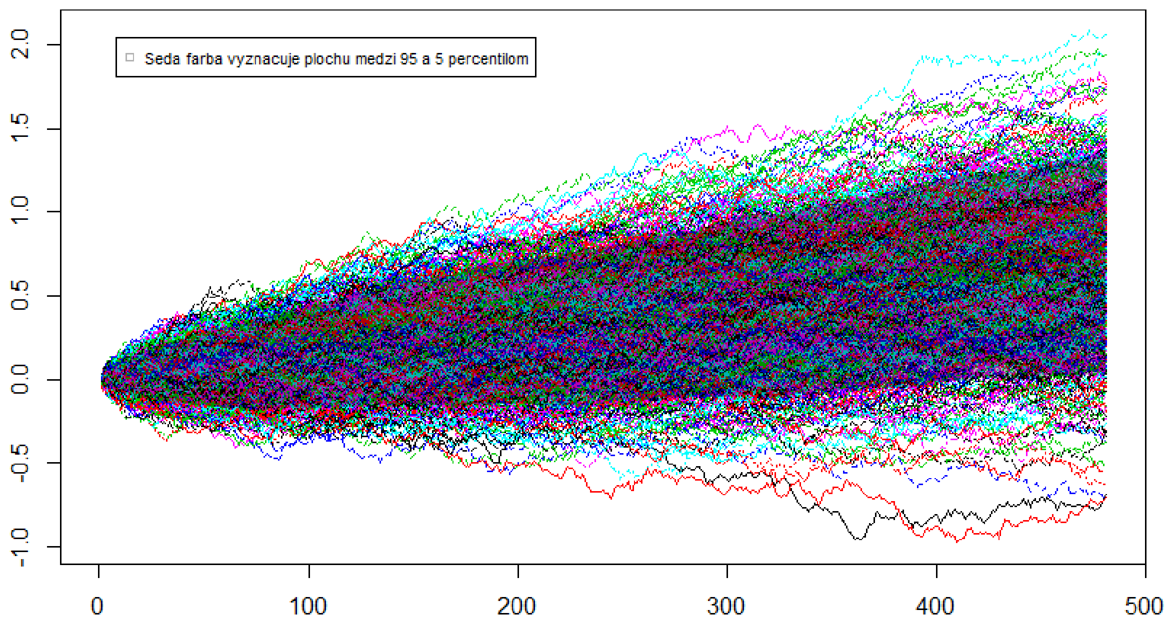
Figure 9 Monte Carlo simulations of equity index prices (log-prices) on the 480 months' timeframe



Source: Mešťan et al., 2018

Figure 10 Monte Carlo simulations of bond index prices (log-prices) on the 480 months timeframe





Source: Mešťan et al., 2018.

Comparing methods for estimating returns and future value of savings

Mešťan et. al (2018) examined differences among results when all above mentioned methods for estimating future returns (as well scenarios) are applied. To demonstrate the differences among projection methods, they created simple pension saving scheme, where an individual contributes 6% of his/her salary for the period of 480 months. They used several indicators to evaluate the results. The first evaluation indicator is the savings performance $SP_{i\ j,T}$ for each individual j and each saving strategy i. Savings performance is presented as a ratio of final savings ($S_{i\ j,T}$) and paid contributions ($\sum_{t=1}^{T} C_{j,t}$). Savings performance indicator is calculated as follows:

$$SP_{i\ j,T} = \frac{S_{i\ j,T}}{\sum_{t=1}^{T} C_{j,t}} - 1 \qquad (9)$$

Second indicator is the monthly retirement indicator ($MRI_{i\ j,T}$), which indicates the number of months during which an individual j will receive pension which is equal to his last pre-retirement wage ($w_{j,T}$). Monthly retirement indicator has an interesting interpretation value, as it allows an individual to modify his consumption behavior based on expected monthly pension benefits. If the desired individual replacement ratio is applied, the indicator can be divided by the desired replacement ratio and it provides the number of months, that the final pension pot ($S_{i\ j,T}$) can cover at certain replacement ratio of the last income ($w_{j,T}$) of an individual. $MRI_{i\ j,T}$ could be calculated as follows:

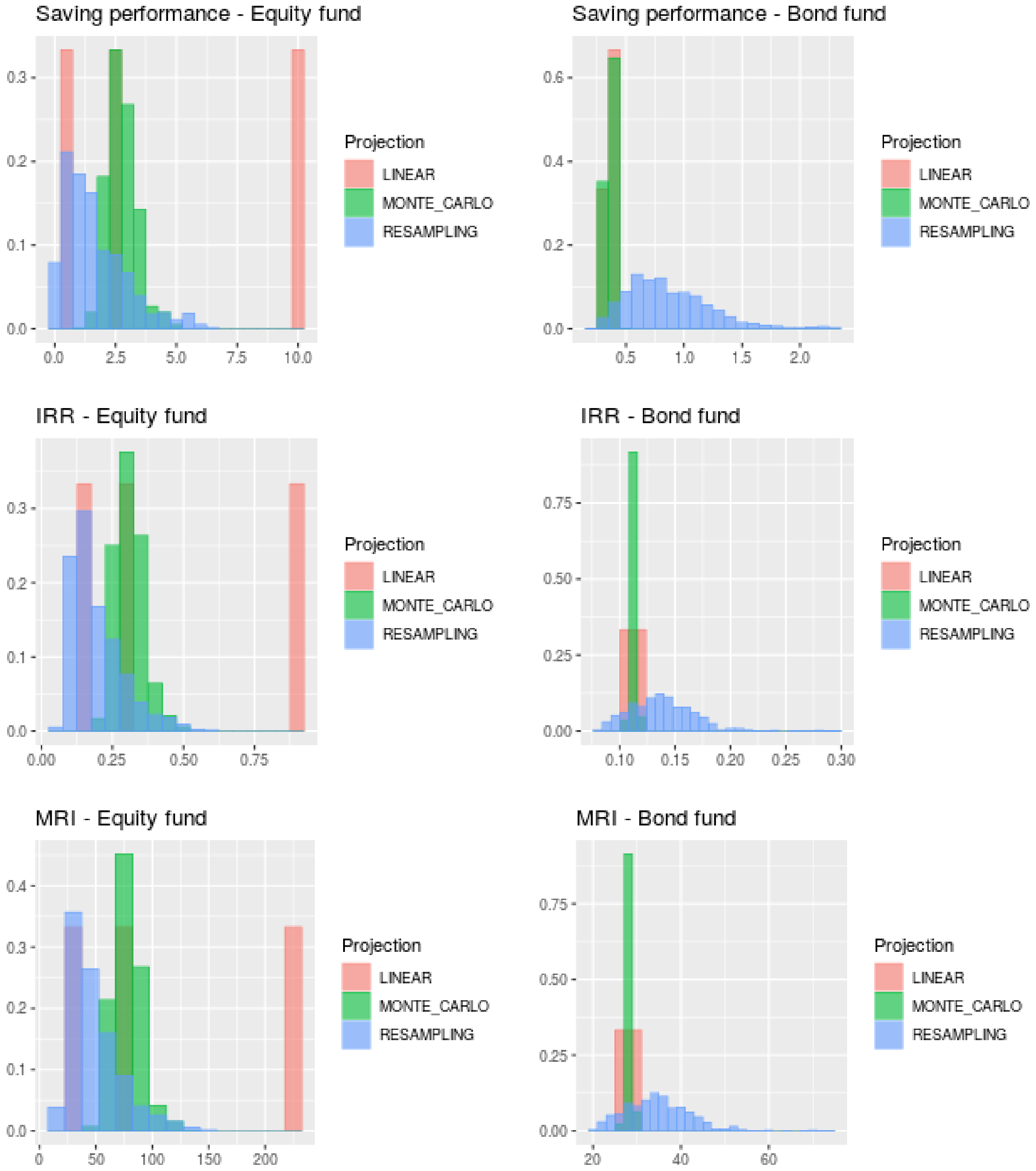
$$MRI_{i\ j,T} = \frac{S_{i\ j,T}}{w_{j,T}} \qquad (10)$$

Third indicator is called individual replacement ratio ($IRR_{i,j,T}$). This ratio presents the ability of the savings converted into life annuity ($PB_{i\ j,T}$) to cover a certain portion of pre-retirement income ($w_{i,j,T}$). We calculate it as follows:

$$IRR_{i\ j,T} = \frac{PB_{i\ j,T}}{w_{i,j,T}} \qquad (11)$$

Results of simulating expected saving scheme outcomes are presented below.

Figure 11 Comparison of expected savings results using 3 different projection techniques



Source: Mešťan et al., 2018

When inspecting the bond fund saving strategy, we can observe that in case of Linear assumptions method as well as Monte Carlo method the results are concentrated among the average. In case of the resampling method, the results are significantly shifted to the right. When the resampling method with longer history of the data is applied, the projections would show more favorable results for the bond funds saving strategy. The reason could be found in the historical data used for the simulations. Opposite results are achieved when the equity fund is inspected. Resampling method would provide more conservative results compared to the Linear assumption and Monte Carlo method. This can lead us to the conclusion that longer history of empirical data could lead to more conservative estimation of equity returns compared to the typical simulation methods like Monte Carlo or linearized assumption (as foreseen by the PRIIPs KID methodology). In other words, simulation technique does matter when presenting estimated value of savings for very long projection period.

Linearized assumptions

This approach is based on the very simple principle that the future (in a certain time horizon in the future) will return the same average returns as in previous periods. However, we know from practice that developments in the financial markets are not linear and assuming a fixed rate of returns in each of the following periods is a big simplification, which can lead to erroneous results. The method based on development scenarios assumes the use of empirical returns of a particular pension fund. This method is used, for example, to create Key Investor Information (KID) for Packaged Retail Investment and Insurance Products (PRIIPs).

From the perspective of the PRIIPs KID methodology, the Market Risk Measurement approach is used to define a standard deviation that calculates an optimistic and pessimistic scenario. At the same time, other approaches such as VaR (Value-at-Risk) can be used. If credit risk is also involved for the bond part of the portfolio, the Synthetic Risk Indicator (SRI) is created to create the investment risk categories and define the risk-return profile of the financial instrument.

Using historical data of a specific fund over a defined and relatively short period (3, 5, 10 years) allows for relatively fast (in terms of calculation) and simple (in terms of applicability) estimation of expected returns of any financial instrument. The manager will use the historical data of the managed fund over a defined period to estimate the average and standard deviation. However, the ease of applying this method is limited by its limitations. The scenarios are not probability weighted. Therefore, it is not possible to say anything more about the predicted returns or to use estimates for certain confidence intervals. At the same time, using relatively short periods (mostly within one single phase of an economic cycle) and applying the estimated variables to project tens of years of returns could be seen as trivial and instable over time.

In a more complex task such as estimating savings in a savings scheme linked to individualized participant / saver parameters, it is not possible to maintain links (dependencies) between the evolution of different asset classes (equities vs. bonds), inflation, unemployment, wage developments, etc. Thus, it is more difficult to compare the results of the estimated value of savings across a given market, i.e. between managers and the funds managed by them.

The question remains, what data should administrators use to estimate future returns? If they use the empirical returns of a particular fund over a specified period (for example, 5 years), then the situation may and will be that we use the short-term trend data to estimate the long-term trend. It is the short-term trend that may be abnormal (for example, the last 8 years of development in the financial markets), and therefore we are completely destroying the predicative ability of estimates. At the same time, we can cause cyclical decision-making on delayed data, causing savers / participants to make decisions in exactly the opposite way they should. Projected high growth in future returns due to the upward trend in the short past signal the savers / participants to transfer the savings into more risky funds, even if we can expect that such a development is unlikely for a long-term horizon. Conversely, after the markets have fallen, incorporating short-term empirical returns into the estimates, we will cause savers / participants to sell the funds after the declines and book the losses. Thus, this approach could lead to the shortism, which is undesirable when considering the long-term saving horizon.

When defining the methodology for the use of linearized scenarios, it is therefore necessary to address not only the length of historical data that enter the calculation of return estimates according to 3 scenarios, but also the question of the consistency of the data used. If we use unified data, i.e. the same for all types of funds (equity vs. bond) based on the SRRI level, the projections could at least not favor one fund with the same SRRI over another. The regulator should thus determine benchmark data for funds with various SRRI. This would ensure the same projections for the fund with the same SRRI. This data can then be provided centrally and thus from the regulator to the fund manager. At the same time, the manager would determine the appropriate benchmark ratio for equities and bonds based on the real structure of its portfolio and thus estimate the returns for each fund managed.

Individualized fund-specific historical data for existing funds can also be used. For each managed fund, the administrator would estimate the average and the standard deviation over a specified period and use them to estimate returns according to future scenarios. The differences between the fund's estimated returns will be significant and will also change significantly over time depending on the length of the history used. At the same time, this approach can trigger inappropriate behavior by savers / participants who will be subject to " chasing projected alpha"; will shift their savings based on past revenue used to estimate for the future. We therefore see this approach as very risky.

The last approach used in practice is the estimation of future returns by asset classes ("asset class specific estimation"). This approach estimates future returns based on past returns by asset classes (stocks, bonds by different maturity and credit risk, commodities, currencies, real estate, precious metals, money market instruments...). For selected asset classes, the value of estimated future returns may be centrally determined and provided to central regulators. Managers will have to take into account the portfolio structure of the managed fund and draw up returns estimated specifically for each asset class. The disadvantage is the difficulty of maintaining the database and the controllability of taking individual asset classes into account for a particular manager with respect to the expected portfolio structure. At the same time, fund managers can optimize their approach for estimated returns.

Monte Carlo simulations (with and without copula functions)

The Monte Carlo approach is a standard approach to modeling financial returns. In practical application two basic approaches from the point of view of used data need to be addressed. In the first approach, we address the question of whether to use data to estimate future returns that are set centrally according to benchmarks for different categories of funds (equity vs. bond), respectively assets classes, or Monte Carlo simulations will be performed for each fund individually based on the historical performance of that particular fund. The second approach requires solving the problem of the relationship between the evolution of equity, bond yields and inflation (necessary for individual income estimation) and wage developments to estimate the savings / participant's savings. However, having sufficiently large number of simulations, it is possible to define the expected future returns at a certain level of confidence and thus determine the quantiles of the expected savings value. However, the use of Monte Carlo simulations requires the determination of the type of revenue distribution through which estimates of future revenue developments will be made.

The main difference between Monte Carlo with copula functions and the “random walk” Monte Carlo simulations is to simulate future returns on financial assets and macroeconomic variables while maintaining the relationship between them. Applying Monte Carlo simulations to any financial instrument or macroeconomic variable would give us time series that, although randomly generated, would violate basic macroeconomic relationships. For example, when generating future returns on equity and bond indices, the relationship between stock and bond returns would be broken - if stock markets grow, bond markets tend to fall or go sideways and vice versa (currently, financial market situations can be found if both markets were growing in parallel, but rather an anomaly). It is precisely the use of the copula function to take into account historical relations between variables when simulating (generating future) revenues or changes in macroeconomic variables (unemployment, inflation). Through the copulas, we would be able to generate future returns using the Monte Carlo method, while maintaining the relationship between the stock market, bond market and inflation (which we need for future estimates of the saver's wage value).

In applying this approach, we have come across several limitations, which we present in more details below:

- choosing an "appropriate" probability distribution that will be used to generate returns on selected financial assets or macroeconomic variables;
- number of probability distributions to be included in the fitting (selection) process of an appropriate distribution to simulate returns;
- the use of the “best fit” method (maximum likelihood estimate - MLE, chi-square method, or other);
- selection of a suitable indicator through which we can judge the quality of the fit and the selection of the best distribution (Kolmogorov-Smirnov statistics, Anderson-Darling statistics, AIC, BIC, R^2 - coefficient or other).

Given the limitations outlined above, experienced statistician would be needed to be assess the process of generating expected / projected stock and bond returns or inflation and select the appropriate distribution based on the results that could be applied for the copulas.

From the point of view of Monte Carlo simulations, high demands can be expected on the processing of input data and the best probability distribution, which logically reduces the willingness of the participating entities to invest significant resources (financial, time, technical or human) in the implementation of this solution.

Moving-block bootstrapping (resampling)

When using the resampling method, the critical point is the choice of input data for the returns of financial instruments. Since bootstrapping assumes a relatively long time series of data from which new blocks can be composed by resampling, it is advisable to use benchmark data for fund types (equity vs. bond) and create blocks of simulated time series centrally (unified approach). Consequently, it is possible to create individualized blocks of simulated data for individual funds according to the real structure of their portfolio.

Resampling as a method is not extremely demanding in terms of computing, software or human work, and much of the tasks can be automated. Data can be collected and provided centrally, while back-checking of created individualized blocks of simulated data according to funds is also ensured.

The biggest advantage is the non-violation of the relations between the development of individual macroeconomic variables, which enables the implementation of the expected inflation, wage growth or unemployment in the calculations and estimates of the future value of savings.

However, the choice of a particular method depends in particular on the requirement for the accuracy and credibility of the estimated returns and, consequently, of the estimated pension benefits. At the same time, it is appropriate to take into account the expected costs and investment into the capacity building. Finally, it is appropriate to address the requirement to ensure the provision and maintenance of data and the control of the calculation methodology used, which should not differ significantly between administrators.

Contributions – fixed and variable

Individual salary tied (variable) contributions

Let´s assume that a saver contributes a part of his salary towards the PEPP regularly. Let the variable contribution as a percentage of one´s salary y at time t be defined as $c(y)_t$. Than the monetary value of a contribution $C(y)$ shall be defined as:

$$C(y)_t = y^i_{h,t} * c(y)_t \tag{12}$$

Let us also consider the possibility of distributing the contributions into two funds with different risk-reward profile, where equity pension fund is defined as s and bond pension fund as b. The weighting w defines the proportion of contributions directed towards the pension fund (vehicle). Therefore:

$$C(y)_t = w^c_{s,t} * C(y)_t + w^c_{b,t} * C(y)_t \tag{13}$$

where $w^c_{s,t}$ represents the share of contributions directed into the equity pension fund (vehicle) at time t and $w^c_{b,t}$ represents the share of contributions allocated into the bond pension fund (vehicle) at time t according to the following conditions:

$$w^c_{s,t} + w^c_{b,t} = 1 \tag{14}$$

$$w^c_{s,t}; w^c_{b,t} \in \langle 0, 1 \rangle \tag{15}$$

It is obvious that the salary tied contributions would be influenced significantly by two factors – labor productivity and inflation, as both have impact on nominal value of salary. Modeling the life-cycle income of an individual is presented in the following sub-chapter.

