

IMPACT OF DIFFERENT LIFE-CYCLE SAVING STRATEGIES AND UNEMPLOYMENT ON INDIVIDUAL SAVINGS IN DEFINED CONTRIBUTION PENSION SCHEME IN SLOVAKIA

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Abstract: Searching for the optimal saving strategy is often tied with the life-cycle strategies where only the age of a saver is considered for setting the allocation profile between equities and bonds. Our article contributes to the debate by looking at the performance and adequacy risks arising from applying age-based saving strategies for savers in funded pension schemes. As many studies have proven the shift of the risk onto savers in defined contribution pension schemes under various saving strategies, we contribute to the debate by providing simulations of expected accumulated savings via funded pension scheme under the various life-cycle income profiles and existence of unemployment risk. Using the resampling simulation technique, we compare the fixed and age-based strategies of three different agents with various life-cycle income paths and different unemployment risk. We compare the expected amount of savings and calculate relative indicators comparing the expected monthly benefits, income replacement rate. We look closely on the impact of unemployment on the value of savings and calculate the unemployment factor explaining the value of savings lost due to the periods of unemployment. By combining life-cycle income functions of individuals with different education level and unemployment risk, we show that decisions of implementing low risk saving strategies are suboptimal and lead to a substantial decrease in replacement ratios not only for higher income cohorts but especially for the lowest ones. At the same time, we prove that employing low risk saving strategy leads to the increase of adequacy risk especially driven by the unemployment risk that is higher for lower education individuals. We conclude that age-based life-cycle saving strategies, where the remaining saving horizon is the only factor defining the allocation profile is not the optimal saving strategy and other factors should be considered as well when searching for optimal saving strategy.

Keywords: Pension savings, unemployment life-cycle income, life-cycle strategy.

JEL Classification: D14, D15, G11, J26.

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Introduction

Individuals in mandatory pension saving (MPS) scheme in Slovakia have their savings allocated mostly in one of the pension funds – equity or bond funds. Saving in only one of these funds will be considered as benchmark strategies. In our article, our goal is to compare the profitability that can be achieved with benchmark strategies compared to life-cycle savings strategies. In their case, the ratio of savings between equity and bond components changes dynamically, depending on the age and remaining savings period of 40 years (480 months). We deal with 3 types of individuals with different education level. In addition to comparing the potentially achievable returns at the end of the saving horizon, we will also be interested in the volatility of achievable returns and their spread from the average with the selected savings strategies. Savers are trying to get the best value for money, but they should also take into account the fact that higher potential appreciation also entails higher risk. The third key area on which we are trying to find the answer is how unemployment will influence the final amount of saving at the end of saving period. In this article, we work with three levels of empirical unemployment rate of selected educational cohorts, which we apply to the income of three individuals.

1. Description of Slovak Defined Contribution Pension Saving Scheme

The Slovak Pillar II was established as a defined contribution (DC) pension saving scheme in 2005. Since September 2012, the enrolment is fully voluntary (in September 2012 it became mandatory) and eligible for persons up to 35 years of age. The principle of the funded pension is based on the accumulation of savings during employment and investing savings in financial markets via special purpose vehicles – pension funds, which are managed and administrated by Pension Fund Management Companies (PFMCs), licensed by the National Bank of Slovakia (Andersen et al., 2019).

According to the applicable law in Slovakia (the Act on Old-Age Saving n. 43/2004), each PFMC is obliged to operate at least two pension funds which can be divided into two main groups:

- Bond guaranteed mandatory pension fund;
- Stock non-guaranteed mandatory pension fund.

Each PFMC is free to choose (mostly based on their business model) if it operates additional pension funds, which are optional. These legislative changes entered into law on April 30, 2013. Before this date, each PFMC had to operate three (respectively four) obligatory pension funds:

- Bond mandatory pension fund (since March 2005);
- Mixed mandatory pension fund (since March 2005);
- Equity mandatory pension fund (since March 2005);
- Index mandatory pension fund (since April 2012).

After the legislative changes became effective in May 2013, Mixed and Index pension funds became optional, and some of PFMCs merged these pension funds with obligatory Equity non-guaranteed mandatory pension funds. It is important to say that the first three categories of pension funds are (from an asset management point of view) actively managed pension funds, and Index pension funds are the only funds managed passively. However, changes in the fee policy (strictly regulated) forced providers to change the investment strategy of pension funds towards being passively managed using mostly ETFs as main financial instruments (Andersen et al., 2019).

Individuals have the possibility to save in one or two pension funds at the same time, it is completely up to a saver how much of his own savings would be invested in one pension fund or another. They can invest limited amount of savings in a Bond guaranteed pension fund and another part in an Index non-guaranteed pension fund. There is no fee or charge to change this allocation ratio or switch pension funds managed by the same PFMC (Andersen et al., 2019). Lots of individuals currently enrolled in a MPS scheme have their saving allocated only in one MPF.

According to Ministry of Labour, Social Affairs and Family Slovak Republic, only very small group of individuals have their savings split between two MPFs. Slovak MPS scheme does not have pre-defined so-called life-cycle saving strategies for individuals. In some Eastern Europe countries (for example Estonia, Latvia and Lithuania) PFMCs provide some life-cycle pension funds to their clients. According to Barnes et al. (2008) “a life-cycle approach to pension investment could involve investing

in equity early in life, and increasing bond holdings as retirement approaches. Investment in equity early in the life cycle ensures a long holding period for equity (e.g., 20–30 years), thus giving a potential for wealth accumulation at relatively high returns and relatively low long-run risks, if the long-term returns and risks of equities are similar to what they have been historically. Switching into bonds as retirement approaches means that the holding period of bonds will be relatively short (e.g., 5–15 years), so the investor could theoretically benefit from the lower risk of bonds in the short term, if bond returns and risks are in line with their historical profile. In general, life-cycle can be described as an investment approach that involves a switching of the portfolio over an individual's life cycle is observed among real-world DC plans." Based on the current law in Slovakia, individuals can benefit from individual life-cycle saving strategies, which allow them to managed their savings during their live without the need to create a new pension fund. According to Malkiel (1996), "life cycle investment strategy is built on the idea of 'age-based investing', or the notion that investors should allocate a larger portion of their long-term investment to equities or other risky assets when they are young and have a relatively long investment horizon, gradually shifting this allocation towards less risky assets as they approach retirement." This concept is discussed in papers from Merton (2007), Ayres and Nalebuff (2008), Basu et al. (2009), Pfau (2010), Ayres and Nalebuff (2013) and Wang et al. (2017). A life cycle strategy does not keep its target mix constant over time. Instead, it deterministically changes the target mix that is held in equities and bonds according to a predefined 'glide path', which gradually tilts the assets mix away from equities and other risky assets towards less risky assets such as bonds and cash as investors approach retirement. For this reason, in our article we focus on designing, testing and comparing life-cycle saving strategies on individual bases. We compare those strategies with passive approach based on saving in one bond or equity fund.