Individual fixed contributions

Most of the voluntary savings and/or investment products assumes fixed contributions that do not change in line with the salary increase. In some cases, only the inflation is taken into account when adjustments to the level of contributions is considered. Let us therefore formulate the fixed contribution $C(a)$ that reflects the absolute fixed value of contributions irrelevant from the future changes in the salary of an individual or inflation.

The absolute nominal amount of the PEPP contribution would therefore remain fixed for the entire saving horizon, but still can be allocated into two vehicles (pension funds). Allocation of fixed contribution among two pension vehicles can be defined as:

$$C(a)_t = w^c_{s,t} * C(a)_t + w^c_{b,t} * C(a)_t \tag{16}$$

where the conditions (14) and (15) are valid.

Simulating life-cycle income

When presenting the expected pension benefits, removing the factor of changing income over the career would produce misleading outcomes regarding the adequacy of savings. Understanding the life-cycle income process of an individual under the conditions of the labor market shocks and permanent components like age and education has a significant impact on the amount of paid social insurance and pension contributions and thus on the expected amount of paid benefits. Robust academic models often surpass the ability of pension providers to apply such models for the estimation of expected benefits as required by a regulation. However, oversimplification of life-cycle income parameters estimation based on trivial fixed parameters and linearized assumptions could lead to misleading information given to the savers. We present a stochastic model for the estimation of age and education specific life-cycle income under the existence of unemployment risk.

Life-cycle income dynamics has been studied since Mincer´s (1958) seminal work and remains in the foresight of many researchers. Generally accepted hypothesis that life-cycle income function is rather hyperbolic than linear has given rise to many empirical studies using longitudinal administrative data. Many influential economic studies have recognized that the use of current income as a proxy for long-run income can generate important errors-in-variables biases (Haider and Solon, 2006). In order to address the concavity of a life-cycle income function, the models should employ several key assumptions like the changing preferences towards the job position with the rising age, diverging paths of the life-cycle income functions for different education levels, earnings inequality due to the persistent and transitory components such as unemployment or maternity. Lagos at al. (2018) analyzed life-cycle wage growth in 18 countries using large-sample household survey data and their main finding is that experience-wage profiles are on average twice as steep in rich countries as in poor countries. In addition, more educated workers have steeper profiles than the less educated ones. Their findings are consistent with theories in which workers in poor countries accumulate less human capital or face greater search frictions over the life cycle.

Guvenen (2009) pointed to the long-term effects the unemployment on future income of an economic agent. Indeed, the long-term effects of unemployment as one of the temporary labor market shocks have led to the study of this shock in the context of the lifetime of the individual's life-expectancy hypothesis. The dynamics of the development of idiosyncratic risks are examined through stochastic models of lifetime income, with the modeling of the likelihood of temporary shocks (Guvenen and Smith, 2014). The influence of the variable associated with years of practice, which essentially increases the labor productivity, was also confirmed by Katz and Murphy (1992). We work with the main assumption that the education of an economic agent is a permanent determinant of his income and has a significant impact on the course of life-long income function (Balco et al., 2018).

Faber (1998) examined the length of the employment for age and educational cohorts using empirical data from the Current Population Survey from 1973 to 1993. In his research, Faber confirmed that the duration of the employment relationship, i.e. the length of staying in the same position, is strongly dependent on the age of an individual. He has shown that younger cohorts (cohorts of 25-34 and 35-44 years of age) frequently change the position, and, contrary, an individual prefers job stability with the increasing age (education cohorts 45-54 and 55-64 years).

At the same time, he rejected the hypothesis that the length of stay in one job is the same across educational cohorts. Raymo et al. (2010), based on data from the Wisconsin Longitudinal Study, examined the impact of work experience in an earlier age of an individual on his preferences for the nature and type of work performed at an older age. They showed that, at a higher age (53+), individuals prefer stable and less demanding work or even part-time work. These findings should be incorporated into the estimation of lifecycle function parameters in the form of time preferences.

Low et al. (2010) distinguish two types of risks in the labor market: exogenous risks such as job disruption that directly affects unemployment, and endogenous risks such as greater variability in labor productivity. Unlike the fall in labor productivity, which is reflected in wage rigidity, job cuts are a transient shock to the individual's income. These risks have a considerable impact on an individual's lifecycle income.

When constructing the model, the main constraint is the reliable long-term series of data for relatively young democracies such as the Central and Eastern European countries. Lack of long-term longitudinal data for individual wages combined with the transitory period of economies do not allow to model stable scenarios for long-term projections. Therefore, we decided to combine long-term data from developed economies and short-term administrative data from Slovakia. Combining longitudinal data on wage profiles with the long-term data series of the macroeconomic variables from the United States and linking them to the Slovak short-term administrative data on the wage profiles allow us to estimate life-cycle income even for countries where the reliable longitudinal data are still unavailable.

First, we present the longitudinal data from the American Community Survey presented by Julian and Kominski (2011). However, these data present the life-cycle income for 9 educational cohorts. In order to compare the Julian and Kominski data to the 2004 – 2018 administrative data for Slovakia (Fodor and Cenker, 2019) obtained from the Ministry of Finance of Slovakia, we need to combine educational cohorts into 3 educational cohorts for which the data are available in Slovakia.

We used longitudinal data from the American Community Survey (ACS, 2014) to estimate income functions and subsequently created 3 educational cohorts (*j*), based on the ISCED 2011 International Education Classification as presented below:

a) Primary education level:
    a. Early childhood Education – ISCED level 0
    b. Primary education – ISCED level 1
    c. Lower secondary education -ISCED level 2
b) Secondary education level:
    a. Upper secondary education – ISCED level 3
    b. Post-secondary non-tertiary education – ISCED level 4
    c. Short-cycle tertiary education – ISCED level 5
c) Tertiary education level:
    a. Bachelor or equivalent – ISCEL level 6
    b. Master or equivalent – ISCED level 7

c. Doctoral or equivalent. ISCED level 8

Then, we transform the values into the coefficients of the average wage. Comparing the transformed values allows us to inspect whether the data from Julian and Kominski would fit the administrative data for Slovakia. Based on the results of the data comparison, we use curve fitting technique to estimate the regressors of age (x) for 3 educational specific (j) income functions that should follow the polynomial function:

$$y_{j;x} = a + b_j x + c_j x^2 + \varepsilon \tag{17}$$

Further, we apply the estimated income functions on the Slovak working population and calculate labor productivity using the simulation method described below. The results are than compared to the projected labor productivity growth from the Ageing Report 2018 (EC, 2018). Differences in the projected labor productivity and estimated labor productivity from our model are then recursively incorporated into the fitted life-cycle income functions.

However, the income function should be influenced also by the temporary labor market risks. According to Cooper (2014) and Guvenen et al. (2015), if an economic agent drops out of the labor market for a certain period, his wage departs from a full uninterrupted income function, since the skills, working habits, and experience during the period of unemployment don´t improve. Thus, we can create the scenarios, where the unemployment risk is incorporated. In order to estimate nominal values of projected income, we incorporate also projected inflation from the macro scenarios. Given the existence of unemployment risk and inflation, the nominal wage (w) could be expressed as:

$$w_{j;t} = \begin{Bmatrix} w_{j;t};\ t = 1 \\ w_{j;t-1} \times (1+\tau_t); U_t = 1, t \in < 1, T > \\ w_{j;t-1} \times \omega^*_{j,t} \times (1+\tau_t); U_t = 0, t \in < 1, T > \end{Bmatrix} \tag{18}$$

Where $\omega^*_{j,t}$ represents monthly changes in the real wage based on the estimated life-cycle income functions; τ_t represents the inflation in time t. $U_t = 1$ means that the economic agent is unemployed at time t, while $U_t = 0$ means that the economic agent is employed at time t. If an economic agent is employed ($U_t = 0$), his income function depends on the development of inflation and the increased labor productivity over time. In the case that the economic agent is unemployed ($U_t = 1$), his lifetime income function changes over time only by the impact of inflation and the labor capital remains constant.

Secondly, in order to get age and educational specific unemployment risk, we developed transition matrix, that transform general unemployment rates into age and specific ones. The probability of unemployment is reviewed every year by the rate of change in total unemployment from the macroeconomic block. In modeling the probability of changes in the employment of an economic agent at age x, education j at time t, the transition matrix has the following form:

$$M_{x,j,t} = \begin{pmatrix} p_{U_t=1 \to U_t=1\ x,j,t} & p_{U_t=1 \to U_t=0\ x,j,t} \\ p_{U_t=0 \to U_t=1\ x,j,t} & p_{U_t=0 \to U_t=0\ x,j,t} \end{pmatrix} \tag{19}$$

For each element of matrix M, the probability of status change (p) applies, where:

$$0 \le p \le 1$$

Initial transition matrix with probabilities (odds ratios) has been created using cross-sectional data on age and educational specific unemployment from the Ministry of Finance of Slovakia for the reference period of 2004 until 2018.

Thirdly, we use the model, that generates macroeconomic scenarios, which in turn influence the individual attributes of age and educational cohorts, mainly the wage and employment status. The model is based on the moving-block bootstrap (resampling) method, which allows to increase the number of simulations by pseudo-randomly generated macroeconomic scenarios while preserving correlations among macroeconomic indicators (k_k). The model has been described in the previous sub-chapter devoted to the modeling fund returns.

Data on monthly macroeconomic indicators for the period of 1919 until 2017 include are richer than solely returns and include also unemployment, inflation, GDP change and labor productivity. The empirical time series of macroeconomic variables (k_k) contain 1164 monthly values. Since we want to obtain monthly changes for each macroeconomic variable, in total we have 1163 monthly changes ($\Delta k_{j;t}$), where $t \in 1; 2; \ldots\ldots; 1163$.

Each period (i) has a precisely identified time series of macroeconomic variables (Δk). Let us define a vector of time series of monthly changes in macroeconomic variables ($\Delta k_{k;t}$) where the lower index k represents the observed macroeconomic variable (in the range *1 to K* variables). Let us call the generated vector as a simulation block ($\boldsymbol{r_N}$). The first simulation block ($\boldsymbol{r_1}$), which consist of empirically measured values of monthly changes in observed macroeconomic variables ($\Delta k_{k;t}$), and contain all up-trending and down-trending periods in a sequential order from 1 up to 18, has a following form:

$$\boldsymbol{r_1} = \begin{bmatrix} \Delta k_{1;1} & \cdots & \Delta k_{1;1163} \\ \vdots & \ddots & \vdots \\ \Delta k_{K;1} & \ldots & \Delta k_{K;1163} \end{bmatrix} \tag{20}$$

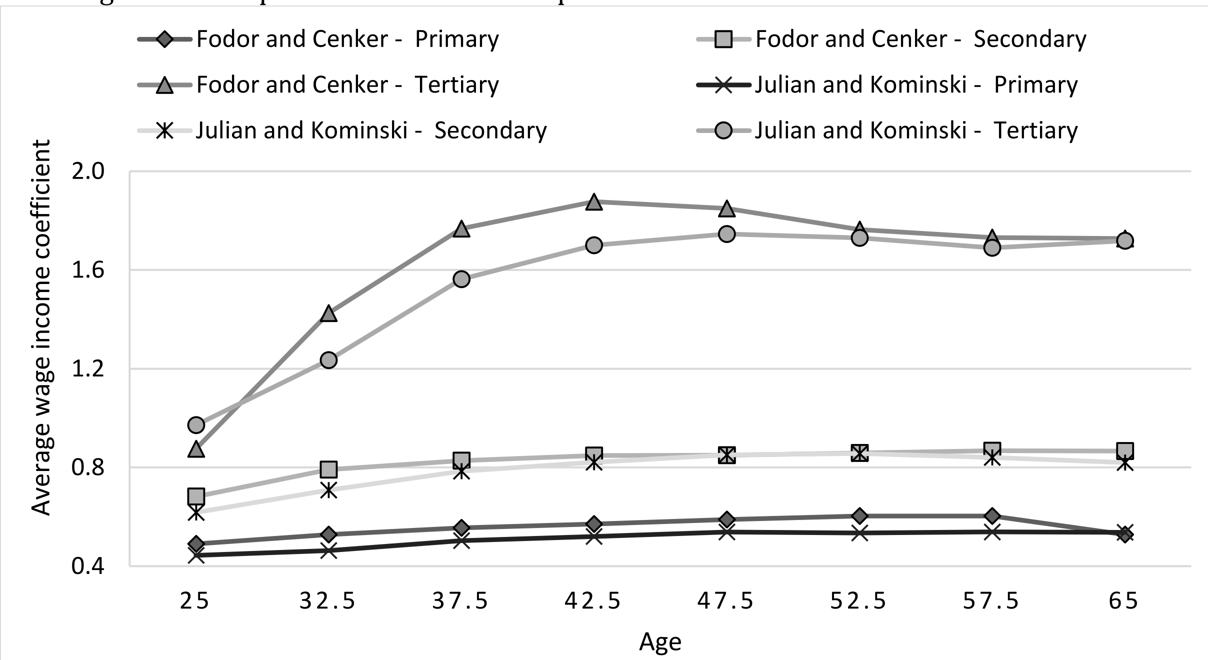
In order to increase the number of simulations, we have created new simulation blocks using resampling procedure. We combined up-trending and down-trending periods without repetition while maintaining the rule that each period (i) can only occur once. Applying resampling technique, we have got a total of 150 simulation blocks ($\boldsymbol{r_N}$, where $N \in 1; \ldots; 150$).

Finally, we can expose our age and education cohorts the randomness of external macroeconomic development. The simulation at the level of a specific age and educational cohort is performed as follows. For each simulation block ($\boldsymbol{r_N}$), we start from the first month (*t = 0*) with the empirically gathered data on wages and respective unemployment rates for each age and educational cohort from Statistical Office of Slovak Republic for the year 2016. Each month the values of the macroeconomic indicators' changes, which affects the individual status parameters of an economic agent, where the employment status is affected by the formula (19) and wage change by the formula (18). We continue with simulations of each age and educational cohort until the age (x) of the cohort reaches the statutory retirement age (R) set at 69 years. For each cohort, we perform simulations of the length from 1 year (age cohort of 68) to the remaining length of the working career (D, where $D = R - x_{j;t}$). If for example, the age of the youngest cohort with professional degree (PhD. degree) is 27 years, then remaining working career (D) equals 42 years. This means, that within each simulation block, we can move this cohort 55 times. The total number of simulations for the cohort at age x and education j, which remains in the labor market for D years is given by the product of the number of blocks, the length of the block, the remaining length of the working career and number of status possibilities (employed / unemployed). For example, for an economic agent with high-school degree who enters the labor market at the age of 19, we perform simulations ranging from 1 year (12 months) to 50 years (600 months) as we anticipate that he retires at 69 years. Totally, for this age and educational cohort, we get 3,330,600 simulations that form the scenarios for the life-cycle income and employment probabilities during the entire working career.

Generated scenarios allow us to inspect, what was the estimated development of individualized (cohort) variables under the various macroeconomic scenarios. The scenarios represent percentiles, where the higher percentile corresponds to the better macroeconomic conditions.

Initial phase of the research was to compare the US longitudinal data on income from ACS survey obtained from Julian and Kominski (2011) and compare them to the relatively short-term data on income for Slovakia obtained from Fodor and Cenker (2019).

Figure 12 Comparison of educational specific income coefficients for US and Slovakia



Source: Own estimations using Julian and Kominski (2011) and Fodor and Cenker (2019) data, 2019

Presented data for 3 educational cohorts suggests the possibility to estimate the income functions using more reliable longitudinal data from Julian and Kominski (2011). However, we can observe higher income growths for younger tertiary education cohorts suggesting higher labor productivity for younger university educated individuals in Slovakia.

Estimated regression parameters for all educational cohorts including the statistics are presented in the table below.

Table 5 Estimation of regression parameters for educational cohorts using Julian and Kominski (ACS) data vs. Fodor and Cenker (Ministry of Finance of Slovakia) data

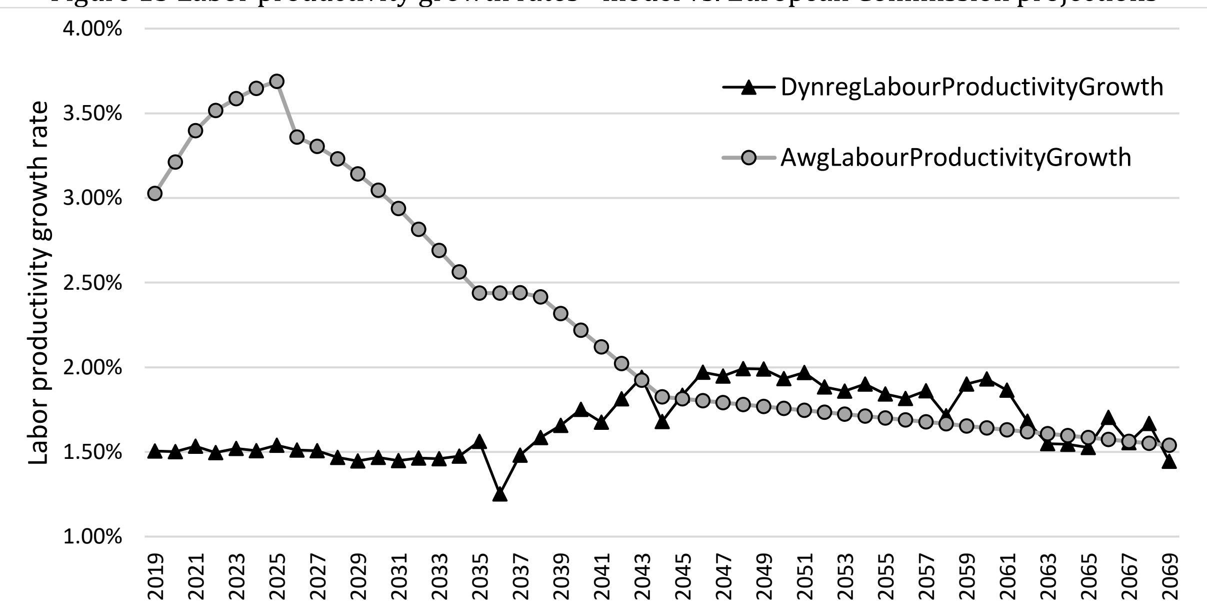
	Fodor and Cenker – Ministry of Finance			Julian and Kominski – ACS		
Regressors:	**Primary**	**Secondary**	**Tertiary**	**Primary**	**Secondary**	**Tertiary**
a	*0,12932159*	*0,28250215*	*-1,74468112*	*0,22421654*	*0,00056538*	*-0,99783602*
b	*0,00155654*	*0,00178797*	*0,01189284*	*0,00090247*	*0,00266206*	*0,00846756*
c	*-0,00000131*	*-0,00000135*	*-0,00000972*	*-0,00000064*	*-0,00000207*	*-0,00000647*
Standard Error	0,01724486	0,01588758	0,11715183	0,00860669	0,00946103	0,07018141
R^2	0,87158229	0,95401296	0,91162257	0,96190934	0,99082153	0,95713682
Correlation	0,93358572	0,97673587	0,95478928	0,98076977	0,99540018	0,97833370
Parameter Standard Deviations:						
a_stddev	*0,07863428*	*0,07244530*	*0,53419697*	*0,03924536*	*0,04314108*	*0,32001804*
b_stddev	*0,00030443*	*0,00028047*	*0,00206811*	*0,00015194*	*0,00016702*	*0,00123893*
c_stddev	*0,00000028*	*0,00000026*	*0,00000190*	*0,00000014*	*0,00000015*	*0,00000114*
Parameter Uncertainties, 95%						
a_unc	*0,20213585*	*0,18622658*	*1,37319704*	*0,10088341*	*0,11089767*	*0,82263257*
b_unc	*0,00078256*	*0,00072096*	*0,00531624*	*0,00039056*	*0,00042933*	*0,00318477*
c_unc	*0,00000072*	*0,00000066*	*0,00000488*	*0,00000036*	*0,00000039*	*0,00000292*

Source: Own calculations, 2019

Comparing US longitudinal data to the Slovak short-term administrative data shows that the model fits better the US longitudinal data, where all key statistics perform better including Standard Error, parameters´ standard deviations and coefficient of determination.