Contributions to the MPS scheme are based on the individual's wage level, which according to Guvenen (2009) varies depending on the individual's education, work experience, age, previous wage and unemployment. According to recent research from OECD (2018),

education have huge impact of individual wages across many developed countries – higher and better education means higher wages for individuals. Katz and Murphy (1992) confirmed in their study the impact of work experience on the productivity of individuals which is also related to their age (assumption that higher age indicate more work experience) and the higher wage. Bukit et al. (2018) confirmed that the experience workers in any ages will increase the value of labour productivity and also shows that the amount of wage influences the labour productivity too. Galdeano and Turunen (2005) show empirical evidence that real wages are lower in local labour markets with higher unemployment. We assume that individuals with lower levels of education are more likely to experience unemployment than individuals with higher levels of education. The negative impact of unemployment on wages should therefore be higher for individuals with lower levels of education. The negative impact of unemployment on wages is also related to saving itself. In the period of unemployment, the individual does not pay contributions to the MPS scheme. The more period of unemployment during the life of an individual, then the less he will contribute to the system, which will negatively affect his savings. That we focus in the article on monitoring the impact of unemployment effect to wages during career of individuals with different levels of education and also on the final amount of savings in the end of saving period.

2. Research Methodology Description

At the beginning of the methodology part, we discuss in more details the forms of contributing to mandatory pension funds (MPFs). Next part contains a detailed description of the selected simulation method used to estimate the future returns for equity and bond MPFs including inflation and description of the savings scheme with implemented contributions, MPFs returns, and a fee policy reflecting the current MPFs set-up. At the end of methodology part, we provide:

- explanation of selected saving strategies:
- two benchmark strategies (I, II) investing during the entire saving period into the equity fund (Stock (I)) or bond fund (Bond (II)) only; and
 - two life-cycle investment strategies called as Aging I. (III) and Aging II. (IV),

which decrease the risky part of savings as the individual ages;

- evaluation criteria of the results obtained by implementing simulation methods and comparison matrix for each combination of results.

Let us have a life-cycle income function (LCI) of 3 modelled individuals, where the LCI functions are defined by their previous income, education level and age of an individual. In the article, we assume that all three individuals will have the same length of saving period set at 480 months (40 years), which is the same as length of the working career in the case of an individual with a master's degree. However, we understand that the working career is higher than length of saving period for an individual with a high school and elementary education level. Next, we assume two possible option:

- individuals with a full career (without the existence of unemployment risk); and
- individuals with an incomplete career (with the existence of unemployment risk).

In order to meet the article's objectives, we do not primarily focus our attention on whether a longer saving period for individuals with lower education level can have a significant impact on the level of accumulated savings compared to an individual with a higher education and a shorter saving period. Rather, we focus on the variance in the simulated final pension pots using three simulation methods.

Tab. 1 presents the achieved education level for each individual, including their income profiles, the initial monthly wages, length of the saving period expressed in months, pension

saving scheme entry age and respective retirement age expressed in months. We should stress that according to the Social Insurance Act N. 461/2003, the retirement age for individuals will be different due to the mechanism that ties the retirement age to the life-expectancy of a retiring cohort. An individual with an elementary education level joins the pension saving scheme in 2018 as a 16-years-old, however an individual with a master's degree entering the labour market in that same year (2018) is already 24 years old. This naturally implies that an individual with master's degree will have a retirement age lower than an individual with Elementary education when entering the labour market in the same year. For a comparability of the results, we unified the pension scheme entry age and thus we can expect the same retirement age for all modeled individuals.

Estimation of life-cycle income for analysed individuals is realized using the lifetime income function presented by Guvenen (2009) and Guvenen and Smith (2014) and detailed for the conditions of the Slovak Republic by Balco et al. (2018) and Šebo et al. (2017). We have modified the LCI model and abstain from both expected and unexpected shocks such as unemployment, disability, maternity leave, etc. The model uses the long-term data from the American Community Survey (ACS, 2014) when estimating the lifetime income functions, as there is no longitudinal data series for Slovakia available. Initial wage for each individual $w_{j,1}$ is estimated using the Slovak Statistical Office data (Tab. 1). Individual income

Tab. 1: Input data for 3 types of individuals

Education level (j)	Wages profile	Initial monthly wage (w_i)	Saving period (T)	Entry age into MPS scheme (x_i)	Retirement age (x_T)
Elementary	Minimum wage	480 € in 2017	480 months (40 years × 12 months)	300 months (25 years)	780 months (65 years)
High school	Average wage	998 € in 2017	480 months (40 years × 12 months)	300 months (25 years)	780 months (65 years)
Master's degree	1.2 × average wage	1,198 € in 2017	480 months (40 years × 12 months)	300 months (25 years)	780 months (65 years)

Source: own

w in education level j and time t is represented as w_{jt}^* , τ_t represents inflation rate over time t . Let $t \in \{1, 2, \dots, T\}$; $T = 480$ and indicates a serial number of the saving rate. Simulated expected future income is calculated as follows:

$$w_{j,t} = \begin{cases} w_{j,t}; t = 1 \text{ see Tab.1} \\ w_{j,t-1} * \omega_{j,t}^* * (1 + \tau_t); t \in \langle 2, T \rangle \end{cases} \quad (1)$$

where $\omega_{j,t}^*$ denotes the real annual wage increase of the individual with the appropriate education j at time t , calculated as:

$$\omega_{j,t}^* = \begin{cases} 1; t = 1 \\ \frac{\tilde{y}_{j,x,t}^*}{\tilde{y}_{j,x,t-1}^*}; t \in \langle 2, T \rangle \end{cases} \quad (2)$$

Formula (2) is taken from the research of Šebo et al. (2015) and Guvenen and Smith (2014). $\tilde{y}_{j,x,t}^*$ and $\tilde{y}_{j,x,t-1}^*$ indicate individual income for each education level j and age x in time t and $t-1$, and represents the accrued labour capital in form of the work skills and experience.