Secondly, applying estimated life-cycle income functions on the Slovak working population and performing microsimulations using resampling method allows us to get expected development of labor productivity and average wage over the next 50 years. Then we compare the labor productivity projections on the 50th percentile with the European Commission projected labor productivity (Figure 13).

Figure 13 Labor productivity growth rates - model vs. European Commission projections

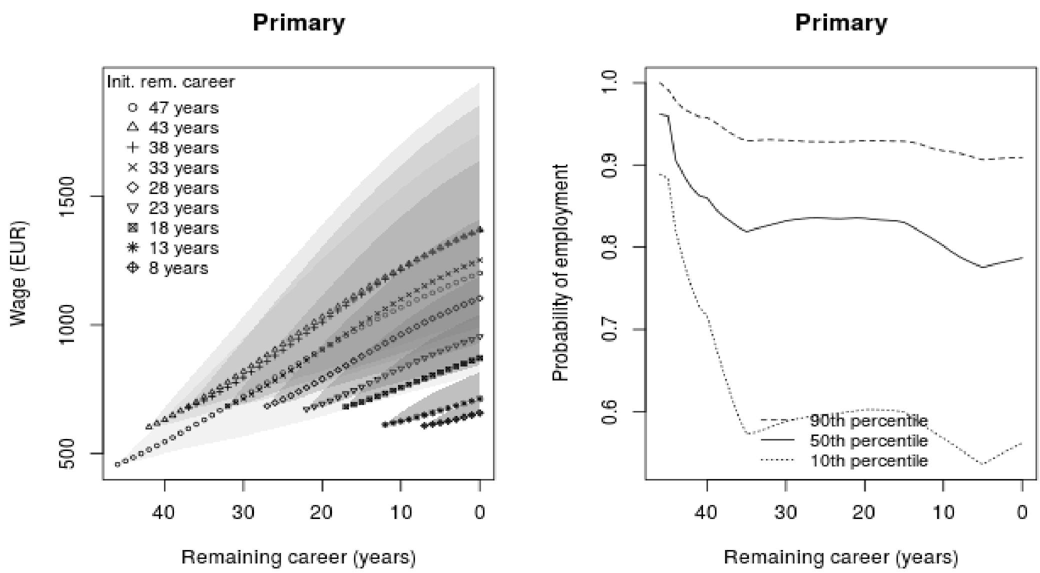


Source: Own calculations, 2019

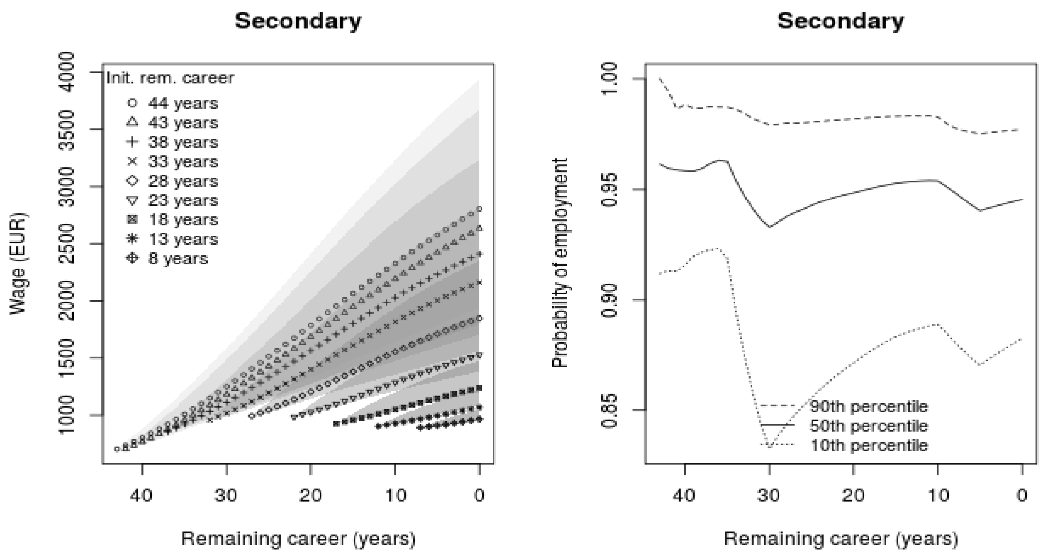
Our model with estimated life-cycle income functions keeps the labor productivity growth rates relatively stable around 1.5% annually for the next 25 years and underestimates expected labor productivity growth rates compared to the European Commission projections. However, the second projected period provides similar projections on the labor productivity growth rates. In order to prepare the model for practical usage, we incorporated the labor productivity convergence factor and adjusted the income functions regression parameters in a way that redistributes the necessary increase in the labor productivity into individual life-cycle income functions evenly. The projected life-cycle income functions for 3 educational cohorts including unemployment risk under various economic conditions (scenarios) are presented below.

Figure 14 Estimation of life-cycle income functions based on the age and education level of an individual (Slovak case)

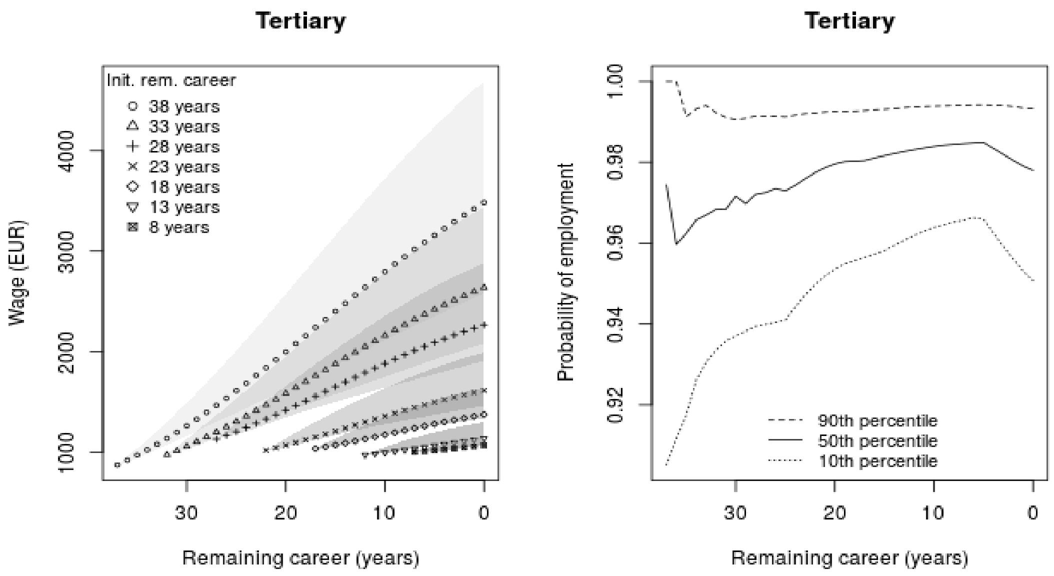
Primary education level



Secondary education level



Tertiary education level



Source: Own calculations (Orange Envelope simulation model), 2019

First, estimation of life-cycle income using our approach brings more realistic outcomes compared to the simplified assumptions of linear growth tied to the general total factor productivity growth that is often used when estimating future wage growths. Decreasing coefficients over the life-cycle clearly emphasize other research findings echoing that an economic agent prefers wage growth during the early stages of his/her career. In opposite, later stages of a career are associated with the preferences for the job stability. An economic agent is willing to accept lower wage growth compared to the rest of the working population in exchange to the job stability and working-hours flexibility.

Our approach also incorporates recent findings, that regardless of the previous career, employers do apply similar wage increase mechanisms for older workers. In other words, later in the career, the age of a worker is more dominant factor than the years of working experience and human capital. For the same age and educational cohort, the coefficients of wage growth during the last 10 years of working career in all scenarios are quite similar with relatively low variability.

At the same time, we can observe, that the model predicts lower changes for significant up-tick for mid and older cohorts with lower education, where the wage growth coefficients suggest even for optimistic scenarios (higher percentiles) relatively modest wage growths.

Fee structure and estimating its impact on returns and value of savings

When modelling the data for the PBS, costs and fees are the key part of the process. Not only because the fees are capped when the PEPP product is provided, but especially because the fees directly and irreversibly influence the final value of savings and thus delay the saver from achieving the saving objective. In fact, the fees are one of the elements for creating long-term risk – adequacy risk or probability of not achieving the saving objective. It is obvious, that not all fees have the same impact. Some fees do not generate compound effect, some do.

In order to recognize the fees based on their effect on savings, we can define them into two groups: one-off and recurring. When inspecting recurring costs, most of them are tied to the value of savings (investment, net asset value) and some are tied to other factors. To apply the fee policy into the model of projecting savings, we work with the following types of costs:

1. Entry fee (F^{Entry}) – this fee is usually charged to the contributions paid towards the individual account and in most cases do include distribution costs for a certain holding (contributing) period;
2. Exit fee (F^{Exit}) – typical fees charged at point of exit are the switching/redemption fees; trading fees or income taxes in form of differed capital gains taxes;
3. Ongoing fee ($F^{Management}$) – key type of fees, which are usually in form of administration and management costs charged regularly (daily, monthly, quarterly, annually) and based on the value of savings/investment;
4. Performance fee ($F^{Performance}$) – this type of fee is usually irregular and tied to the outperformance of the fund manager based either on respective benchmark or past performance in form of High-Water Mark (Goetzmann et. al., 2003).

We are fully aware, that the fee structure could be complex, but most of the fees with could be classified under the above-mentioned types.

Entry fees effectively reduce the volume of allocated contributions and therefore we express the net absolute amount of contributions that is credited to the personal pension account of the saver and subsequently allocated to the fund according to the investment strategy.

We denote the net absolute amount of contributions at time t as C_t^n and denote the entry fees expressed as a percentage of each contribution C_t as F^{Entry}. We calculate the net contributions as follows:

$$C_t^n = (1 - F^{Entry}) * C_t \tag{21}$$

Similarly, when inspecting the impact of exit fees, we express the net value of savings S_t^n at certain point of time t as a fraction of savings before the exit fee is applied. The formula could be as follows:

$$S_t^n = \left(1 - F^{Exit}\right) * S_t \tag{22}$$

Tracking entry and exit (transfer) fees over time will allow us to track the total amount of one-off fees paid during savings and thus express a reduction in the volume of savings due to the existence of entry as well as exit fees, which by definition do not have multiplication effect on the savings.

Ongoing fees in form of asset (administration) and/or management fee (F^M) is determined as a relative amount of the average annual provisional net asset value of the fund. In terms of modeled revenue, the management fee represents the amount of the decrease in revenue for the relevant trading day, and thus we receive a new modeled return, which we call the first preliminary net return and denote it as r_t^1. Considering that the fee is charged daily or that the returns are calculated based on daily data, we can apply the fee expressed as a relative value for one year on a daily basis. Suppose that one year has 250 trading (business) days, we can express the impact of the management fee on the daily return of the fund as follows:

$$r_t^1 = r_t - \frac{F^M}{250} \tag{23}$$

Similarly, it is possible to adjust the net return after the management fee even if the fee is charged monthly, quarterly or annually. It depends on the timeframe of modelled returns.

Performance fee (F^{Perf}) represents the conditional reduction in returns. Performance fee is conditional on achieving a proportion between the net asset value of fund unit from a previous business day P_{t-1} and a defined performance factor (outperforming benchmark or past maximum net asset value of fund unit). If the performance fee is tied to the previous maximum net asset value of a fund unit, we still need to define the look-back period in days (n). If the performance fee is defined as a proportion of outperformance (K), then the formula could be as follows:

$$F_t^{Perf} = \begin{cases} K \times \left(\frac{P_{t-1} \times (1 + r_t^1)}{\max\limits_{t-n} P} - 1 \right), \; if \;\; P_{t-1} \times (1 + r_t^1) > \max\limits_{t-n} P \\ 0 \end{cases} \tag{24}$$

By analogy, if respective market benchmark (P^B) is used, we can reformulate the denominator to reflect the performance of benchmark (r_t^B) as follows:

$$F_t^{Perf} = \begin{cases} K \times \left(\frac{P_{t-1} \times (1 + r_t^1)}{P_{t-1}^B \times (1 + r_t^{B,1})} - 1 \right), \; if \;\; P_{t-1} \times (1 + r_t^1) > P_{t-1}^B \times (1 + r_t^{B,1}) \\ 0 \end{cases} \tag{25}$$

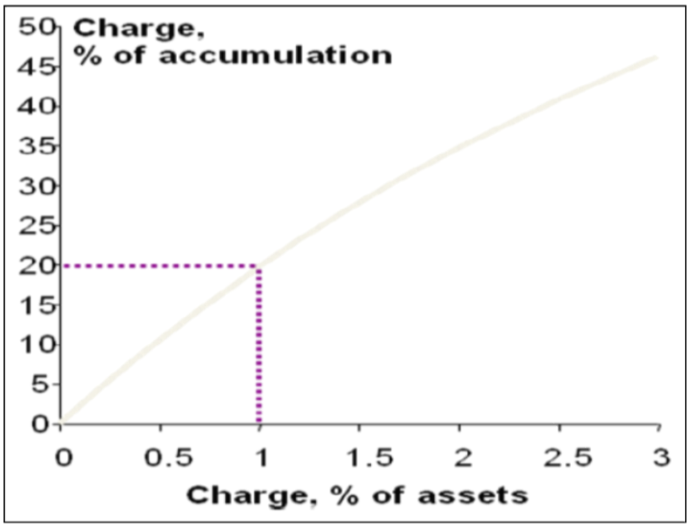
Essentially, the performance fee is an additional return reduction for the business day. By applying the performance fee to the first net return (r_t^1), we receive the net return of a fund for the relevant business day, which can be expressed as follows:

$$r_t^* = r_t - \frac{F^M}{n} - F_t^{Perf} \tag{26}$$

Using the procedures outlined in previous formulas for applying fees into the modelled returns, we are able to adjust the gross nominal returns by fees and get the net nominal returns of a fund, which respect particular fee structure of a fund and individualized contributions of a saver / investor. This procedure complements the modeling technique presented in the previous chapter and could be applied to generate expected net (after fees) nominal returns of PEPP product.

Being able to model the fee structure, we can calculate the ***charge ratio*** explaining the impact of fees on final net value of savings under individually set saving parameters or in other words, reduction in wealth (RiW). The amount by which the accumulated savings are reduced is known as the charge ratio. Charge ratio measures the impact that any type of administrative charge can have on the final balance (for example after 40 years) of an individual retirement account compared to the hypothetical amount of savings that could be obtained if no administrative fees were charged at all (Hernandez and Stewart, 2008). This measure has been used to compare administrative charges in Latin America and in other countries with privately managed retirement savings accounts (Whitehouse, 2000). The other comparative indicator referred to in this report is the ***equivalent fee rate***. This measure is related to the charge ratio but stated as an annual ratio for comparative purposes. The relationship between these two measures is shown in Figure 15, which compares on the horizontal axis the charge as a percentage of assets (or reduction in yield - RiY) and on the vertical axis the charge ratio (or reduction in wealth), which shows the effect this charge would have on the final pension value.

Figure 15 Relationship between Charge ratio and Equivalent Fee



Source: Whitehouse, E.R. (2001), "Administrative charges for funded pensions: comparison and assessment of 13 countries", in OECD, Private Pension Systems: Administrative Costs and Reforms, Private Pensions Series, Paris

Figure 15 shows that even low charges on assets build up over the long period of a pension investment can reduce the pension value substantially. For example, a charge on assets of 1% can reduce the value of the pension by around 20% (Whitehouse, 2001). However, we claim that taking into account the fee structure and stochastic aspect of some charges (especially the success fee), charge ratio is higher than originally though.

We also assume, that the slope of curve is not concave as originally presented by Whitehouse (2009) or assumed by Hernandez and Stewart (2008). Having in mind the impact of particular fees on accumulated savings, if management or success fees play dominant role in a pension provider fee structure, we claim that the curve is convex (see also Šebo and Virdzek, 2013).

Another aspect of fees is their impact on economic behavior of agents. While the behavior of asset managers under the different fee structure is quite known, behavior of demand side actors is usually tied to the taxation theory. Tax theory recognizes the income substitution effect (see for example Šebo at al., 2014). Under the effect, saver is motivated to avoid the tax by substituting the higher taxed goods by lower taxed substitutes. This behavior should be, however, considered suboptimal for saving schemes (Šebo and Virdzek, 2013).

Income effect is directly tied to the decreasing level of accumulated savings. Taking into account cumulative effect of charges, the overall impact of applied fee structure could decrease the accumulated savings to a level close to poverty. However, these wider socio-economic aspects should be analyzed in a connection to the default options set in legislature. In our study, we do not pay attention to this significant aspect of private DC schemes and refer to many existing studies on this topic (see for example Salou et al., 2012; Šebo et al., 2014).

In order to explain the impact of fee structure on final value of savings, we created simple saving scheme, where an individual contributes monthly a salary-tied contribution into equity fund for 40 years (480 months). In our research, we compare impact of these fees (presented in Table 67) on total savings. For our research, we used the most recent fees identified in the national legislation and pension fund statues for a basis Pillar II equity pension fund in Slovakia, which can be viewed as a typical simple (basic) PEPP investment-based saving product.

Table 6 Example fee structure of PEPP fund

Fee type	Value
Management fee ($F^{Management}$)**	0,30 %
Depository fee (F^{Entry})**	0,035 %
Performance fee ($F^{Performance}$)***	10,00 %
Entry fee (F^{Entry})*	1,00 %
Estimated Reduction-in-Yield (RiY)	*0,98%*

Source: Own research based on Slovak legislature and pension fund statues, 2019
** Entry fee is expressed as a % of new contributions*
*** Ongoing charges (Management fee and Custodian fee) are expressed on annual basis*
**** Performance fee is expressed as a % of the unit value change*

Further, we design a simple model of saving scheme, where individual as well as policy parameters are set. Individual parameters are connected to the defining the level of salary used as a contribution base and level of monthly contributions. Even if we understand the random nature of income influenced by permanent and transitory shocks (Guvenen, 2009), for sake of comparison and in order to control for impact of fees, we used static input variables for life-cycle income path. In order to define retirement wealth in form of accumulated savings (s_T) we created a savings model were an individual deposits once a month a τ_t-part of his monthly salary w_t adjusted for impact of entry fees (F_t^{Entry}) to a PEPP product for a period of *t (1,...,T)*. The budget-constraint equations read as follows:

$$s_{t+1} = s_t\left(r^{Net}(t, t+1)\right) + \frac{w_{t+1}\tau_{t+1}}{1+F_t^U} \qquad (27)$$

where $r^{Net}(t, t+1)$ are the net after management, custodian (entry) and performance (if applied) fees monthly returns of pension fund in the time interval $(t; t+1)$.

Gross monthly returns (r) are generated using 98 years of daily historical data on equity returns in US. The data for historical equity returns for Dow Jones since January 1919 till December 2017 were retrieved from the Federal Reserve Economic Data database of Federal Reserve Bank of St. Louis (FRED, 2019).

However, the returns are presented as gross nominal returns, which means that we have to apply the above presented procedure to take into account the fess that are applied directly to the value of the assets under management of a respective PEPP product. These ongoing charges cover management fee and custodian fee (F_t^M) and performance fee (F_t^{Perf}). In order to express the impact of ongoing fees on the value of savings, we can simply reduce the monthly return by ongoing fees charged to the fund assets. If the fund assets are redistributed by the number of issued units, that the impact of ongoing management fees (management and custodian) on a monthly return (change in the value of one pension unit) can be expressed as follows:

$$r_t^{Net} = r_t^{Gross} - \frac{F^M + F^D}{n} \qquad (28)$$

where n is the number of periods (e.g. business days, months, quarters,...) per year for which the returns are generated.

The last fee that is usually applied is a performance fee. This fee rewards the fund manager for achieving positive returns if certain conditions are met. If the return for a tested period is negative, then the success fee usually equals 0. If the return for a tested period is positive, performance fee can be charged by fund manager. To calculate the performance fee, we need to create additional variable accommodating the value of pension fund assets. In our example, fund assets are distributed on individual accounts based on the number of units. Each unit is valuated on a daily basis, which gives a current (or accounting) value of unit (NAV). Logically, the value of one unit is than subject to achieved investment returns and ongoing fees. Formula for the returns after ongoing fees and impact of performance fee (r_t^{Net}) can be calculated as follows:

$$r_t^{Net} = \frac{r_t^{F^M}}{1+\left(F^P\left(\frac{NAV_{t-1}\left(1+r_t^{F^M}\right)}{\max NAV_{t-n}}-1\right)\right)} \tag{29}$$

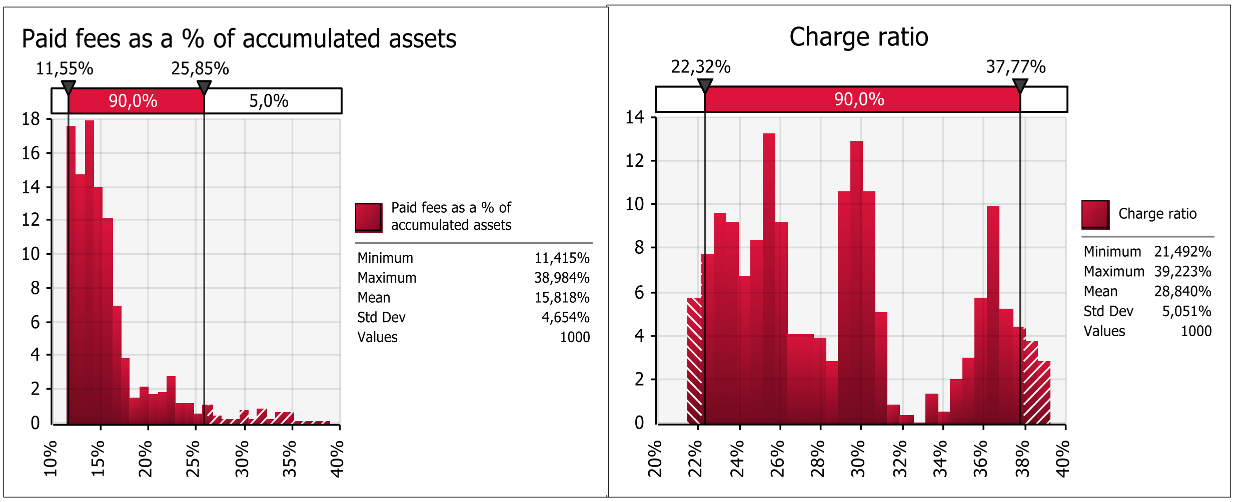
where $\max NAV_{t-n}$ represents the maximum (highest) value of NAV looking n periods backward. In our analysis, parameter n is set to 36 months (3 years).

To perform simulations using historical returns, we apply a moving block bootstrapping method (resampling) as described in the previous chapter. In our case, the block length (l) is 40 consecutive years, i.e. the full career and saving (investment) horizon of an individual saver. For each unit of a block bootstrap, a vector of variables is defined. Pulling consecutive block of data out from the database of 94 years of monthly data of variables, each block (k) than consists of variable observations (X_{k-1+1}), $j = 1, \dots, l$. Then the simulation is performed for each block (k). In total we have performed 1000 simulations. Simulations are performed in the MS Excel environment using Palisade @RISK software allowing us to define the model and control for additional input variable. In order to control for impact of fee policy on a final value of savings, we assume that a hypothetical saver contributes for a 40-year long working carrier uninterruptedly. The monthly wage (w_t) is growing by CPI index and the contribution (τ_t) is at 4 %. At the same time, we assume that a saver continuously saves in the selected fund and performs no switching during the saving period.

The results are presented in form of histograms, where the impact of fee policy applied to the final value of savings is presented in form of charge ratio using formulas above.

We conclude that under the defined methodology, the proportion of paid fees on accumulated assets, and respective charge ratio, varies significantly with mean of 15,82%, 28,84% respectively. Detailed results are presented in the Figure 16 below.

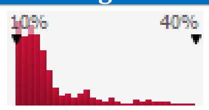
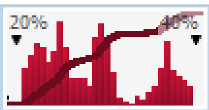
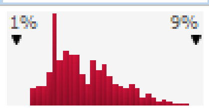
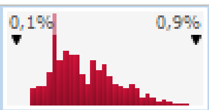
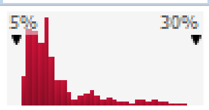
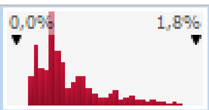
Figure 16 Charge ratio of example PEPP product fee structure and 40 years of contributions



Source: Own calculations using @RISK software package, 2019

One can see the vastly different distribution when considering two approaches. Leptokurtic distribution skewed to the right when considering the paid fees as a % of accumulated assets is in a steep contrast to the charge ratio distribution. The difference in values and distributions can be analyzed further by looking at particular fees (see Table 7 below).

Table 7 Impact of particular example fees on accumulated assets and savings

Output	Histogram	Min	Mean	Max	5%	95%
Paid fees as a % of accumulated assets		11,42%	15,84%	38,98%	11,55%	25,93%
Charge ratio		*21,49%*	*28,84%*	*39,22%*	*22,32%*	*37,77%*
Management fee		1,96%	4,14%	8,49%	2,39%	6,46%
Depository fee		0,20%	0,41%	0,85%	0,24%	0,65%
Performance fee		6,74%	10,75%	28,02%	7,44%	18,36%
Entry fee		0,19%	0,54%	1,62%	0,24%	1,12%

Source: Own calculations using @RISK software package, 2019

Interesting finding is the impact of performance fee on total amount of accumulated assets, where it surpassed even the management fee deemed to have the highest impact. On the other hand, performance fee is highly sensitive to the returns and if the portfolio returns would assume different distribution of returns, impact of performance fee would differ significantly. More detailed analysis using sensitivity tests is required to understand the dependence of performance fee on other aspects, like returns´ distribution, reset period (*m*) and length of saving period (see suggestions of Goetzmann, Ingersoll and Ross, 2003). Results of our simple analysis suggest that the detriment to savers is even bigger than the findings of Hernandez and Stewart (2008). We conclude that 1% of fees (equivalent ratio or RiY) applied on the NAV (AuM) on an annual basis exceeds significantly Hernandez and Stewart (2008) proclaimed charge ratio of 20 % over the 40-years saving period. Another interesting approach would be continuing with investigation of mutual relationship among various fees and returns. We do not intend to replicate existing studies which cover the asset management side (for example Alda and Ferruz, 2012), instead we implement the charge ratio as a key indicator of the effect the fees can have on a final value of savings and thus the adequacy risk.

Life-cycle saving strategies for simple investment-based PEPP

The goal of life-cycle portfolio allocation problems is to determine the optimal consumption and investment choices of an investor with total wealth consisting of human capital, financial wealth and other real assets, such as housing property. Without devoting much space to the introduction of the life-cycle investment strategy concept, we rather refer to seminal papers of Samuelson (1969) or Merton (1972), which perfectly present key aspects of building optimal life-cycle portfolios under various constraints.

In this chapter, we rather go "in-media-res" to the presenting simple life-cycle saving strategies, both passive based on the age and remaining saving horizon as well as quasi-active ones.

Let us have a saver, who buys an investment-based PEPP offering various life-cycle strategies build on mixing the portfolio consisting of only two passively managed ETFs – equity and bond based. Let the ETFs have the same net (after fees) performance as the US equity index DJIA30 and 7-10 years government bonds (for more details on the data structure, we refer to the previous chapter, where we used the same data for estimating expected returns). A retail saver buys the PEPP product at the age of 25 and decides to contribute 6% of his salary (c_t) monthly for a 40-year period. During his entire career he follows the life-cycle income path for a secondary education level including the labor market risk (unemployment) as referred in the chapter "Simulating life-cycle income".

The value of savings at the end of saving period for specific saving strategy is represented by $S_{i\ j,T}$, where $C_{j,t}$ is explained by formula (12), can be calculated as follows:

$$S_{i\ j,T} = \sum_{t=1}^{T} C_{j,t} \left(1 + \left(r_{s,t}^{*} * w_{i\ s,t} + r_{b,t}^{*} * w_{i\ b,t}\right)\right)^{T-t+1} \tag{30}$$

and i indicates saving strategy. We assume that new contributions $C_{j,t}$ are invested at the beginning of each saving period (t). It means, that the first contribution is invested for a period of 480 months, second contribution is invested for 479 months and the last one is invested only for 1 month. When choosing the saving strategy, he/she can only change the allocation once a year.

Let us have various life-cycle products consisting of two asset classes – equities and bonds represented by wide-spread ETFs described in the first chapter. The PEPP provider offers two strategy options – quasi-active and fully passive strategy supplemented by the mix of these two asset classes with various decision-making algorithms on changing the allocation profile as the saver ages. The following sub-chapters describe the quasi-active and passive life-cycle strategies and their modifications.

Quasi-active saving strategies

The first option is the quasi-active portfolio, where the decision on reallocation between the asset classes is made and $w_{i\,s,t}$, resp. $\left(w_{i\,b,t} = 1 - w_{i\,s,t}\right)$, can be between $< 0; 1 >$ and can take place only once a year, which in fact demonstrate its "quasi" active style with some elements of de-risking during the saving horizon.

Quasi active saving strategies selected for this paper include 3 various decision mechanism based on the price of the underlying assets (ETFs) and the risk tolerance of a saver expressed as the remaining saving horizon.

CrossEMA saving strategy

The first quasi-active saving strategy is called *CrossEMA.* The *CrossEMA* strategy is based on the fairly simple trend of moving average averages. The principle of the strategy is based on a simple algorithm of crossing exponential moving averages of two underlying assets (ETFs). *CrossEMA* strategy is based on the exponential moving averages (EMAs), which are calculated as follows:

$$EMA_t\,(p) = P_t * \frac{2}{p+1} + EMA_{t-1}(p) * \left(1 - \frac{2}{p+1}\right) \tag{31}$$

Where:
EMA - value of the exponential moving average over the last p days at time t;

P_t - price of the underlying asset (ETFs) at time t;

EMA_{t-1} - value of the exponential moving average over the last p days at time t-1.

In our case, the strategy decides whether to invest savings into the equity ETF based on the following rule:

$$EMA_t(p_S) > EMA_t(p_L) \tag{32}$$

Where:
p is the number of trading days for which EMA is calculated,
S and L - short (*S-short*) and long (*L-long*) periods defined by the number of days.

In our case, we consider p_S = 5 days and p_L = 130 days. The lengths of the periods were deliberately determined to coincide with a length of one week (p_S) and about half a year (p_L). For other moving average strategies, we also use other trading day parameter settings that are based on different approaches. Thus, in the literature, it often appears to set the length of the season by the number of trading days from 240 to 270, for the half-year period from 120 to 135 and the like. The setting of the number of trading days for the moving average calculation thus depends solely on the approach of the particular researcher, resp. user. If the condition (32) is met, strategy allocates 100% of savings ($w_{i\,s,t}$) to the equity ETF, otherwise 0%.

MaxMin saving strategy

Another quasi-active strategy is the *MaxMin* strategy. The principle of this strategy is based on game theory and risk and uncertainty decisions. However, the decision-making mechanism is based on the fact that the saver does not have the opportunity to obtain information about the probability of the price of the underlying asset for the future and therefore does not try to estimate the probability of the price (expected return). However, we know the past prices and assumes that if the price exceeds the past local maximum, it tends to rise. At the same time, this assumption also applies when the local minimum is exceeded downwards. If this happens, the price is expected to fall further. This determines the saver's behavioral characteristics based on the effort to maximize the minimum profits that can be achieved and minimize the maximum losses that may occur over time. If the price of the ETF rises above its local maximum during the period under review, it tends to maintain the growth trend and continue to grow further in the short term. The saver uses this period to allocate savings to the risky asset (equity ETF). Otherwise, strategy allocates savings into the bond ETF. The *MaxMin* strategy determines the allocation ratio to a risky asset based on the proximity of the price to the local extreme (maximum or minimum) over the reference period. The strategy allocates 100% savings to the equity ETF the following condition is met:

$$StopLoss = 0 \wedge BUY = 1 \tag{33}$$

The decision mechanism for the *BUY* signal is as follows:

$$P_{S_t} \geq maxP_{S_{t,t-120}} \tag{34}$$

Where:

P is the price of the equity ETF at time t;

maxP - maximum price of the equity ETF over the last 120 trading days.

BUY = 1 if there is an inequality in relation (34). The value of 120 was chosen based on the widespread use of this value in investment strategies based on technical analysis of daily data using moving averages. However, other settings for this parameter can also be used. The decision-making mechanism of *StopLoss* is based on a comparison of the price *P* of the equity ETF at time *t* with the minimum *EMA* of the equity ETF over the last 133 trading days, while the price is multiplied by so called sensitivity (cit_t). *StopLoss = 0* if there is no inequality in the formula (33). Thus, the *StopLoss* decision algorithm has the form:

$$P_{S_t} \leq minEMA_{S_{t,t-133}} * cit_t \tag{35}$$

and

$$EMA_t = [P_t * k + minP_{t,t-133} * (1-k)] * cit_t \tag{36}$$

Where:

minEMA of equity ETF at the time *t* is lowest EMA during the period $< t - 133; t >$;

P is the price of the equity ETF at time *t*;

k - coefficient calculated as the ratio of number 2 and number of days of EMA calculation + 1;

minP - minimum price of the equity ETF at time t during the period $< t - 133; t >$.

Sensitivity (cit_t) expresses the rate of reaction of savings U_t at time t exposed to investment risk to the total expected value of savings U_T at the end of savings period *T*. Sensitivity is based on the assumption that an individual reacts sensitively to negative deviation in the value of savings in the later savings phase. The greater the amount of savings accumulated, the higher the risk of loss in absolute terms than in the case of a similar situation at the beginning of saving horizon with a lower accumulated amount of savings. Sortino (2010) introduced a negative deviation (*Sortino ratio*) when assessing the performance of fund managers against the *Desired Target Return* (*DTR*), trying to filter out that part of volatility that resulted in an increase in the price of financial assets. By sensitivity in this case we understand the function of time t dependent on the total saving horizon (T) expressed in days (months, years), if the decision algorithm is based on days (months, years). We denote the sensitivity at time t as:

$$cit_t = \frac{t^{\frac{t}{T}}+t}{2T} \tag{37}$$

Where:

t is the time period (day, month, year) from the start to the end of total saving horizon (T),

T – total saving period expressed in days (months, years);

The course of the sensitivity curve more accurately captures the evolution of the savings value in the savings scheme, where future regular contributions are foreseen, as opposed to using a simple approach with an exponential function used in a one-off investment.