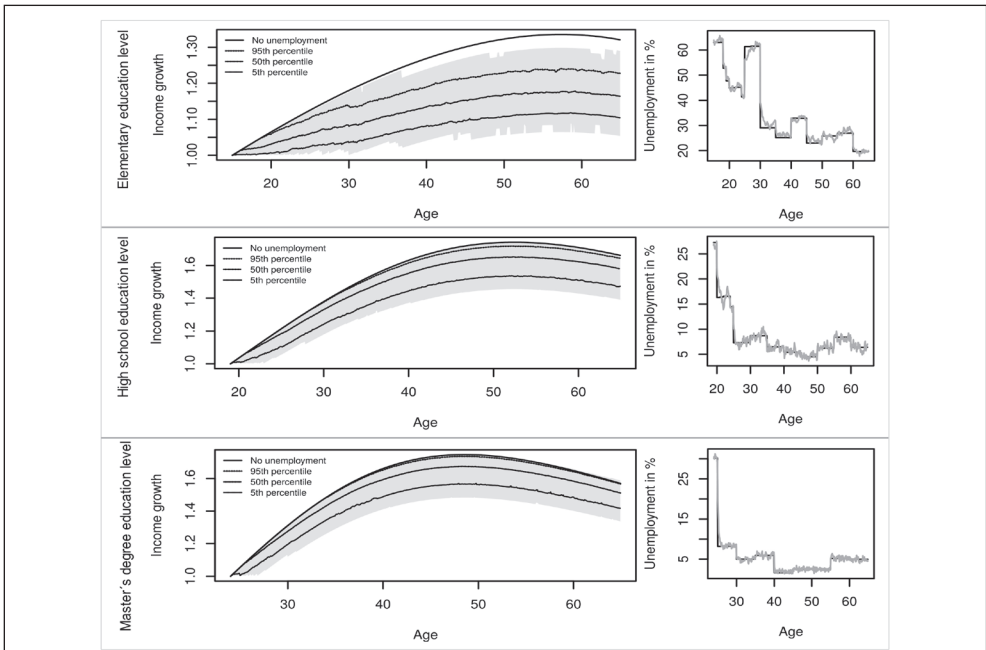
According to Cooper (2014) and Guvenen et al. (2015), if an individual was unemployed for a certain period, his wage does not follow the original full-career income function due to the missed skills, working habits, experience etc. When he returns to the labour market, he can expect to negotiate the wage lower than his peers with higher accrued labour capital. His negotiated wage is expected to copy only the inflation, or in other words, he is able to negotiate the wage that is of the same real value as before becoming unemployed.

Due to existence of unemployment risk, we modify formula (1) as follows:

$$w_{j,t} = \begin{cases} w_{j,t}; t = 1 \\ w_{j,t-1}(1 + \tau_t); U_t = 1, t \in \langle 2, T \rangle \\ w_{j,t-1} * \omega_{j,t}^* * (1 + \tau_t); U_t = 0, t \in \langle 2, T \rangle \end{cases} \quad (3)$$

where U indicates the employment status in time t . $U_t = 1$ indicates that an individual is unemployed, while $U_t = 0$ indicates that an individual is employed. When individual is employed ($U_t = 0$), the formula is equal to the

Fig. 1: Income growth and unemployment rate for 3 types of individuals



Source: own in R

formula presented in formula (1) and income function in time t depends on inflation rate as well as on accrued labour capital during the period. If an individual is unemployed ($U_t = 1$), his income function in time changes only due to the inflation.

Level of unemployment rates for selected individuals with respected education level and age was obtained from official database of Statistics office of Slovak Republic for quarterly periods from 2008 till 2018. The graphs in Fig. 1 present the estimated income functions and unemployment rates of modeled individuals for a defined education level and different ages. Simulations, calculations and their graphical interpretation were performed using R – free software environment for statistical computing and graphics.

Further, we can reasonably expect that individuals contribute to the MPS scheme only if they are employed ($U = 0$). In the case of unemployment ($U = 1$), individual receives a temporary unemployment benefit, but they do not contribute into the pension scheme. In order to estimate the level of contributions, we define the wage an individual receives as $w_{j,t}^*$ and we can define the contribution base as follows:

$$w_{j,t}^* = \left\{ \begin{array}{l} w_{j,t}; t = 1 \\ 0; U_t = 1, t \in \{2, T\} \\ w_{j,t-1} * \omega_{j,t}^* * (1 + \tau_t); U_t = 0, t \in \{2, T\} \end{array} \right\} \quad (4)$$

Thus, the contributions toward the pension scheme are tied to the wages paid and can be expressed in relative terms (contribution rate). Let us have mandatory contributions c_t and voluntary contributions $c_{va,t}$ toward the pension scheme. Mandatory contribution rate is set by law and voluntary contributions are based on the discretionary decision of an individual. For purpose of this article we consider only mandatory contributions based on current law, so the voluntary contribution rate $c_{va,t}$ for $t \in \{1; 480\} = 0$. The mandatory contribution rate c_t defined for Slovak pension scheme for time t is as follows:

- c_t for $t \in \{1; 12\} = 4.50\%$;
- c_t for $t \in \{13; 24\} = 4.75\%$;
- c_t for $t \in \{25; 36\} = 5.00\%$;
- c_t for $t \in \{37; 48\} = 5.25\%$;
- c_t for $t \in \{49; 60\} = 5.50\%$;
- c_t for $t \in \{61; 72\} = 5.75\%$;
- c_t for $t \in \{73; 480\} = 6.00\%$.

Amount of gross contributions paid by individual in absolute terms ($C_{j,t}$) is calculated as follows:

$$C_{j,t} = c_t * w_{j,t}^* \quad (5)$$

Further, we have to factor in the fee policy applied for the pension scheme. The contribution fee φ in Slovak pension scheme is equal to 1.25%, out of which 1% of contributions $c_{j,t}$ is paid to the pension asset management company and remaining 0.25% to the Social Insurance Company, which administrates the mandatory contributions. Net contribution is calculated as follows:

$$C_{j,t}^* = C_{j,t} * (1 - \varphi) \quad (6)$$

Pension asset management companies apply two additional fees – management fee and a performance fee. Process of fee implementation is presented by Mešarová et al. (2015) where they transformed gross returns $r_{s,t}$ and $r_{b,t}$ into net returns $r_{s,t}^*$ and $r_{b,t}^*$ as follows:

$$r_{s,t}^* = r_{s,t} - F_t^M - F_t^V \quad (7)$$

$$r_{b,t}^* = r_{b,t} - F_t^M - F_t^V \quad (8)$$

where F_t^M represents monthly management fee. The management fee charged by pension asset management company is applied on assets under management. Level of annual management fee is 0.3% p.a., so the monthly management fee can be calculated as follows:

$$F_t^M = \frac{0.3\%}{12} = 0.025\% p.m \quad (9)$$

F_t^V represents the performance fee, applied by an investment manager for generating positive returns. According to the Slovak law, the performance fee can be charged only if the pension fund closing price (P_t) reaches new highs (High-Water-Mark Principle according to Shin et al., 2017). Performance fee is set at 10% of the difference between new and old highs reached during the last 36 months (3 years). Performance fee can be calculated as follows:

$$F_t^V = \left\{ 0.1 \left(\frac{P_{t-1}(1+r_t - F_t^M)}{\max_{t-36} P} - 1 \right); \right. \quad (10)$$

$\left. \begin{array}{l} \text{under the condition } P_{t-1}(1+r_t - F_t^M) > \max_{t-36} P \\ 0 \end{array} \right\}$

Many different simulation approaches can be found in the literature. The most popular method is the Monte Carlo method with the best fit distribution (Rubinstein & Kroese, 2007; Wiersema, 2008; Vajargah & Shoghi, 2015). This approach allows us to create basically unlimited amount of simulations for almost any financial instrument with sufficient time series. Disadvantage of this method is that they do not maintain relations among financial instrument returns or macroeconomic variables. If we want to maintain a relationship between variables, we could use copula function with Monte Carlo simulation method. It is computationally and numerically very difficult method (the difficulty increases with the number of simulated parameters).

The simulation method that overcomes the disadvantage of the Monte Carlo method and therefore used in this article is called resampling. The purpose of this method is to use a long historical time series of various parameters and simulated the expected future paths without destroying the relations among the parameters. The reason why we decided to use this approach is that in our model we could potentially work with many different macroeconomics indicators as well as many different financial instruments, so the combination of parameters is unlimited. We must choose one parameter which will define the size of the blocks. In our model, we work with two asset classes (equities and bonds) and supplement the data with the inflation. This method is described in detail by Šebo et al. (2017), Balco et al. (2018), and Mešťan et al. (2018, 2021).

Resampling method works with almost 100 years-long block of historical financial data series (from January 1919 to September 2018) consisting of:

Equity returns represented by monthly historic returns (dividends included) of Dow Jones Industrial Average 30 (DJIA 30) index since January 1919 until December 2001, and since January 2002 until September 2018 we use monthly returns of ETF DIA which is the exchange traded financial instrument designed to copy DJIA30 index performance.

Bond returns represented by monthly historic returns of 7–10 US treasury bond (constant maturity) from January 1919 to December 2001, and from January 2002 to September 2018 we use monthly returns of

ETF IEF which copies the US treasury bonds with 7–10 years duration.

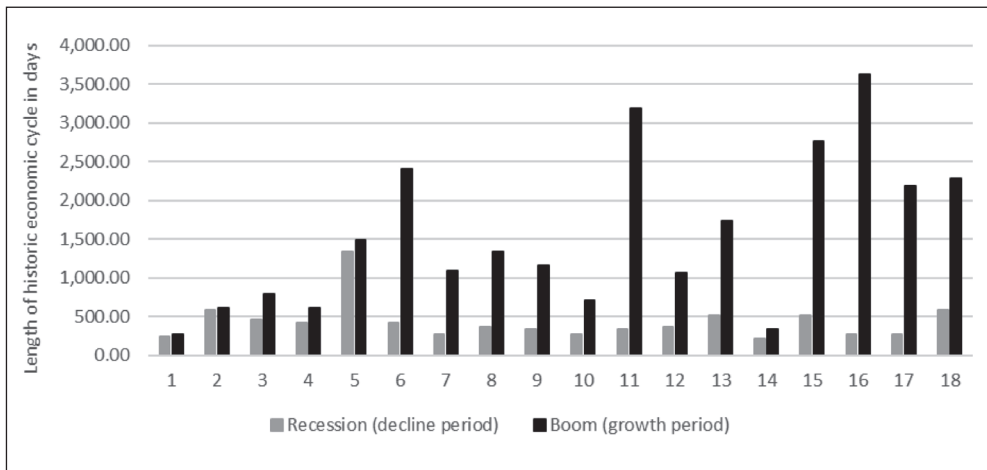
Inflation rate represented by monthly changes in US customer price index (CPI) since January 1919 until September 2018.

All datasets described above have been extracted from the FRED – FED St. Louis database. This dataset (called block (B)) consists of 3 columns represented by monthly inflation changes, equity and bond monthly returns for a given period. We divide this original block of data into 36 shorter blocks of data based on the business cycle (expansion, contraction) using the National Bureau of Economic Research methodology, which provides information on US Business Cycle and Expansions and Contractions. We get 18 expansion blocks (B_G) and 18 contraction blocks (B_D). Then we start generating 480-months (40-year) long blocks containing monthly returns of equities, bonds and inflation. Combining expansion and contraction blocks, we get 1,000 new data series for bonds, equities and inflation, which gives the total number of simulations. We mark monthly forecasted return for equities $r_{s,t}$, for bonds as $r_{b,t}$ and for inflation rate as τ_t .

Based on the analysis of the pension funds' portfolio structures (ManazerUspor.sk, 2018), we can reasonably expect than almost 99% of the portfolios consist from ETFs tracking one or more equity and/or bond indices. For purpose of this article we will consider that equity MPF fund will invest 100% of the portfolio into equities and bond MPF fund will invest 100% of the portfolio in bonds.

In order to present reasonable results of simulations, we present three scenarios – neutral, optimistic and pessimistic. Neutral scenario is represented by the 50th percentile of all simulations results, negative and positive scenario is represented by the 10th, respectively 90th, percentile. There is no specific national regulation on the methodology for simulation methods in this scheme. For this reason, the percentiles have been set according to the Slovak regulation on Pension Benefit Statement for supplementary pension fund providers in supplementary pension scheme in Slovakia starting from 2019.

In order to calculate expected pension savings, we apply four different saving strategies – two benchmark strategies and two life-cycle strategies. Benchmark strategies are marked as Stock (I) and Bond (II) strategy.

Fig. 2: Length of economic cycles from January 1919 to September 2018


Source: own based on data from NBER, FRED, Thomson Reuters Eikon, Morningstar Direct and Finance Yahoo

Under the strategy (I), individuals allocate $we_{i,s,t} = 100\%$ of their savings exclusively to the equities (bonds weights are $we_{i,b,t} = 0\%$), under the strategy (II), they allocate $we_{ii,b,t} = 100\%$ of their savings exclusively to bonds (equities weights are $we_{ii,s,t} = 0\%$).

The remaining two saving strategies, Aging I. (III) and Aging II. (IV), are based on a dynamic change in the individual savings allocation ratio over the saving period. We speak about so called life-cycle saving strategies that use de-risking over time depending both on the individual age or the overall remaining length of saving period. The significance of life-cycle saving strategies in the case of long-term savings (including retirement savings) was expressed by several authors Merton (2007), Ayres and Nalebuff (2008), Basu et al. (2009) or Ayres and Nalebuff (2013). Fernandes (2013) highlights the importance of life-cycle strategies as follows: according to lifecycle strategies, portfolio's exposure to risky assets should decline and investors should allocate more capital to riskless assets as they get older. We check if our results support two arguments behind lifecycle strategies. The first part of the previous sentence claims that equities outperform bonds in the long term and the second one that the risk of equity decreases

in the long term. Aim of these strategies is to reduce expected risk through reducing exposure to riskier assets on an asset-weighted basis over the lifecycle, decrease potential volatility of savings close to the retirement and deliver higher return (accumulated wealth) for individual compared to any different strategy.