Risk Tolerance saving strategy

The third quasi-active saving strategy is called *RiskTolerance* and contains in its decision-making mechanism a key element of the savings-risk tolerance and, similarly to the previous strategy, is based on a comparison of the development of the price of an underlying asset based on the dynamic development of the price over time. The *RiskTolerance* strategy is based on the following decision algorithm:

$$w_{1t} = \frac{\sum_{t-n}^{t} BUY}{n} \tag{38}$$

The term $\frac{\sum_{t-n}^{t} BUY}{n}$ represents the average value of the *BUY* indicator over the last *n* days (from *t-n* to *t*), with *n* being, for example, 22 days for a monthly frequency, about 66 days for a quarterly frequency, from 120 to 135 days for half-year frequency and 240 to 270 days for annual decision-making frequency. The *BUY* indicator at time *t* could be as follows:

$$BUY_t = 1 - DR_t \tag{39}$$

The term DR_t represents the dynamic risk at certain point in time t and is calculated as:

$$DR_t = \begin{cases} \frac{D_{max_t} - P_{s_t}}{D_{max_t} - D_{min_t}}, & if\ D_{max_t} \neq D_{min_t} \\ 0, & if\ D_{max_t} - D_{min_t} < 0 \end{cases} \tag{40}$$

Where:

D_{max} represents the maximum price P_{s_t} of equity ETF at time *t* within the interval $\langle k, t \rangle$;

D_{min} represents the minimum price (P_{s_t}) of equity ETF at time *t* within the interval $\langle k, t \rangle$, while $k = max(1; 2t - T)$.

The interval $\langle k, t\rangle$ for finding the local minimum and maximum in the first half of a savings horizon causes an increase in the preference for allocating savings into the riskier equity ETF. As the interval $\langle k, t\rangle$ gets shorter in the second half of a saving horizon, the strategy increases the preference for allocating savings into the bond ETF.

Passive life-cycle saving strategies

Blanchet (2015) states in his article that determining the right allocation ratio over time depends on age, because with older age and shorter saving horizon the saver becomes more conservative and reduces the share of savings invested in riskier financial instruments. One reason for this is the risk of volatility, which is higher in the case of equity investments than in the case of bond investments. Recent studies by Kitces and Pfau (2014) and Delormea (2015), however, take a different approach to determining the allocation ratio in pension savings schemes. It is based on the assumption that the older a person gets and the closer he is to retirement, the higher proportion of savings should be allocated to equities and less to bonds. This approach has a design constraint and is recommended especially by savers who know that when they reach retirement age, they will not immediately annuities the entire portfolio (buying a lifetime annuity for a substantial part of the savings). They thus have the opportunity to use the strategy also for the decumulation phase and extend the "saving" horizon from the retirement age till the life expectancy.

"Aging" based saving strategies

Typical life-cycle saving strategies are the Poterba style old-age scheme allocation strategies (Poterba et al., 2006), where the glide path is followed based on prescribed rules. Typically, the exposure to the riskier assets should decrease with the age. In order to account for this glide path, we constructed two typical life-cycle strategies that takes into account only the age of a saver and ignore the price of underlying assets or their development over time. To complement these two typical life-cycle strategies, we in addition turned the logic upside down and constructed two inverse life-cycle strategies in order to see, whether the key logic of the glide path is valid. In total, we present 4 life-cycle strategies based on the age of a saver.

The first life-cycle strategy called *Aging(1)* is based on the well-known rule of thumb, where the allocation weight ($w_{i\ s,t}$) into the riskier equity ETF is based on the rule "*100 – age*" or:

$$w_{s;t}^{Aging(1)} = 100 - x_t \tag{41}$$

Where:

$w_{s;t}^{Aging(1)}$ represents a portion of savings allocated into the equity ETF;

x represents the age of an economic agent (saver/investor) at time t, while $t \in \langle 1, T\rangle$, where T is the total saving horizon in years.

The remaining portion $(1 - \mathrm{w}_{\mathrm{i\ s,t}})$ of the savings is allocated into the bond ETF.

Aging(2) strategy is slightly modified version of previous strategy and reduces the proportion of savings invested into the equity ETF relatively to the ratio of the number of years t a saver has already saved to the years of a total saving horizon (T):

$$w_{s;t}^{Aging(2)} = \left(1 - \frac{t}{T}\right) \times 100 \tag{42}$$

Comparing to the Aging(1) strategy, the Aging(2) strategy allocates higher proportion of saving into the equity ETF at the beginning of the saving horizon, but the decrease rate is steeper.

Remaining two ageing strategies are inverse in their logic. The Aging(3) strategy increases the exposure to the equities with the raising age:

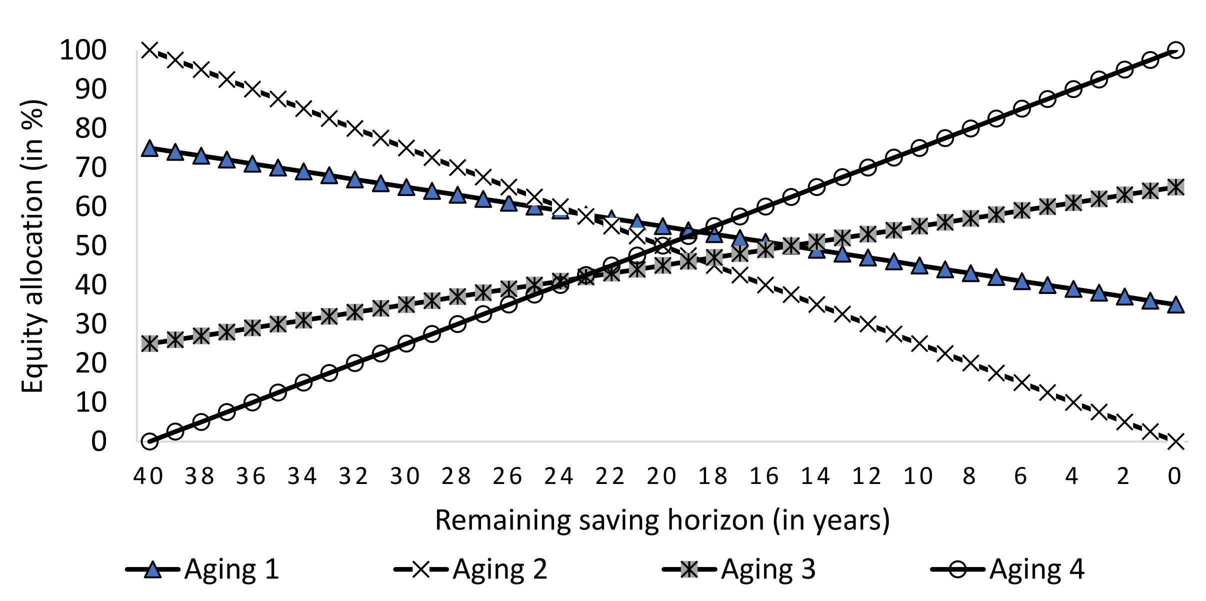
$$w_{s;t}^{Aging(3)} = x_t \tag{43}$$

Aging(4) strategy increases the exposure to the equity ETF base on the ratio of the number of years t a saver has already saved to the years of a total saving horizon (T):

$$w_{s;t}^{Aging(4)} = \frac{t}{T} \times 100 \tag{44}$$

The allocation profile for all 4 ageing strategies over the saving horizon of a saver could be visualized as follows.

Figure 17 Equity allocation of "aging" saving strategies



Source: Own elaboration, 2019

Static saving strategies

In reality, many providers offer static saving strategies whose allocation profile do not change over time. To account for this, we have developed static passive strategies, that constantly regardless of a saver´s age or underlying assets price movement, invest a constant proportion of savings into the equity ETF. In total, we have constructed 11 strategies as presented in the table below.

Table 8 Allocation profile of static passive saving strategies

Static passive saving strategy	**Proportion of savings in the Equity ETF** (in %)	**Proportion of savings in the Bond ETF** ***(in %)***
Aggressive (Equities)	*100*	*0*
90:10	*90*	*10*
80:20	*80*	*20*
70:30	*70*	*30*

60:40	*60*	*40*
50:50	*50*	*50*
40:60	*40*	*60*
30:70	*30*	*70*
20:80	*20*	*80*
10:90	*10*	*90*
Conservative (Bond)	0	100

Source: Own elaboration, 2019

Overall, we have 18 saving strategies representing quasi-active strategies and age-based strategies respecting the de-risking principle and static, fully passive, saving strategies with constant allocation profile, which do not change and do not reflect nor the age of a saver nor the price development of underlying assets.

Assessment of life-cycle saving strategies

Usually, any strategy is assessed using several indicators. In our case, we have tried to simplify the approach and focus only on 3 indicators that should reflect the expected performance over the whole saving horizon, the short-term risk as well as the saving objective.

The first indicator ($\mathrm{Perf_T}$) compares the volume of accumulated savings ($\mathrm{U_T}$) at the end of the savings horizon T and the volume of contributions paid over the entire saving period ($\sum_{t=1}^{T} C_t$), where $\sum_{t=1}^{T} C_t = C_T^*$. The savings performance indicator is calculated as follows:

$$Perf_T = \frac{U_T}{C_T^*} - 1 \tag{45}$$

The Savings performance indicator ($\mathrm{Perf_T}$) expresses the rate of appreciation of contributions made by a saver under the chosen savings strategy during the whole saving period. In essence, it represents an individual rate of appreciation of savings due to the existence of a saving strategy and an individualized lifetime income function.

Secondly, we try to assess what kind of investment risk a saver has to undergo in order to achieve above mentioned savings performance. In most cases, the investment risk is viewed as a short-term risk represented by volatility or VaR (value-at-risk), which in short is the 95th percentile of all down-side movements. In our case, we want to be stricter and use the maximum drawdown ($\mathrm{MaxDD(\%)_t}$) an individual suffers during the saving horizon represented by the 100th percentile of all simulations. MaxDD can be calculated as follows:

$$MaxDD(\%)_t = MIN_t\left\{\frac{[U_t - MAX(U_{\hat{t}})]}{MAX(U_{\hat{t}})} \times 100, MaxDD(\%)_{\hat{t}*}\right\}; \hat{t} \in \langle 1, t\rangle, t \in \langle 2, T\rangle \tag{46}$$

The third indicator focuses on the long-term risk. This risk is quite neglected in the theory as well as practice. In fact, the long-term risk reflects the adequacy of the whole saving scheme or the suitability of the product (including the fees, saving/investment strategy, contribution rate, etc.) on the expected/desired or targeted outcome ($\mathrm{TargetU_T}$). In the case of buying a long-term investment-based product, the desired outcome could be expressed as the proportion of the final income that could be covered by the final value of savings if the expected rate of return ($r_{s,t}^*$) is used as defined in the formula (30). Desired outcome is than used to calculate the adequacy risk expressing the deviation of final value of savings ($\mathrm{U_T}$) from the desired outcome or targeted level of savings ($\mathrm{TargetU_T}$):

$$Adequacy\ risk_T = \frac{U_T}{TargetU_T} - 1 \tag{47}$$

The value of Adequacy $\text{risk}_T \geq 0$ indicates that a saver has achieved the desired outcome, respectively the level of final savings exceeded the targeted level of savings using the expected rate of return for the equity based portfolio. Conversely, a value of Adequacy $\text{risk}_T < 0$ indicates that a saver has not achieved the targeted level of savings, and hence by applying a savings strategy, the saver was not able to accumulate sufficient level of savings and the adequacy risk occurs in the form that a saver would need to accept lower income flow at retirement or increase the short-term risk during the retirement.

First, we present the savings performance indicator for all 18 savings strategies.

Table 9 Performance (*Perf*) of saving strategies

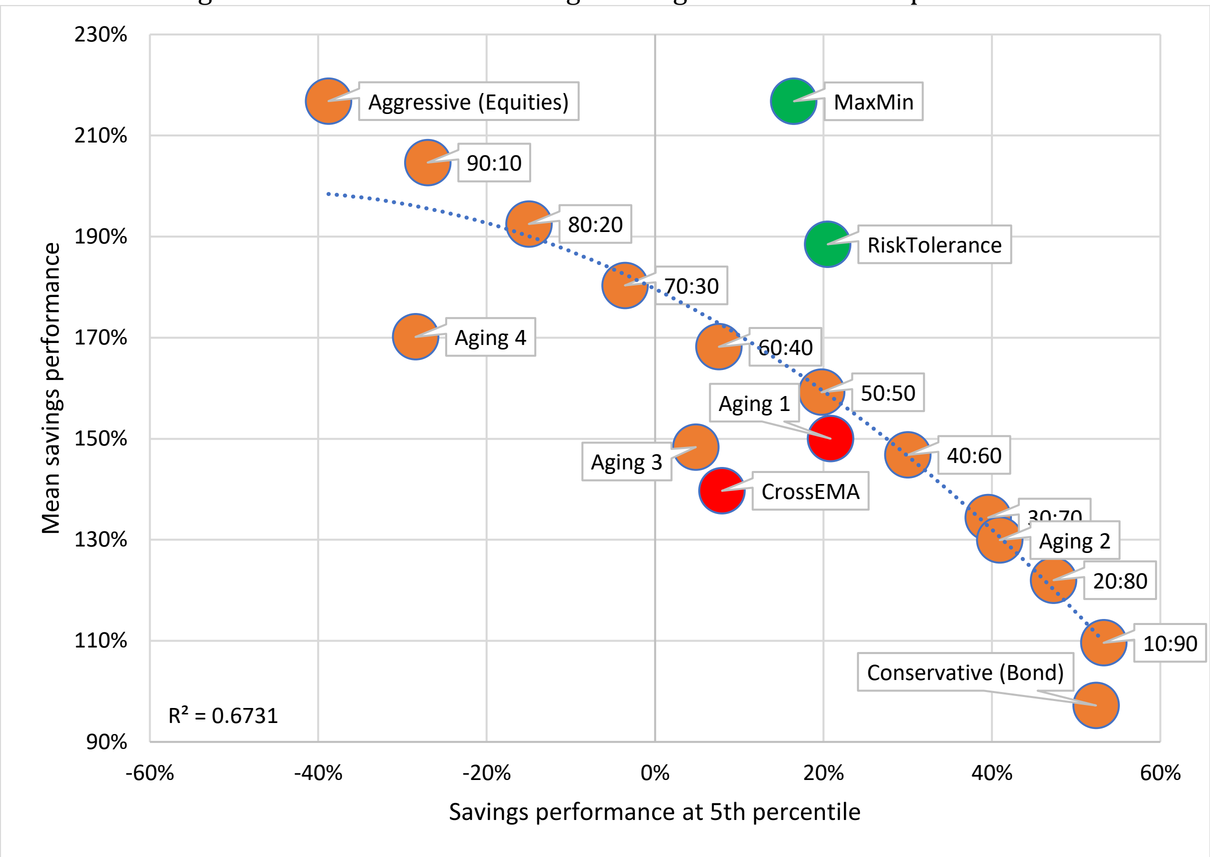
Savings Performance	Mean	*Std. Dev.*	*5th percentile*	*25th percentile*	*50th percentile*	*75th percentile*	*95th percentile*	*Max*	*Min*
Conservative (Bond)	97%	*36%*	*52%*	*69%*	*91%*	*118%*	*167%*	*239%*	*27%*
Aggressive (Equities)	217%	*228%*	*-39%*	*51%*	*169%*	*310%*	*677%*	*1784%*	*-79%*
90:10	205%	*206%*	*-27%*	*55%*	*161%*	*288%*	*623%*	*1621%*	*-64%*
80:20	192%	*184%*	*-15%*	*59%*	*154%*	*267%*	*566%*	*1458%*	*-49%*
70:30	180%	*163%*	*-4%*	*62%*	*146%*	*246%*	*511%*	*1295%*	*-37%*
60:40	168%	*141%*	*8%*	*65%*	*138%*	*227%*	*450%*	*1132%*	*-26%*
50:50	159%	*122%*	*20%*	*70%*	*133%*	*213%*	*402%*	*992%*	*-15%*
40:60	147%	*101%*	*30%*	*73%*	*126%*	*193%*	*345%*	*825%*	*-4%*
30:70	134%	*80%*	*40%*	*76%*	*119%*	*174%*	*289%*	*658%*	*8%*
20:80	122%	*61%*	*47%*	*76%*	*110%*	*156%*	*233%*	*491%*	*19%*
10:90	110%	*44%*	*53%*	*74%*	*102%*	*137%*	*191%*	*324%*	*30%*
CrossEMA	140%	*113%*	*8%*	*63%*	*115%*	*189%*	*343%*	*1050%*	*-56%*
MaxMin	217%	*182%*	*16%*	*92%*	*175%*	*284%*	*572%*	*1341%*	*-50%*
RiskTolerance	188%	*161%*	*20%*	*81%*	*146%*	*247%*	*510%*	*1416%*	*-33%*
Aging 1	150%	*97%*	*21%*	*77%*	*137%*	*206%*	*327%*	*665%*	*-19%*
Aging 2	130%	*66%*	*41%*	*80%*	*121%*	*167%*	*249%*	*465%*	*7%*
Aging 3	148%	*99%*	*5%*	*75%*	*138%*	*208%*	*329%*	*568%*	*-45%*
Aging 4	170%	*144%*	*-28%*	*65%*	*149%*	*251%*	*446%*	*824%*	*-75%*

Source: Own calculations, 2019

When inspecting the savings performance indicator, logically, the lower risk allocation strategies delivered the lowest performance (Conservative saving strategy and the static strategies investing low proportion of savings into the riskier assets). A little surprisingly, Aging(1) and Aging(2) strategies, which are admired by many researchers and policy-makers did not delivered exceptional returns and could not beat even the static strategy that constantly invests 50% of the portfolio into the equity ETFs. On the other hand, the standard deviations of aging strategies are lower than the static ones. Quasi-active saving strategies delivered mixed results. Simple and often recommended active strategy based on the EMAs (CrossEMA) has delivered lower than average results with relatively high volatility. However, quasi-active strategies (MaxMin and RiskTolerance) that take into account the age of a saver (or the remaining saving horizon) delivered quite exceptional performance compared to the other life-cycle or static strategies.

Considering both the average performance and the performance achieved at the 5th percentile, the picture might look little differently.

Figure 18 Performance of savings strategies - Mean vs. 5th percentile

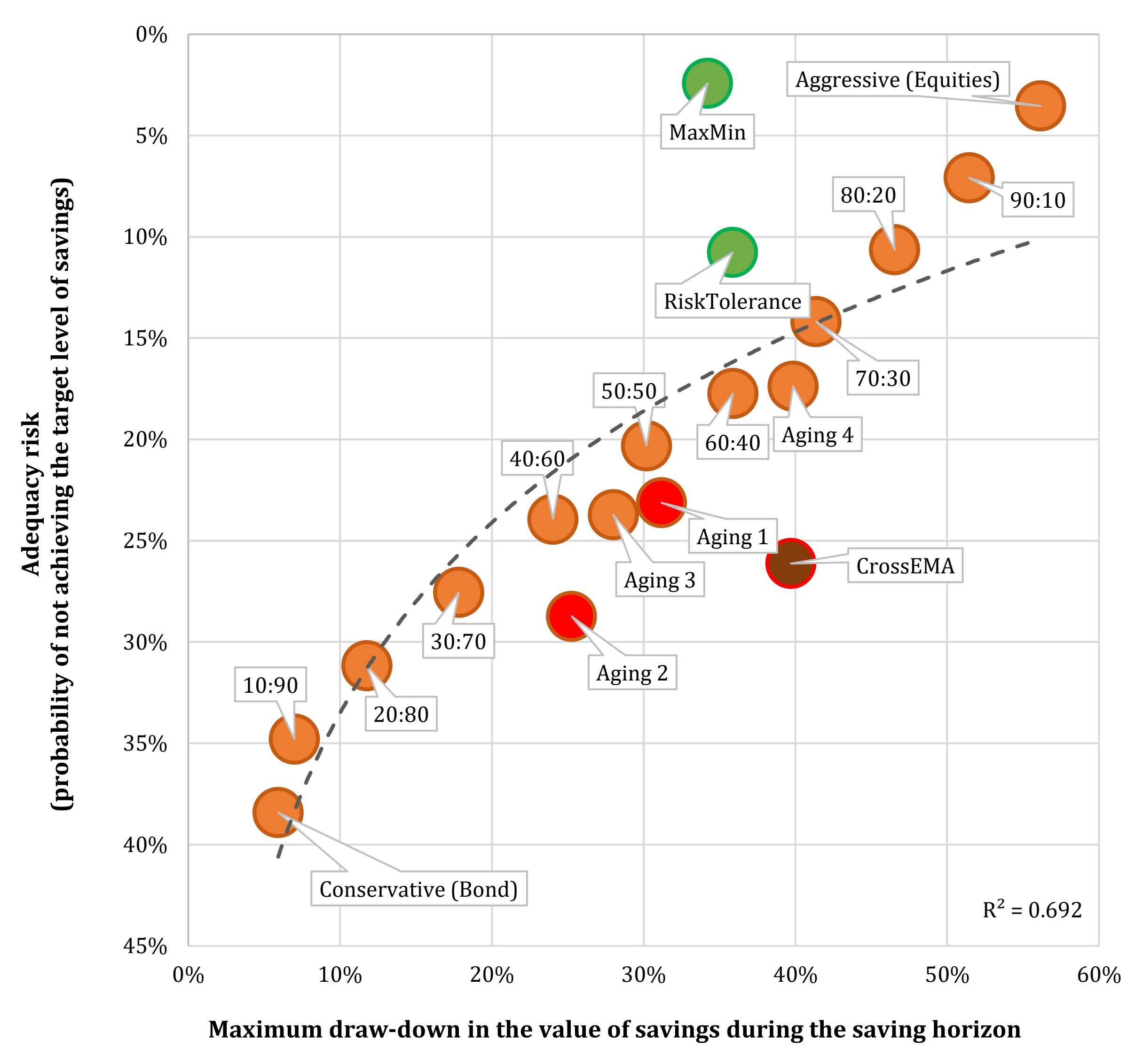


Source: Own calculations, 2019

One can see that most of the static saving strategies delivered proportionally higher mean savings performance (vertical "y" axis) and lower performance at 5th percentile (horizontal "x" axis) of all simulations. Generally recommended Aging(1) strategy delivered below average results both on the average as well as at the 5th percentile. Quasi-active strategy CrossEMA delivered poor results as well. Other quasi-active strategies that takes into account the risk tolerance and the remaining saving horizon (MaxMin and RiskTolerance) delivered above average performance both at the mean as well as at the 5th percentile. MaxMin strategy delivered almost the same mean performance as the most aggressive strategy investing all the time 100% into the equity ETF but at the same time at the 5th percentile was still able to deliver at 16% performance compared to the fully equity strategy that delivered only poor -39% (lost 39% of the total number of contributions paid during the entire saving horizon).

Secondly, we present the mutual relationship of short-term and long-term risks using the indicators of maximum draw-down and adequacy. By doing so, we can easily examine the trade-off between the short and long term risk and assess both the potential down-side risk a saver can expect to suffer and the adequacy risk or the probability that he/she will not be able to save enough. By mentioning the maximum draw-down indicator it should be clear that this is not the maximum draw-down one can experience at the end of the saving horizon but anytime during the saving horizon and has to survive it.

Figure 19 Maximum draw-down and adequacy risk of saving strategies



Source: Own calculations, 2019

Logically, the full equity saving strategy has the lowest adequacy risk over the entire saving horizon and lead the group of analyzed saving strategies. In order to achieve this objective on the long-term, one has to be prepared to suffer more than 50% draw-down of his/her savings during the saving horizon, which can be quite hard to sustain. On the other side of the spectrum, the full bond strategy leads that delivers the lowest short-term risk (maximum draw-down of savings), but it leaves the saver with huge adequacy risk of almost 40% or in other words, full bond strategy is capable to deliver (on the average) only 60% of expected or targeted value of savings. Surprisingly, all "aging" strategies performed below average and delivered higher adequacy risks and short-term risks compared to the static saving strategies. This leads us to the conclusion that general application of saving strategies that would take into account only the age of a saver or the remaining saving horizon would harm the saver and expose him/her to the higher adequacy risk as well as potential short-term losses. However, two quasi-active strategies that takes into account the development of underlying assets´ prices as well as the remaining saving horizon (MaxMin and RiskTolerance) performed rather well when delivering both the lower adequacy risks and lower maximum draw-downs during the accumulation phase compared to the static peers.

Behavioral aspects of understanding financial information and financial decision-making

Making complex and long-term decisions without understanding the „game rules" should create many sub-optimal choices where only the decision-maker bears the risk of such decision. Making the right choice, maximizing pension benefits and making the most of your product offer is difficult. This requires not only time but also enough information that the individual must have. Šebo et al. (2017) claim that consumers are often uninformed about the system they participate in. However, it is not a question of the extent („how much") of the information, but of the manner and quality of the information provided. It is the quality of the information (the need for information in terms of action, i.e. „what is important") and the way (how the information is presented, i.e. „how to translate information into knowledge") that are the basis for rational decision making. And if most savers do not understand the principles of pension savings, it is not possible to make informed decisions for which the individual is still responsible (both legally and financially).

Behavioral aspects

Linking to information asymmetry and information overload creates a potentially dangerous state where, from a legal point of view, an individual has enough information but is unable to process it and make an optimal profit maximizing decision. In the case of financial services, where benefits are maximized in the long run, there is a paradox of short-term decisions that tend to increase the risk rather than reduce it. A typical example of preferring short-term benefit over the long-term ones is the good feeling of not making a decision because the individual does not know how to maximize his/her benefit and therefore prefers not to make a decision and wait in good faith that it will not adversely affect his/her expected benefits (van Putten et al., 2013).

Pension financial products (whether investment or insurance based) are accompanied by extensive documentation that sets out the operating conditions. We can assume that if we provide enough information, savers will be able to make the right financial decisions. However, research has indicated that most people are unable to understand these documents because they are unable to select important information for the right decision. This is particularly true because the information is difficult to interpret and therefore savers are not able to make decisions regarding their financial security for old age. (Van Dijk & Zeelenberg, 2007).

The problem of long-term savings is the hyperbolic discounting and the existence of information asymmetry. As evidenced by research of behavioral economists, this is mainly due to the fact that individuals tend to think short-term and become interested in retirement only few years before retirement. For long-term savings, the effect of compound interests on savings is high but invisible, and the short-term maximization of benefits occurs in hyperbolic discounting. Therefore, there should be regulation helping the saver understand the relationship between today's decision and the savings objective, and thus ensuring the relations between today´s decisions on future old-age income. Otherwise, it tends to favor a relatively known near future over a more distant future. On the other hand, there is a regulator that has all the information on the pension system (EIOPA, 2013). It is the information asymmetry that should be addressed by the regulator. This justifies the intervention where the regulator sets information obligations towards the supply side of the market on behalf of the demand side.

EIOPA study (2013) contains basic recommendations for policy makers. When formulating regulation that is aimed at the financial consumer, they should foresee the financial decisions that savers should make and therefore:

1. think about your behavioral goals (i.e. ask yourself: "How should savers - participants - investors look in terms of their behavior before, during and at the end of saving?");
2. provide layers of information so that the first layer answers the key questions of the saver and all other layers explain and reassure the saver in a decision he / she will consider correct;
3. legal or more complex information can be found at other levels to address specific situations;
4. provide only information that is understandable and understandable to individuals in terms of making their decision (information like this has already happened and you will not change it is incomprehensible in terms of its decision);
5. try to motivate individuals as much as possible in relation to financial decisions.

In the long run, the existence of information asymmetry is inevitably linked to the failure of the market mechanism in the form of inappropriate decisions by individuals (the demand side of the market). Information asymmetry is a state in which one contract party, whether supply or demand market side, has a different volume, structure and quality of information than the other contract party. This means that in this case one party has an advantage over another and it is not possible to enter an effective contract between the two sides of the market. Considering that the market fails in the case of varying awareness, there is a perspective for state intervention in the system. In the case of information asymmetry, there are two different ways of addressing:

1. **screening**, which is mainly used by insurance companies to verify the status of the future policyholder in the form of questionnaires to obtain additional number and quality of client data. Legislation itself is set up so that the provision of this information is required and the refusal or false provision of information by the client can lead to the contract being canceled from the beginning.
2. **signaling**, which is based on sending a signal to an individual about a given product. Most often it is a brand and reputation. It is also very common to send marketing information, tests, etc. In case of pension products, signaling should be viewed as a hint of what the impact of costs on final pension pot could be.

If we examine the problem from the demand side, then the whole initiative of regulators (especially at the transnational level) is directed to this area where the consumer should receive information enabling on one hand to understand the product, understand its functioning and expected costs and benefits, and especially be able to easily compare products with each other. Additional activities in this area are aimed at demonstrating the quality of client information and verifying the understanding of the information provided (as in the KID PRIIPs Regulation and in particular MiFID II).

Research in financial information shows that information must be interpreted in a manner close to savers so that it is easy to understand and transformed into optimal decision. However, in reality savers find mainly legal information in their personal pension account statements that is difficult for an ordinary saver to understand and use. Often, the saver is overloaded, whose information does not motivate him to read, but discourages him from reading. It is therefore necessary to avoid information overload (Toms, 2002). This phenomenon arises when an individual is provided with so much information that he/she is unable to process, and it is easier for him/her not to take a decision at all. Although trustees fulfill their obligation under the law by informing the saver, no one further examines whether they are able to make rational, utility maximizing decisions.

To solve the problem of complex information, layering technique is used, where information is provided from simple ones that introduce the individual to the issue, to legal and more complex information (EIOPA, 2019). Structuring the information will allow the saver to easily answer other questions that are more specific and thereby streamline the information submitted (Hartley & Trueman, 1983). Information layering allows easier orientation and the saver will remain motivated to continue reading and thus the process of gathering knowledge could be foreseen.

According to Glenberg & Langston (1992), information is easier to understand when it comes to combining text and graphics. Providing information in an attractive graphical form can increase the saver's motivation to develop a cognitive part of the perception of information. The font size and the limited number of words on the page should allow easy reading, and the number of words on the page should be limited (Antolín & Severinson, 2010). The combination of text and graphics usually reduces complexity and helps address savers' unwillingness to be interested in the issue.

Petty et al. (2005) and Kahneman (2003) in their research papers presented the existence of dual information processing. They describe two relatively different ways in which individuals make decisions. The dual information processing model contains a conscious and subconscious path (Kahneman, 2011). The subconscious works automatically and quickly. With little or no effort and no sense of voluntary control over factors. It involves no, at most small, cognitive efforts and occurs when a person relies on a relatively simple strategy. The conscious way involves thorough thought and examination of information, which requires looking for context and estimating impacts. It is the basis of logical and rational thinking. Kahneman (2003) concludes that cognitive tensions are difficult to understand, which reduces the motivation to solve the problem and reach a decision. This increases the use of the subconscious road influenced by emotions. Information that is easy to read and understand is treated with cognitive ease, which takes less time while increasing the individual's rational attitude to decision.

Therefore, the proposed Pension Benefit Statement should also respect both levels of information processing. The subconscious way should be activated by means of quick information whether everything is OK with the savings. At the same time, the basic information should give a quick overview of the state of savings and the expected result and whether “I am on track” to reach set savings objective. This information should be clear and evident from the entire statement. It will give the saver - participant - the investor quick information about whether it is necessary to change something or just continue with the set savings strategy. The ideal way is to give this quick information a central place on the report.

Therefore, PBS should respect the fact that information should be given on a personal level. The words "YOU" or personally filed by a "YOUR" manager should be used. The second recommendation is to provide information so that the saver can process it. A good way to do this is to provide information in the form of answers to typical saver's questions, such as “Do I have a good savings plan?” Or “How much do I have today?”. The questions formed in this way draw the saver into the issue because they help him to form questions through which PBS provides him with essential information. Alternatively, PBS can be constructed as direct answers to these questions. This will give the saver the incentive to read the statement and activate its cognitive functions.

Layering and clarity of information

EIOPA (2019) clearly advises to design the PEPP using layering of information: “*It is important that the approach on layering facilitates comprehensibility and usefulness of pre-contractual information. Although layering is not mentioned in a PEPP Benefit Statement context, it makes sense for the same principles to apply to this document as well.*”

Layering is used to solve the problem of providing more complex information. Legally and more complex information should be provided to the saver at lower tiers (EIOPA, 2019). This approach does not prevent the provision of complete information but suggests providing additional information in layers to move from simpler (and more straightforward) information to more complex information requiring more cognitive access. More complex information, abstract information and legal information may be provided at the lower layers. Structuring information can help savers easily obtain answers to other more specific questions and substantially improve information efficiency (Hartley & Trueman, 1983). This layering of information may be performed within a single information document. However, this may also apply to a collection of information documents or to the use some different media. Taking into account the fact that PBS should be an electronic document, layering is easy to implement and could be well supplemented with the online individual saving account, which is designed in the same manner.

Providing information via online interfaces seems to be the ideal solution, where information layering is easy to implement and even allows “customization”. A typical example is a “dashboard” that the client can easily create according to his/her own preferences. Web applications are a very effective means of providing multilayered information and supporting actions because they are interactive. This is in line with EIOPA (2019) recommendation to leverage new technological possibilities – the regulatory objectives of disclosure could be potentially enhanced by incorporating such digital features such as video, audio, interactive menu features, dynamic pop-up Q&As, animations and ‘gamification’.

Another important aspect is the use of comprehensible language, i.e. avoiding the use of technical terms used in financial economics, which should be explained in a way that the saver understands, because research has shown that he/she is easily discouraged if he/she encounters heavy texts and ambiguities that he/she does not understand. (Antolin & Severinson, 2010). At the same time, the information thus provided is more likely to achieve the desired action by the saver. If the information is incomprehensible, it requires more time invested that the saver does not tend to do. It is therefore appropriate to provide information in plain language and in adequate text length. If the PBS should contain technical terms, using “pop-ups” or “hint bubbles” could be used to spur the cognitive process.

It is also necessary to avoid ambiguity of information (Just & Carpenter 1992). With ambiguous text, savers tend to deduce number of interpretations that may cause uncertainty and unwillingness to make decisions. In this respect, it should not be forgotten that, when building an information document within the online interface, there should be references to other layers of information through question formation.

Cox (2011) states that understanding risk is more difficult and risk averse savers tend to be more sensitive to risk and underestimate potential benefits from the savings scheme. In his research, he suggests that the ideal is to present risk in three scenarios.

Any regular retirement statement should provide information on uncertainty along with information on how savers can address it. It is important that in the first layer of information, the impact of risks is presented in scenarios such as expressed in euro per month. At lower tiers, it is possible to provide probabilities and more accurate and detailed risk information. Therefore, uncertainty information should be automatically linked to information that achieves an understanding of the impact of a saver's decision on the savings aspect (for example, to increase the monthly allowance or to change the pension fund to a higher risk). The saver will be able to understand the relationship of return and risk, increased contribution or fees to the expected value of savings in the long run. The saver will thus understand what the result of an increase in monthly contribution or a change in the pension fund´s risk-reward characteristics on the expected savings in the long run will be and will feel more comfortable in making a real decision. However, short-term risks (volatility of savings value) as well as long-term risks (adequacy risk or probability of not achieving target level of savings) need to be explained in detail. Most meaningful is to show scenarios where both risks are combined.

Presentation of numerical values and risks when designing the pension benefit statement

Numbers (numerical values) that are an essential part of PBS and must be presented in an understandable form that will be understandable to most savers. In addition, in order to understand any figure, a saver must be able to unambiguously assess whether the savings scheme or current savings strategy (allocation profile) is suitable for him.

If the aim of a PBS is to provide the saver with information on the expected value of savings in a relatively far future, this information must be understandable. Therefore, it is a crucial policy to ensure that all assumptions and calculations themselves will be uniform not only across PEPP providers, but also across other similar saving schemes.