The life-cycle saving strategy (III) is based on individual's current age and follow the simple equity allocation rule '100 - age'. As the age is expressed in months (not years), equities allocation ratio is calculated as follows:

$$we_{III,s,t} = 1 - \frac{x_t}{1200} \quad (11)$$

and respective bond allocation ratio is calculated as follows:

$$we_{III,b,t} = 1 - we_{III,s,t} \quad (12)$$

Second life-cycle saving strategy (IV) is based on the length of a remaining saving period, not on the age of an individual. In our case, the de-risking is realized during the saving horizon. The equity allocation ratio is expressed as follows:

$$we_{IV,s,t} = 1 - \frac{t}{T} \quad (13)$$

and respective bond allocation ratio is calculated as follows:

$$w_{e_{IV} b,t} = 1 - w_{e_{IV} s,t} \tag{14}$$

In order to respect legal restrictions on equity allocation in Slovak pension scheme, we have implemented the mechanism limits the equity allocation based on following rules:

$$w_{e_{i s,t}} = \left\{ \begin{array}{l} \max 100\%; t \in \{360; 372\} \\ \max 90\%; t \in \{373; 384\} \\ \max 80\%; t \in \{385; 396\} \\ \max 70\%; t \in \{397; 408\} \\ \max 60\%; t \in \{409; 420\} \\ \max 50\%; t \in \{421; 432\} \\ \max 40\%; t \in \{433; 444\} \\ \max 30\%; t \in \{445; 456\} \\ \max 20\%; t \in \{457; 468\} \\ \max 10\%; t \in \{469; 480\} \end{array} \right\} \tag{15}$$

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 (5), can be calculated as follows:

$$S_{i j,T} = \sum_{t=1}^T C_{j,t} \left(1 + (r_{s,t}^* * w_{e_{i s,t}} + r_{b,t}^* * w_{e_{i b,t}}) \right)^{T-t+1} \tag{16}$$

and i indicates a serial number of saving strategy where $i \in \{I, II, III, IV\}$. We assume that new contributions $C_{j,t}$ are invested at the beginning of the each saving period (t). It means, that the first contribution is invested for a period of 480 months, second contribution is invested 479 months and the last one is invested only for 1 month. Current regulation on Pension Benefit Statement in Slovakia uses formula (12) with $T - t$ instead of $T - t + 1$. Using $T - t$ approach compared to the $T - t + 1$ approach logically slightly underestimate the final value of savings.

Based on the above-mentioned methodology, we attempt to answer the following scientific questions:

Which saving strategy deliver higher returns or accumulated wealth in the end of the saving period?

Does life-cycle saving strategies decrease potential risk/volatility at the end of saving period and deliver higher saving performance than the benchmark strategies?

How does the existence of unemployment affect the final value of savings for modeled individuals?

Final methodological part focuses on the evaluation of achieved results and should provide the solid ground for the discussion part. The first evaluation indicator is the savings performance $SP_{i j,T}$ for each individual j and each saving strategy i . It can be viewed as a ratio of final savings and paid contributions. Savings performance indicator, as presented by Šebo et al. (2017) and Mešťan et al. (2021), is calculated as follows:

$$SP_{i j,T} = \frac{S_{i j,T}}{\sum_{t=1}^T C_{j,t}} - 1 \tag{17}$$

Second indicator (used by Kilianová et al., 2006; and later Melicherčík et al., 2015) is the monthly retirement indicator ($MRI_{i j,T}$), which indicates the number of months during which an individual j will receive pension for each strategy i which is equal to his last pre-retirement wage. Monthly retirement indicator has an interesting interpretation value, as it allows an individual to modify his consumption behaviour 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 can cover at certain replacement ratio of the last income of an individual. $MRI_{i j,T}$ could be calculated as follows:

$$MRI_{i j,T} = \frac{S_{i j,T}}{w_{j,T}} \tag{18}$$

Third indicator is called individual replacement ratio ($IRR_{i j,T}$). This ratio told us ratio between the individual last wage in time of retirement and expected pension benefit. In optimal case, this ratio should be 1 or 100% (or if we multiply this ratio by 100). If this ratio is equal 1.0, the pension benefit is equaled as their last wage before retirement and their standards of living will not decrease. But if this ratio is 0.5, then it means that an individual will have resources to cover only half what he could afford from his last pay. We calculate it as follows:

$$IRR_{i j,T} = \frac{PB_{i j,T}}{w_{i j,T}} \tag{19}$$

Through the fourth indicator, we identify the impact of unemployment on the final savings. We examine the difference in the amount of accumulated savings under the unemployment risk compared to the amount of accumulated savings when there is a full-career and no unemployment. We mark this indicator as $\Delta S_{ij,T}$ and it is calculated as follows:

$$\Delta S_{ij,T} = \frac{S_{ij,U=0,T}}{S_{ij,U=1,T}} - 1 \quad (20)$$

where $S_{ij,U=1,T}$ indicates the amount of savings for each individual j at the end of saving period at time T for each strategy i with existence of unemployment ($U = 1$); and $S_{ij,U=0,T}$ indicates the amount of savings for each individual j at the end of saving period at time T for each strategy i under the full-career ($U = 0$).

Fifth indicator is called Pension Benefit ($PB_{ij,T}$) and indicates monthly expected pension for each individual j and for each strategy i in the end of saving period T . $e_{j,T}$ indicates expected life expectancy in years for individual j in time of retirement T . This indicator is calculated as:

$$PB_{ij,T} = \frac{S_{ij,T}}{e_{j,T} * 12} \quad (21)$$

Last indicator is called an Unemployment effect ($UE_{ij,T}$) and it describe average monthly amount of saving which individual lost due to unemployment. It is calculated as follow:

$$UE_{ij,T} = \frac{S_{ij,U=0,T} - S_{ij,U=1,T}}{\sum_{t=U=1}^T t} \quad (22)$$

where $\sum_{t=U=1}^T t$ is sum of months in which individual have been an unemployed.

3. Results and Discussion

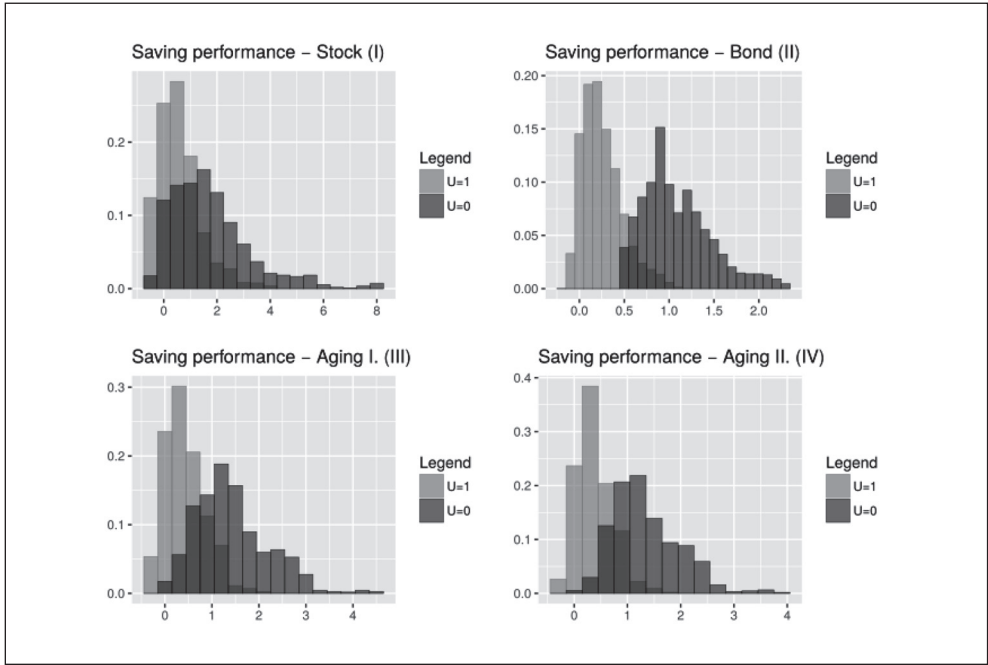
First, we discuss the results of an individual with a minimum wage that has either worked continuously throughout the entire savings period of 480 months ($U = 0$) or was unemployed for a certain period ($U = 1$). Fig. 3 compares (using histograms) the distribution of returns using the SP indicator for each strategy. Regardless of being unemployed during the saving period, we show that the highest value of savings measured by the SP indicator could be expected by employing the Stock (I) strategy of saving solely in the equity fund. The lowest value of SP can be expected when saving in a bond fund through Bond (II) strategies. Between the