To ensure comparable numbers, it is important to follow a uniform, standardized methodology. The information provided by the numerically expressed expected value of savings at the end of the accumulation phase should clearly support the saver in long-term planning rather than short-term decision-making. Therefore, the whole PBS should be based on long-term decision making. For example, it is not desirable to present the performance of savings (pension fund) in the PBS over the last year, as this figure is unnecessary and is not relevant to the decision-making of the saver in the long run. Conflicts of annual performance and long-term performance are a typical mistake in presenting information to savers (EIOPA, 2013).

Regarding the pension projections, net pension income presented in euro per month is used in many countries (Antolín & Severinson, 2010). In the case of PBS, the net real value of the monthly income from accumulated savings, calculated for the life expectancy of particular age, sex and educational (income) cohorts or for a predetermined time period (for example 20 years) seems to be the best option. Presented value should be expressed in terms of the present value of money considering at least the impact of inflation. However, it is ideal to present this amount to the saver's current income. Being able to present pension-to-income ratio would allow the PBS to provide the most relevant figure on the real net value of savings and thus allow to set the saving objective more clearly. By default, the saver sets its reference point as a comparison of the net salary per month and the expected monthly pension. It is very important to set a reference point for further understanding of information by the saver. We therefore propose to link this value not only to the purchasing power of the expected savings but also to the expected income level. For planning an electronic (online) Integrated Pension Benefit Statement in a multi-pillar system, it is appropriate for savers to obtain similar data from other schemes across the entire pension system.

Another issue is the presentation of fees. Fees expressed as a percentage per year are difficult to understand (Chater, Huck & Inderst, 2010). The expression of costs in the form of fees paid for one year of savings is inappropriate. It is more appropriate to present the overall impact of the fees throughout the savings period. Therefore, costs should be presented over the entire saving period, backwards as well as forwards. Therefore, charge ratio seems to be a good indicator, where the entire saving horizon is considered and thus, we are able to present the reduction in wealth. Where appropriate, social comparison can serve to provide information because the saver is primarily and instinctively interested to compare the product/scheme to the other products/alternatives (EIOPA, 2013). Research on the understanding of financial information suggests that figures are best expressed not as a ratio or percentage, but as EUR 1 per EUR 100 and covering the entire saving horizon. It should be noted that understanding often complex fee structure would distress the saver. Therefore, one comprehensive indicator should be used and should be individualized, so the indicator reflects the cost structure of the product/scheme, but presents the figure based on individualized saving set-up. It is obvious, that as the fund performance do not present the exact development of the savings performance, the same is true for the impact of costs. Reduction-in-yield as an indicator fits the fund framework, but the reduction-in-wealth (charge ratio) fits better the individual level of savings.

The online provision of information is an effective way of introducing interactive tools that a saver can “play with”. Therefore, information on uncertainty should be automatically linked to a “tool” which helps to understand the impact of the saver's decision on the savings aspect (for example, increasing the monthly contribution by EUR 10 or increasing the riskiness of an investment strategy). The saver will be able to understand the relationship of one unit of performance (return and risk), increased contribution or fees on the expected value of savings in the long run. Thus, the saver will understand what will be the result of an increase in the monthly contribution or a change in the pension fund with other risk-reward characteristics on the total expected value of savings in the long run and will feel more comfortable in making practical steps towards setting the objective and performing necessary decisions to achieve it. In many countries, partial online tools are being created that allow members to create pension forecasts based on assumptions the user can choose.

PEPP benefit statement (PBS) proposal

When designing the statement of expected pension benefits (PBS), we follow the recommendations of behavioral studies as well as the recommendations of EIOPA (2013, 2019) presented in the previous chapter. Based on research into the behavior of individuals of requirements for compiling similar statements, the following suggestions can be made for PBS production.

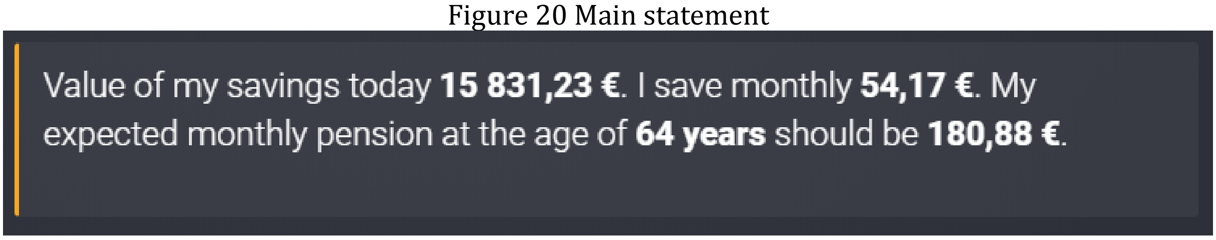
We also incorporate the requirements set out in the Directive (EU) 2016/2341 of the European Parliament and of the Council of 14 December 2016 on the activities and supervision of institutions for occupational retirement provision (IORP). First, it is a question of grasping the problem from the point of view of the introduction of PBS as defined in recital 66 of the IORPII Directive:

„ For members, IORPs should draw up a Pension Benefit Statement containing key personal and generic information about the pension scheme. The Pension Benefit Statement should be clear and comprehensive and should contain ***relevant and appropriate information to facilitate the understanding of pension entitlements over time*** *and* ***across schemes*** *and serve labor mobility.“*

Therefore, designed PBS should respect the fact that information should be given on a personal level. That is, in a clear and understandable way for both the experienced as well as less educated client. Therefore, it is appropriate to present the information through questions and answers, which increases the clarity of the entire PBS. For this purpose, we have created the main text that is dominant on the entire PBS statement. An even greater understanding can be achieved by grouping information into smaller units, arranged in chronological order, from now to projections or alternative scenarios (see Figure 27). Grouping information into sections also improves document navigation. The information should be provided from the most important to the least important - therefore, the main page of the proposed PBS provides the key information about saving combining current savings parameters and expected benefits (outcomes).

Designed PBS is a part of the online platform offering integrated pension benefit statement for all available pension schemes in Slovakia – Orange Envelope (www.oranzovaobalka.sk).

Figure 20 Main statement



Source: Orange Envelope PBS on Personal Pension Product, 2019

The final design of PBS should therefore contain textual information in a similar form, and this information should be visually dominant over the rest of the text and graphics. This statement is a key message and gives the clear information on the expected benefits (saving objective under the given pension scheme set-up, projected performance, product fees, inflation, expected life-cycle income development, etc.).

Through this dominant information, the saver / participant is able to obtain 4 responses that are also logically linked to an "action / response" state. He/she knows how much he/she has saved today. He/she knows how much he/she regularly contributes. These two key information leads to the expected result in the future, i.e. he/she knows that he/she will retire at a certain age and his/her savings will be enough for a monthly amount of benefit at a specific amount.

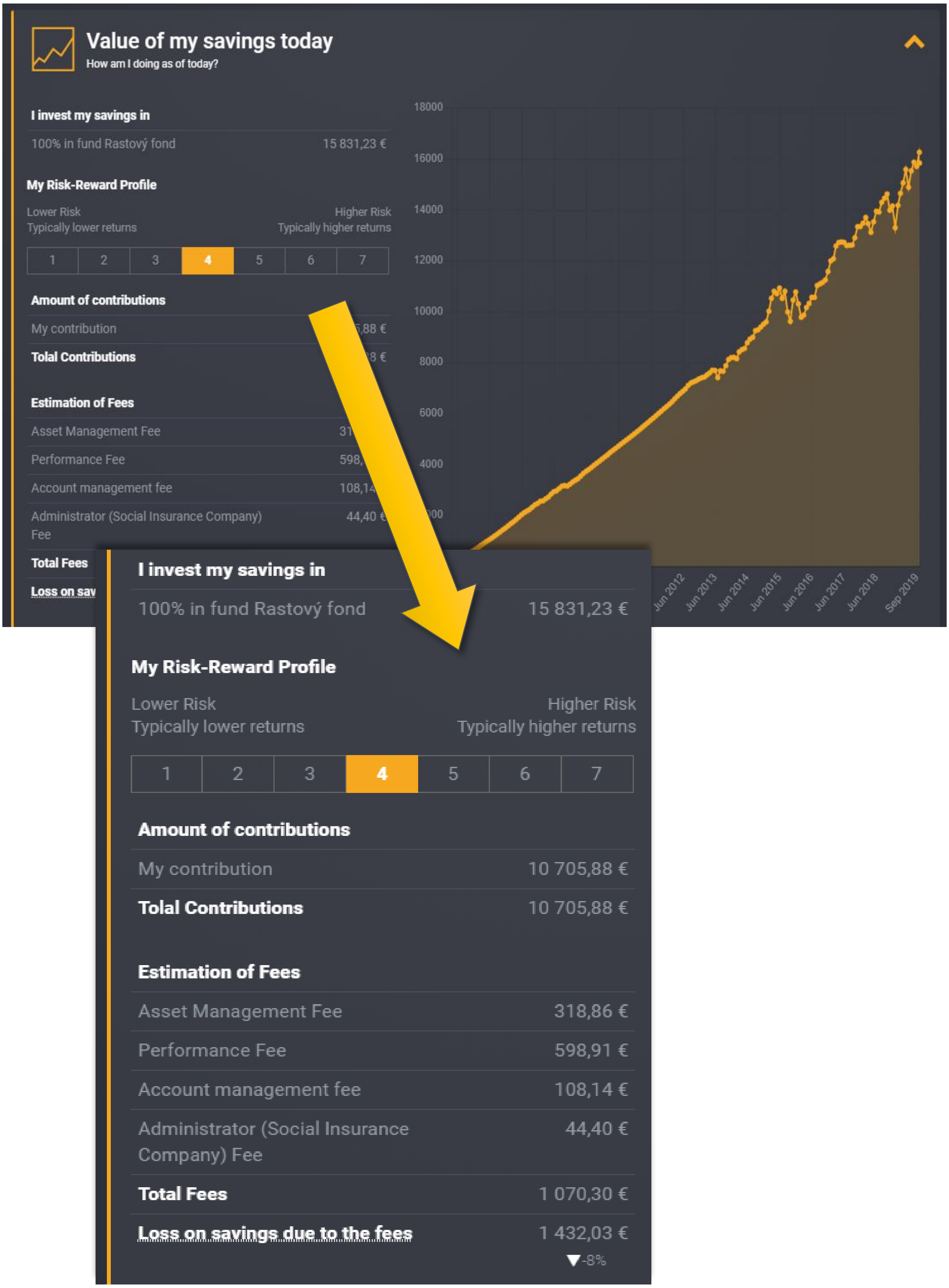
The estimated amount of the monthly pension is based on the assumption of payment of the saved amount for remaining life expectancy.

Behavioral research suggests that graphic design and structure of the layout significantly increase savers' willingness to open a statement and extract information. It is therefore essential that PBS should be designed in collaboration with graphic designers, to provide information in an attractive graphical form to motivate savers to be curious and to read the information.

From the research we know that some people perceive better text; others prefer visualization through graphs and pictures. It is therefore necessary to interpret the data not only in text form, but also graphically (using graphs, visualizations, bold colors). After obtaining the dominant information, the saver participant logically seeks more detailed information about the set savings “as of today”. Figure 21 provides information on the distribution of savings, risk-reward class of the saving vehicle (fund), amount of contributions and fees paid as of today. When presenting fees, we follow the EIOPA (2019) guidelines:

1. The PEPP cost presentation requires total aggregate costs expressed in both monetary terms (Euro) and as a percentage value in *Article 4(2)(h) of the PEPP Regulation*. Consumer testing research in the context of the legislative process of the PRIIPs Regulation, has shown that retail investors can understand monetary figures (Euro amounts) more readily than percentages. Small differences in costs expressed in percentages may correlate with large differences in the costs borne by the saver when expressed in monetary terms.
2. For the PEPP Benefit Statement it is necessary to present the impact of the costs on the final PEPP benefits. This requires setting assumptions and following the valuation methodology of the pension projections. It is suggested to use the so called ‘Reduction in Wealth’ approach.

Figure 21 Overview of current savings ("How I am doing as of today?")



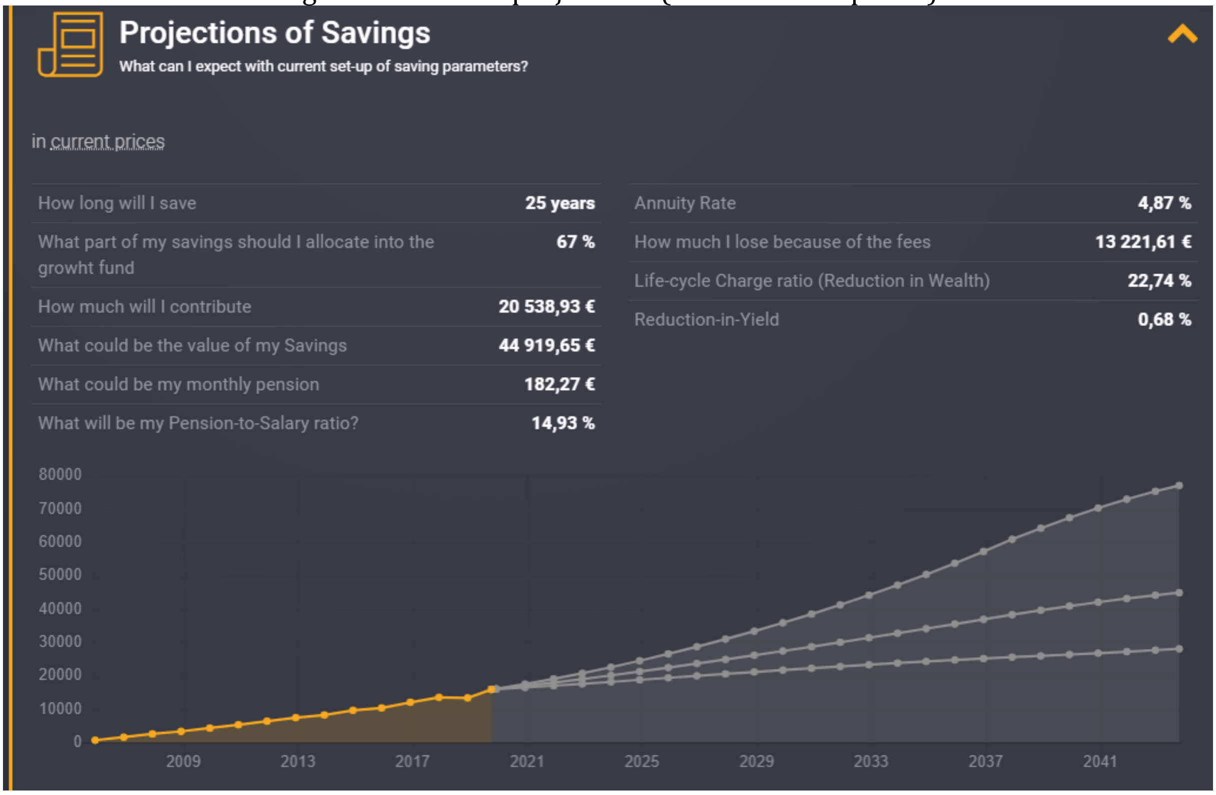
Source: Orange Envelope, 2019

The overview of the current status / settings is provided chronologically, followed by a projection section. We made forecasts of pension benefits through the moving block bootstrap, where we considered the current value of savings, the selected allocation ratio and the historical returns of the relevant financial instrument according to the risk-reward profile (SRRI) of a selected fund. For cost projections, we use RiY and RiW as recommended by EIOPA (2019):

1. The RiY shows what impact the total costs a retail investor pays will have on the investment returns. The total costs take into account one-off, ongoing and incidental costs. The RiY is calculated by comparing a notional gross yield for a product (i.e. the return that would have been achieved if there had been no costs) with the return achieved taking into account those costs. This cost measure is applied to all types of investment products within the scope of PRIIPs and therefore aims to effectively facilitate comparison.
2. In this regard, it is argued that consumers seem to find it difficult to grasp the idea of reducing the yield (compared to actual monetary terms that are more easily understood) and there has been criticism about the ability of consumers to understand RiY figures. Notably, there may be specific challenges when looking at longer term products: a RiY of 2% over the life of a personal pension may seem low or relatively insignificant to a consumer, whereas 2% lost yield over 40 years represents a significant impact of costs. Absolute numbers focused on the reduction in benefits or absolute difference between gross and net returns are much larger and for consumers there is reported to be a dissonance between these numbers, reflecting also consumer comprehension issues related to compounding over time.
3. Given the characteristics of the PEPP, in particular the long-term nature of this product, and the clear differences to PRIIPs, it might be meaningful to deviate from the RiY approach and instead to follow concepts such as the Reduction in Wealth (RiW) / charge ratio concept. This could help consumers as these approaches underpin the severe impact of costs on PEPP savers' retirement income and likewise allow PEPP savers to easily compare products from different providers. Moreover, the RiW / charge ratio rationale could allow for a concrete statement about the impact of costs on savers' income after retirement which is proven to be the key concern for savers.

Recommendations given by EIOPA (2019) as well as other research findings have been accommodated into the PBS and presented both graphically and textually.

Figure 22 Pension projections ("What can I expect?")