two life-cycle strategies, Aging I. (III) and Aging II. (IV), we observe very negligible differences of the performance. At the same time, these two strategies have achieved a significantly lower performance than the Stock (I) strategy, with significantly lower performance spreads and, at the same time, higher performance with a slightly higher performance spread than Bond (II) strategy. When inspecting the results, a right-sided slope can be observed, which suggests that most of the savings performance results are below average. The occurrence of above-average high performance is observed mainly in the more aggressive strategies, but at the same time it is unlikely to occur. Further on, the histograms in Fig. 3 presents rather significant impact of unemployment on the overall contributions and savings performance for all inspected strategies. For all 4 savings strategies, we see a decline in the overall savings performance. The explanation can be found in the higher probability of unemployment in the early stages of a working life and missing contributions that miss the longer investing period and resulting compound interest effect. The impact of unemployment on the ability of an individual to cumulate sufficient level of pension savings is more pronounced, the longer he/she is unemployed. As already presented on the Fig. 1, the unemployment rate of individuals with primary education aged between 15 and 30 is around 50%. In the majority of cases, this represents a low-skilled worker with low or missing prior working experience and thus facing higher unemployment probability. In turn, higher unemployment probability results in missing contributions at the beginning of the working career (during the first 15 years), which have the highest impact on the overall savings performance.

Tab. 2 presents the simulation results for all strategies for an individual with an elementary education level. In the column called the results are assumed to be full employment, assumes the existence of unemployment and the columns 'Absolute difference' and 'Relative difference' indicate the difference in the results under no unemployment risk and under the existence of unemployment risk in absolute and relative terms. In the case of unemployment risk, an individual with an elementary education contributed on average € 2,427.68 less during the saving period (-7.31%). An individual with a minimum wage was unemployed on

Fig. 3:

Saving performance distribution for each saving strategy without and with the unemployment risk for an individual with elementary education level



Source: own in R

Tab. 2:

Average results for each strategy and each indicator for individual with elementary education level – Part 1

		<i>U</i> = 0	<i>U</i> = 1	Absolute difference	Relative difference
	Contributions $\sum_{t=1}^T C_{j,t}$	33,358.97€ (10,106.54€)*	30,889.44€ (9,369.13€)*	-2,427.68€ (-740.02€)*	-7.31%
	Last wage $w_{j,T}^*$	1,859.43€ (557.08€)*	1,704.79€ (511.50€)*	-150.63€ (-45.58€)*	-8.18%
	Months of unemployment	-	200 (10.47)**	-	-
Stock (Strategy I)	Saving $S_{ij,T}$	100,751.92€ (30,429.93€)*	54,523.68€ (16,364.68€)*	-46,432.15€ (-14,008.40€)*	-45.71%
	Pension benefit $PB_{ij,T}$	401.53€ (121.27€)*	217.30€ (65.22€)*	-185.05€ (-55.83€)*	-45.71%
	Saving performance $SP_{ij,T}$	2.08 (1.60)**	0.79 (0.83)**	-1.27	-41.46%
	$IRR_{ij,T}$	0.22 (0.12)**	0.13 (0.06)**	-0.09	-40.92%
	$MRI_{ij,T}$	54.62 (29.91)**	32.10 (15.55)**	-22.52	-40.92%
	Unemployment effect $UE_{ij,T}$	-	200.87€ (134,05€)**	-	-

Tab. 2: Average results for each strategy and each indicator for individual with elementary education level – Part 2

		$U = 0$	$U = 1$	Absolute difference	Relative difference
Bond (Strategy II)	Saving $S_{ij,T}$	70,217.92€ (21,314.93€)*	39,634.95€ (11,958.23€)*	-30,550.47€ (-9,374.04€)*	-43.88%
	Pension benefit $PB_{ij,T}$	279.84€ (84.95€)*	157.96€ (47.66€)*	-121.75€ (-37.36€)*	-43.88%
	Saving performance $SP_{ij,T}$	1.10 (0.46)**	0.26 (0.26)**	-0.83	-39.45%
	$IRR_{ij,T}$	0.15 (0.04)**	0.09 (0.02)**	-0.06	-38.88%
	$MRI_{ij,T}$	38.26 (9.64)**	23.38 (5.42)**	-14.92	-38.88%
	Unemployment effect $UE_{ij,T}$	-	129.98€ (45.45€)**	-	-
Aging I. (Strategy III)	Saving $S_{ij,T}$	85,081.97€ (25,836.04€)*	46,332.08€ (14,198.42€)*	-38,636.56€ (-11,679.10€)*	-45.14%
	Pension benefit $PB_{ij,T}$	339.08€ (102.97€)*	184.65€ (56.59€)*	-153.98€ (-46.55€)*	-45.14%
	Saving performance $SP_{ij,T}$	1.59 (0.82)**	0.52 (0.44)**	-1.06	-40.81%
	$IRR_{ij,T}$	0.18 (0.06)**	0.11 (0.03)**	-0.07	-40.26%
	$MRI_{ij,T}$	46.38 (15.46)**	27.75 (8.24)**	-18.70	-40.26%
	Unemployment effect $UE_{ij,T}$	-	167.22€ (74.82€)**	-	-
Aging II. (Strategy IV)	Saving $S_{ij,T}$	82,465.01€ (24,304.13€)*	45,057.92€ (13,422.30€)*	-37,114.77€ (-10,864.70€)*	-45.03%
	Pension benefit $PB_{ij,T}$	328.65€ (96.86€)*	179.57€ (54.49€)*	-147.91€ (-43.30€)*	-45.03%
	Saving performance $SP_{ij,T}$	1.39 (0.69)**	0.43 (0.36)**	-0.98	-40.70%
	$IRR_{ij,T}$	0.17 (0.05)**	0.10 (0.03)**	-0.07	-40.15%
	$MRI_{ij,T}$	43.63 (13.79)**	26.24 (7.24)**	-17.38	-40.15%
	Unemployment effect $UE_{ij,T}$	-	160.17€ (66.68€)**	-	-