Source: Orange Envelope, 2019

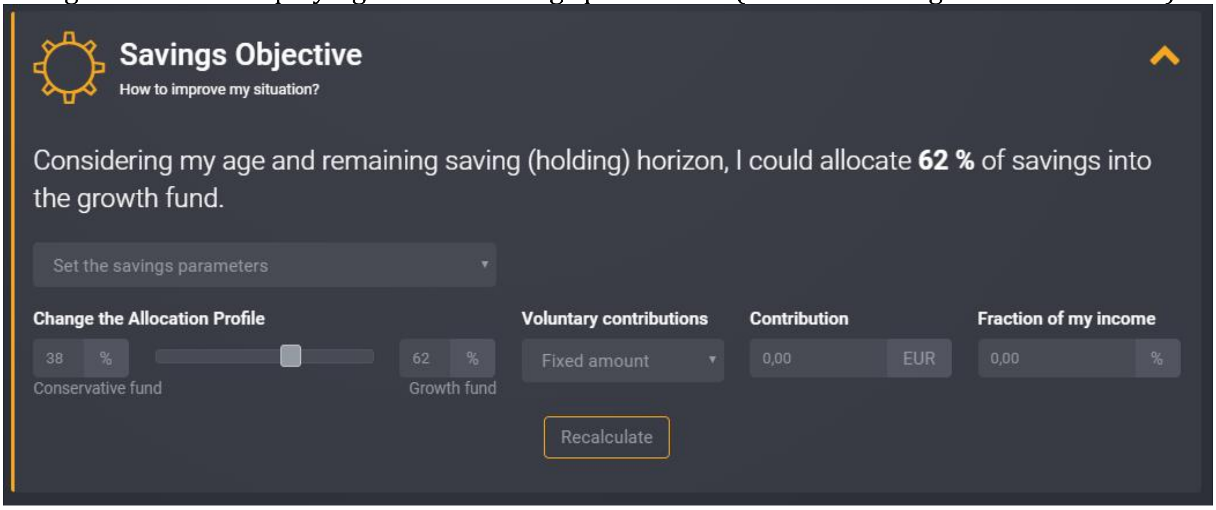
As the presentation of expected savings in nominal values is misleading from an economic point of view, we used inflation-discounted values and converted the values to today's prices. The PEPP Regulation requires the PEPP Benefit Statement to use the best estimate and an unfavorable scenario. In order to implement a simplified approach to quantification of the risk, it is suggested to add a favorable scenario and to set a reasonable range of outcomes. The best estimate scenario should be highlighted to the consumer as expected, probability-weighted, but not necessarily most probable. When projecting the expected value of savings in the form of figures, we model 3 scenarios and name them "optimistic, neutral and pessimistic". At the same time, we have added a chart showing the evolution of savings till today (in nominal terms – orange line) and the main projections are presented on three scenarios consisting of the 90th percentile (optimistic scenario), 50th percentile (neutral scenario) and 10th percentile (pessimistic scenario) of simulations based on the moving-block bootstrapping technique described in the previous chapter.

When adding additional confidence-enhancing tools, we accept the existence of hyperbolic discounting, which causes the saver / participant to prefer today's value over the future. Therefore, as part of the online (web) version of the PBS report, we propose the use of simple tools to understand the relationship between today's savings, savings settings (contributions and allocation ratio) and future expected savings.

It is inappropriate to warn clients of potential risks with complex formulations of financial econometrics. Simple tools, which act as a "toy" with which the saver / participant can play, seem more appropriate. They will help him/her to better understand the risks, because he/she directly sees the relationship between the set savings and the expected impact of the "action" on the future value of savings. One way to increase confidence in the decision-making process is to let the saver

/ participant alone to try out a tool simulating the effects of changing the allocation ratio. We implemented this tool in the PBS report web interface (Figure 23).

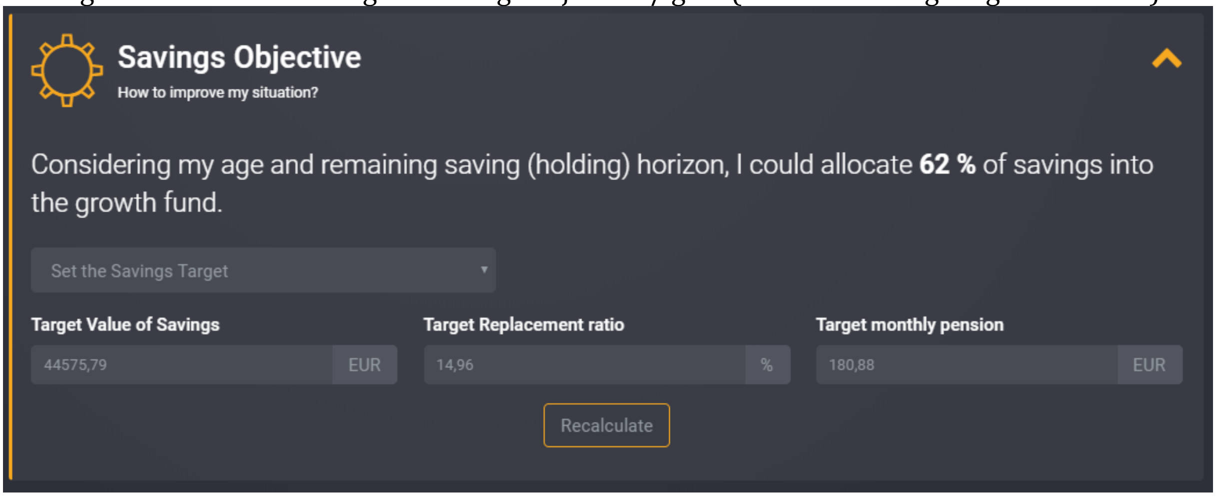
Figure 23 "Tool" – playing with the savings parameters ("Understanding short-term risks")



Source: Orange Envelope, 2019

Alternatively, the saver / participant may also set the desired savings target, either through the target savings value, the target pension-to-salary ratio (the share of monthly pension to the salary one can expect based on his/her life-cycle income), or the target pension amount (Figure 24).

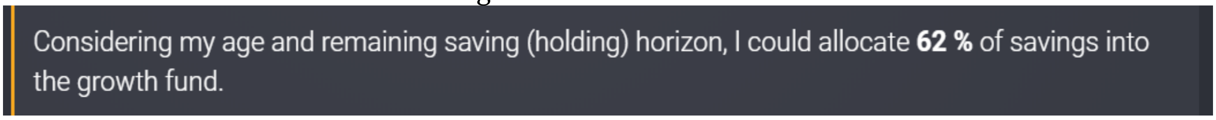
Figure 24 "Tool" – Setting the savings objective / goal ("Understanding long-term risks")



Source: Orange Envelope, 2019

The second way to increase the confidence in the decision-making process and to increase the saver's / participant's ability to act is to add a "assurance" tool in the form of an administrator's statement as a professional to the set savings parameters. We've implemented the "assurance" tool under the savings settings information so that it sums-up the entire savings settings section. The assurance tool can take a variety of forms, ranging from the ordering ("You have an improperly set saving. Change your fund to a riskier/safer one!") to a softer recommendation ("Consider changing the pension fund."). We have chosen a softer recommendation form (Figure 25), applying the recommendation to the age of the saver / participant and thus copying the life-cycle saving strategy.

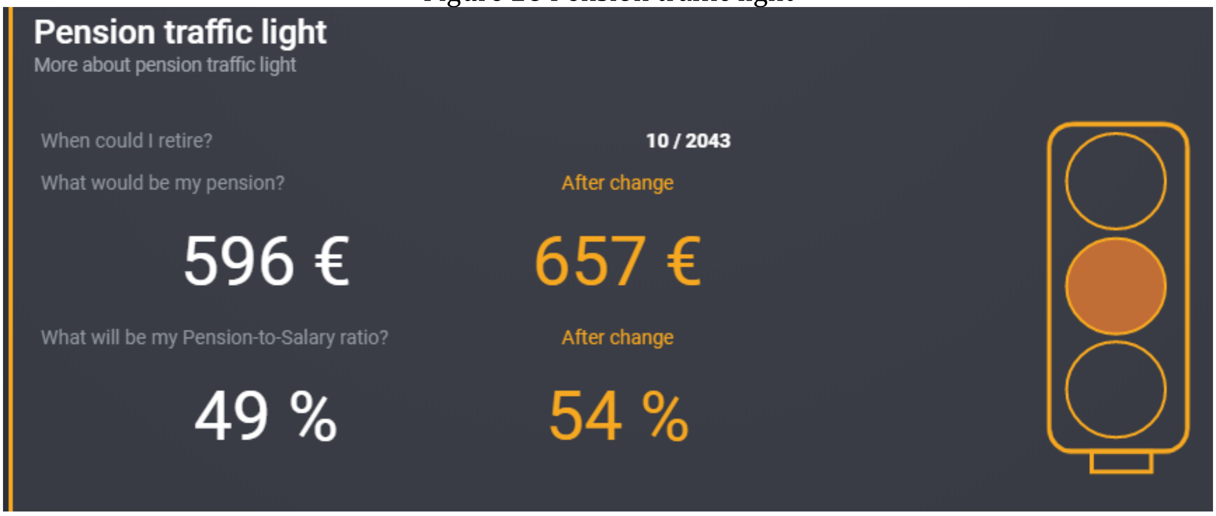
Figure 25 Assurance tool



Source: Orange Envelope, 2019

We consider necessary to motivate clients to choose, where possible, the fund in which they want to save and to review their decision as their get older. However, there are several risks related to the possibility that savers may transfer the savings into the inappropriate fund, or transfer at the wrong time. It is therefore appropriate to ensure that savers are convinced and reassured in their decision whether or not to consider changing the fund. It should be noted that any PBS may contribute to savers' overconfidence in their own capabilities in the opposite way the regulation intended. Savers may have the impression that they understand the financial decisions and make the fund change at the wrong time or choose an inappropriate allocation ratio. Therefore, we consider it necessary for a saver to have a tool to answer the question “Am I on track?”, considering both the current savings setting and after using the interactive tool (changes in saving parameters / saving target settings). The results of current savings set-up as well as changes resulting from using the interactive “tools” will appear at the zero layer screen in form the of the traffic light (Figure 26). If the expected benefit ratio (total monthly pension from all pension schemes to salary) is below 50%, the pension traffic light signals high adequacy risk (red light flashing). If the benefit ratio is between 50% and 67%, the traffic light flashes orange and above the 67%, the traffic light indicates low adequacy risk at retirement.

Figure 26 Pension traffic light



Source: Orange Envelope, 2019

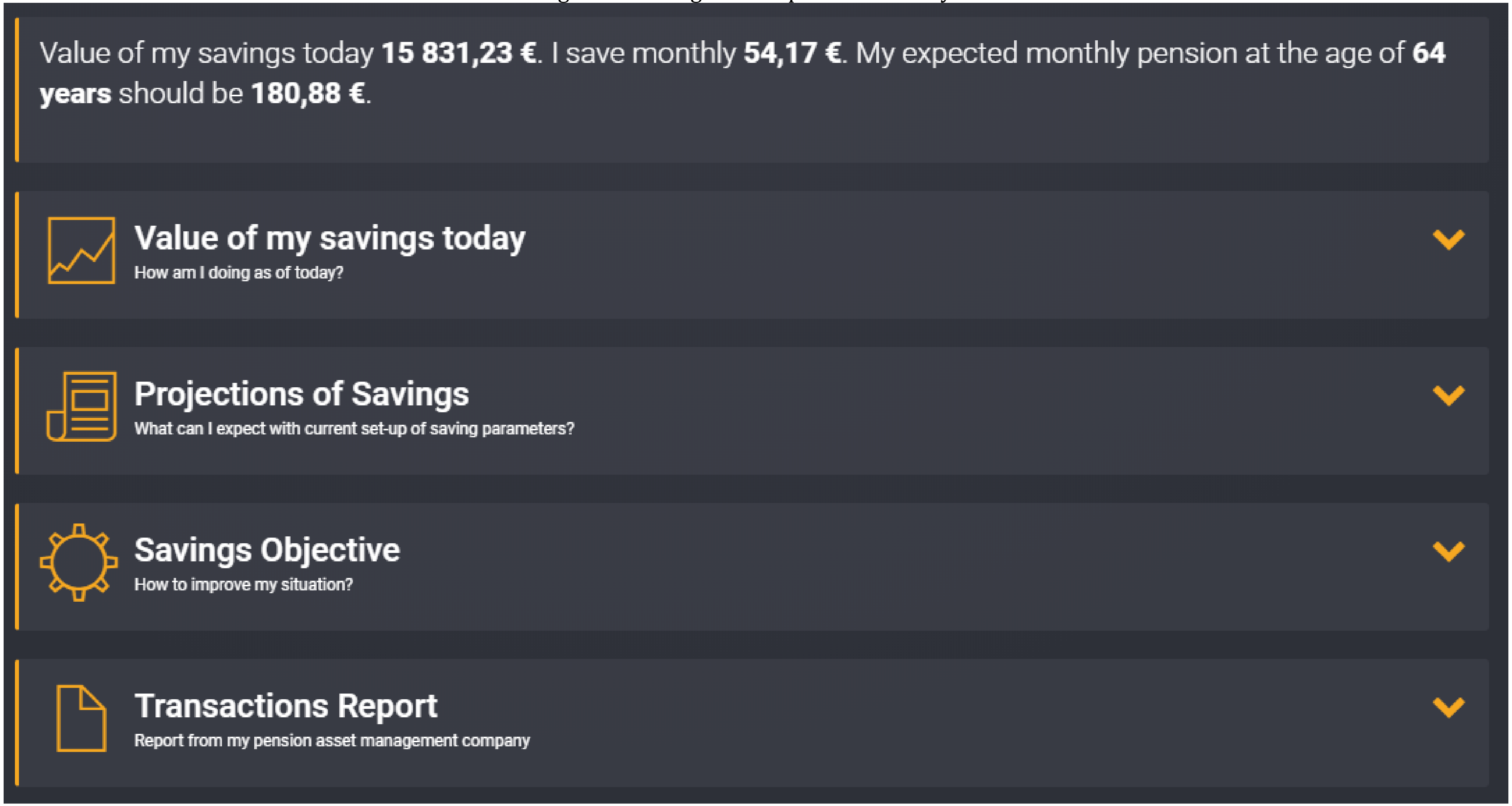
For all estimates of the future value of savings, we present the values in real terms (taking into account expected inflation from the respective simulations).

The zero layer (overview) of the proposed PBS report presents the basic facts about the set savings and the current state of savings (Figure 28). The online PBS within the zero layer provides the saver with information on what pension from individual pension schemes can be expected at the current state of savings and savings settings considering the neutral scenario and unchanged savings parameters including fees.

The first layer is then divided into 4 sections (Figure 27) that are chronologically ordered from (i) the current state of savings, (ii) the savings projection, (iii) the interactive tools, which is dedicated to saving settings and projections, which include tools to enable recognize the consequences of different settings of the allocation profile, the amount of contributions and pension objective, and (iv) report on transactions, which represents the second layer of the PBS report.

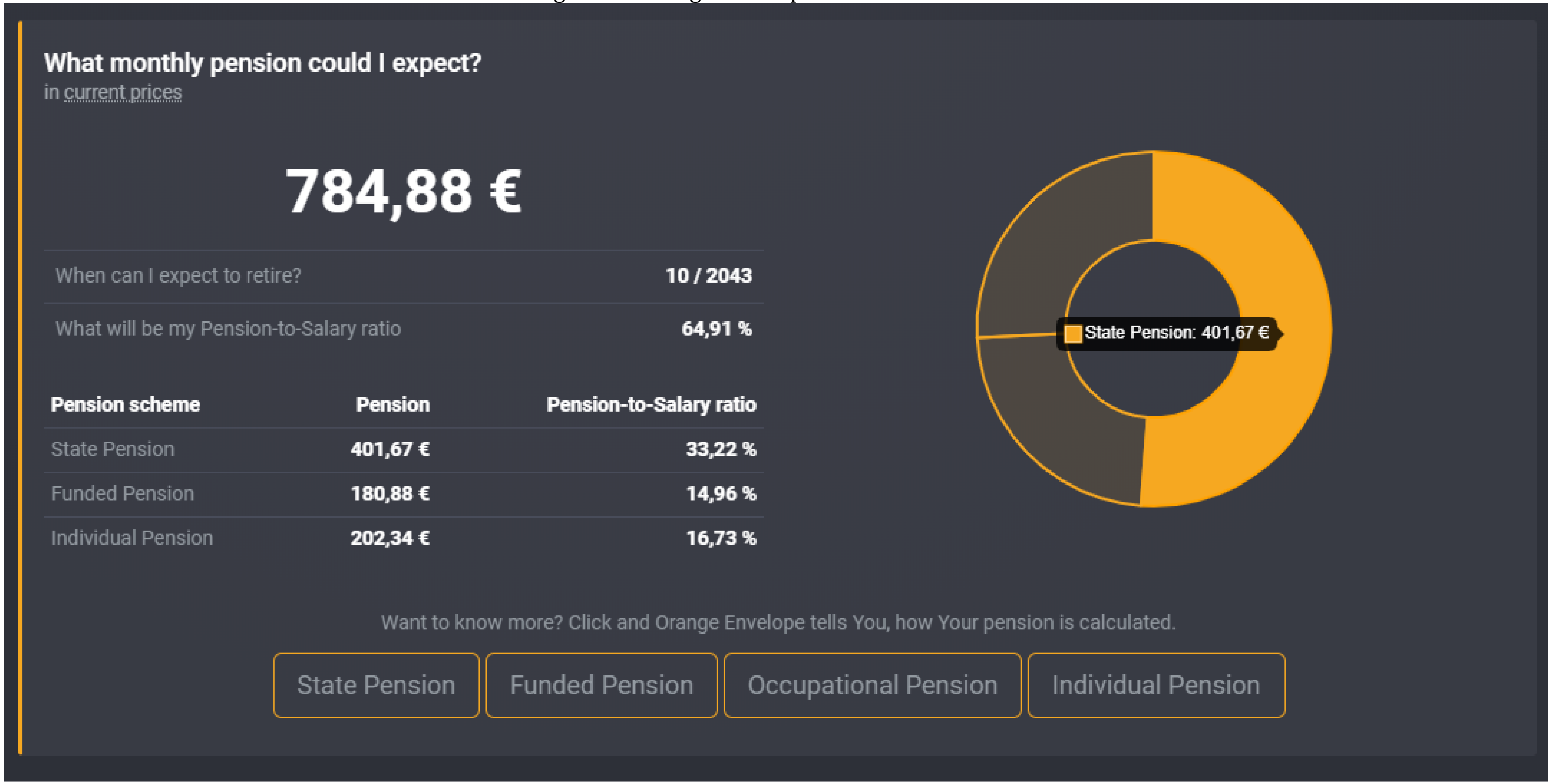
The proposed PBS statement has been designed according to knowledge of many behavioral studies to present information to the saver / participant in the form of questions and answers. At the same time, the information is categorized into several smaller sections arranged chronologically, which increases the clarity of the entire PBS report. The essence of the PBS report should be to provide the saver / user with an answer to the question "How am I doing today?" While allowing alternative scenarios to be tested through a tool ("toys") to change the saving parameters or set the savings target. At the end of the day, the saver should be able to answer the key questions: "What can I expect when I retire?" and "How can I improve my situation?".

Figure 27 Orange Envelope PBS - first layer



Source: Orange Envelope, 2019

Figure 28 Orange Envelope - Pension overview



Source: Orange Envelope, 2019

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