Source: own in R

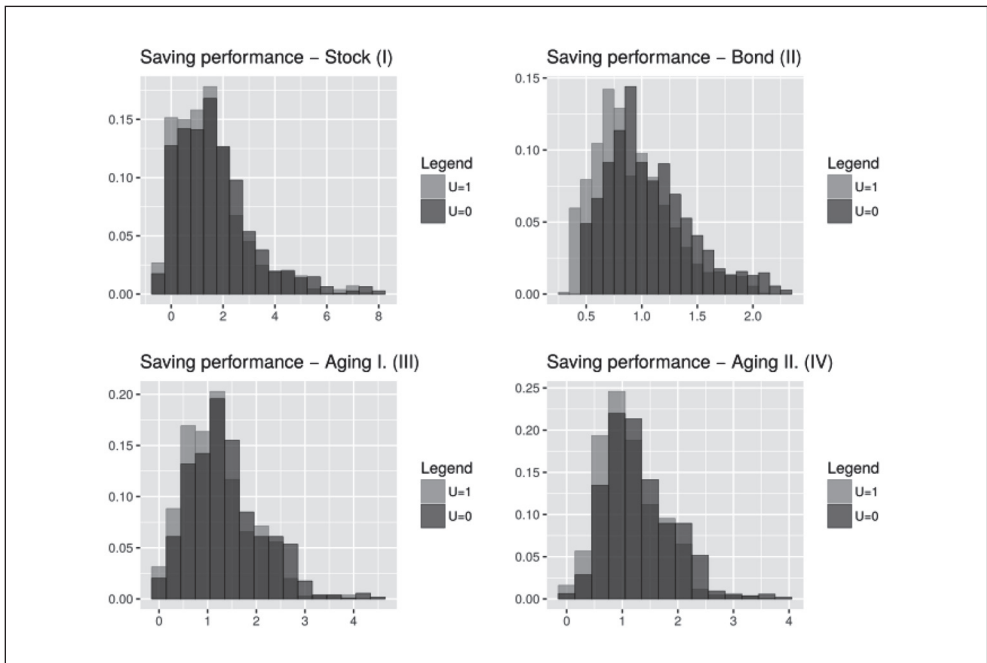
Note: * presented in real terms (discounted by inflation);
** represents a standard deviation (StdDev) from the average.

average for 200 months, which means that almost 42% of the time, they did not contribute to the old-age pension saving system. It is interesting to note that the differences between the saved amount at full employment and the existence of unemployment are negligible in individual strategies (the smallest difference was recorded in saving in the bond fund and the biggest difference in saving in the equity fund). Clearly the largest average amount saved would be achieved by an individual with an elementary education in saving into a stock fund and the lowest accumulated savings under the bond strategy. In general, an individual receiving income at the minimum wage level cannot expect a high rate of compensation from a system he does not regularly contribute to. Despite a significantly higher average return of equity fund, a person with a minimum wage rate would achieve an individual replacement rate of 22% under the full employment conditions and only 13% under the existence of unemployment. The slightly lower replacement

rates were achieved under using the life-cycle Aging I. (III) and Aging II. (IV) strategies, and the lowest replacement rate has been observed for the conservative Bond (II) strategy. Appendix 1 contains additional histograms of the indicators under the full employment and the existence of unemployment risk.

Fig. 4 below presents the simulation results for an individual with the high school degree. Comparing to the results presented in the Fig. 3, we observe very similar distributions of savings performance for each tested saving strategy. When taking into account the existence of unemployment risk, the performance is slightly lower compared to the full employment case. At the same time, we observe considerably lower differences in the savings performance under full employment and the existence of unemployment risk at the end of the saving horizon. Even in the case of an individual with a high school degree, it can be stated that he/she can expect the highest savings performance under the Stock

Fig. 4: Saving performance distribution for each saving strategy without and with the unemployment risk for an individual with high school education level



Source: own in R

(I) strategy where all the contributions are fully invested into the equity fund. Again, for all tested saving strategies, we observe a right-sided skewness, indicating a higher incidence of performance below the average and, at the same time, extreme observations on the right. The minimum differences in achieved savings performance under the unemployment risk ($U = 1$) and full employment ($U = 0$) could be explained by a relatively low estimation of lifetime unemployment, which stood on average at 40 months for an individual with a high school degree, or about 8% unemployment rate over the working career, as can be also seen on Fig. 1. The highest unemployment rates for an

individual with a high school degree have been empirically observed during the initial years of working career between the ages 20–25 years.

Tab. 3 presents the simulation results in form of average values for particular outcome indicators for an individual with a high school degree. This individual earns significantly more compared to an individual with the minimum wage. This influences the overall level of paid contributions towards the individual pension savings account. Due to the lower unemployment rate, the differences between the accumulated savings under the existence of unemployment risk and full employment are significantly lower compared to an individual with an elementary

Tab. 3: Average results for each strategy for an individual with high school education level – Part 1

		$U = 0$	$U = 1$	$U = 0 - U = 1$	$U = 1/U0 - 1$
	Contributions $\sum_{t=1}^T C_{j,t}$	81,821.70€ (24,779.72€)*	79,360.37€ (24,090.12€)*	-2,273.38€ (-703.90€)*	-2.84%
	Last wage $w_{j,T}^*$	4,455.26€ (1,334.79€)*	4,320.92€ (1,297.14€)*	-120.55€ (-37.65€)*	-2.82%
	Months of unemployment	–	40 (6.04)**	–	–
Stock (Strategy I)	Saving $S_{ij,T}$	245,069.40€ (73,593.13€)*	218,965.66€ (65,896.23€)*	-24,536.73€ (-7,364.94€)*	-10.16%
	Pension benefit $PB_{ij,T}$	976.68€ (293.29€)*	872.65€ (262.62€)*	-97.79€ (-29.35€)*	-10.16%
	Saving performance $SP_{ij,T}$	2.04 (1.55)**	1.81 (1.43)**	-0.22	-7.53%
	$IRR_{ij,T}$	0.22 (0.12)**	0.21 (0.11)**	-0.01	-7.55%
	$MRI_{ij,T}$	55.13 (29.73)**	50.82 (27.38)**	-4.11	-7.55%
	Unemployment effect $UE_{ij,T}$	–	469.90€ (289.21€)**	–	–
Bond (Strategy II)	Saving $S_{ij,T}$	170,407.40€ (51,735.35€)*	153,323.02€ (46,502.22€)*	-17,009.52€ (-5,214.30€)*	-10.10%
	Pension benefit $PB_{ij,T}$	679.13€ (206.18€)*	611.04€ (185.33€)*	-67.79€ (-20.78€)*	-10.10%
	Saving performance $SP_{ij,T}$	1.07 (0.45)**	0.92 (0.42)**	-0.15	-7.46%
	$IRR_{ij,T}$	0.15 (0.04)**	0.14 (0.04)**	-0.01	-7.48%
	$MRI_{ij,T}$	38.75 (9.72)**	35.84 (8.97)**	-2.90	-7.48%
	Unemployment effect $UE_{ij,T}$	–	319.56€ (109.15€)**	–	–

Tab. 3: Average results for each strategy for an individual with high school education level – Part 2

		$U = 0$	$U = 1$	$U = 0 - U = 1$	$U = 1/U0 - 1$
Aging I. (Strategy III)	Saving $S_{ij,T}$	205,126.29€ (62,706.49€)*	184,079.98€ (56,291.81€)*	-20,685.33€ (-6,372.84€)*	-10.16%
	Pension benefit $PB_{ij,T}$	817.50€ (249.91€)*	733.62€ (224.34€)*	-82.44€ (-25.40€)*	-10.16%
	Saving performance $SP_{ij,T}$	1.55 (0.80)**	1.35 (0.73)**	-0.19	-7.52%
	$IRR_{ij,T}$	0.18 (0.06)**	0.17 (0.06)**	-0.01	-7.55%
	$MRI_{ij,T}$	46.98 (15.41)**	43.41 (14.20)**	-3.56	-7.55%
	Unemployment effect $UE_{ij,T}$	-	395.24€ (168.83€)**	-	-
Aging II. (Strategy IV)	Saving $S_{ij,T}$	199,687.59€ (59,023.94€)*	179,189.61€ (52,909.82€)*	-19,880.22€ (-5,979.12€)*	-10.15%
	Pension benefit $PB_{ij,T}$	795.82€ (235.23€)*	714.13€ (210.86€)*	-79.23€ (-23.83€)*	-10.15%
	Saving performance $SP_{ij,T}$	1.37 (0.66)**	1.19 (0.61)**	-0.18	-7.52%
	$IRR_{ij,T}$	0.17 (0.05)**	0.16 (0.05)**	-0.01	-7.54%
	$MRI_{ij,T}$	44.22 (13.65)**	40.84 (12.58)**	-3.33	-7.54%
	Unemployment effect $UE_{ij,T}$	-	380.25€ (150.59€)**	-	-

Source: own in R

Note: * presented in real terms (discounted by inflation);
 ** represents a standard deviation (StdDev) from the average.

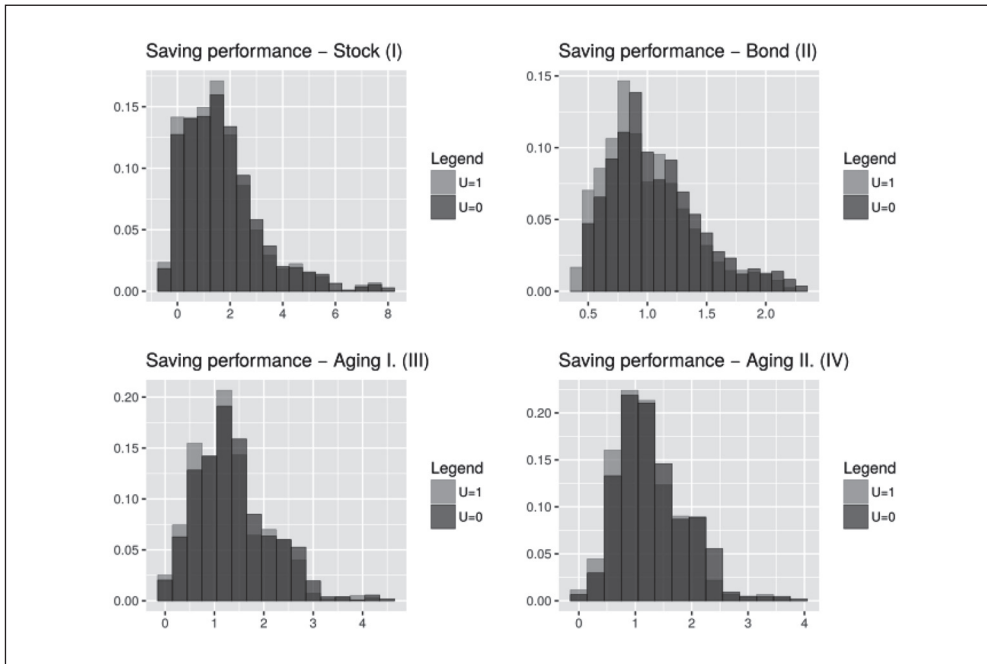
education level. For each strategy, we observe around 10% differences under the existence of unemployment risk instead of 45% observed in the previous case. The significantly lower number of months in unemployment was also positively reflected in the differences in other indicators, in particular the smaller differences in earnings, the replacement rate, and the number of months during which an individual would receive the benefits equal to his last pre-retirement wage (MRI). Overall, an individual with a high school degree contributed on average by almost 50,000.00€ more than an individual with an elementary education. Significantly greater differences, compared to an individual with an elementary education, are seen for the strategies Aging I. (III) and Aging II. (IV). Appendix 2 presents detailed histograms of results for other analyzed indicators.

The last type of saver analyzed is an individual with a master's degree. These are mostly second-level university graduates who are expected to exercise professions that have a higher added value and are expected to have higher labor productivity than the previous two types of individuals. On the other hand, compared to the lower education level individuals, the saving period is shorter due to the later entry into the labor market.

As can be seen on the histograms in Fig. 5, the differences caused by the impact of unemployment are the smallest for an individual with a master's degree. Again, the highest savings performance with the largest deviation of results could be observed when applying the Stock (I) strategy and lowest for the Bond (II) strategy. Similar results are observed for the life-cycle strategies Aging I.

Fig. 5:

Saving performance distribution for each saving strategy without and with the unemployment risk for an individual with master's degree education level



Source: own in R

(III) as well as Aging II. (IV). Due to the relatively low unemployment risk for an individual with the master's degree (see the Fig. 1), the simulation results under the full employment and under the existence of unemployment risk delivered almost similar results (see Tab. 4). Unlike the previous two individuals with lower education levels, an individual with a master's degree could face the unemployment duration of only 21 months, which is less than 2 years over the whole working career. As can be seen in Fig. 1, an individual with a master's degree could face the highest unemployment risk (almost 30%) only during the first 1–2 years after graduation. Later in the career, the unemployment risk falls significantly, which gives the opportunity to the pension pot to rise steadily with no significant interruption over the remaining working career as the unemployment rate for the remaining age cohorts decreases and oscillates around 5%. Tab. 4 presents the results of indicators for each strategy. We observe similar distribution of savings performance simulations as in the

previous two educational cohorts. As there are no major interruptions in the contributions, the indicators of replacement ratio as well as MRI are on average higher compared to the lower educated individuals. We refer to the Appendix 3 for more detailed results for each analyzed indicator.

It should be noted, that there is a handful of researches investigating pension saving process under various risk factors, including unemployment. However, most of the authors factor in the effect of unemployment, but focus either on comparing saving and/or investment strategies within DC schemes (EIOPA, 2020; Šebo et al., 2017, 2015; Wang et al., 2017; Fernandes, 2013; Melicherčík et al., 2015; Basu et al., 2009) or the effect of unemployment on life-cycle income processes (Bukit et al., 2018; Galdeano & Turunen, 2005; Guvenen, 2009; Guvenen & Smith, 2014; Guvenen et al., 2015; Katz & Murphy, 1992). There is no straightforward research that would analyze the impact of education-specific unemployment

Tab. 4: Average results for each strategy for an individual with master's degree education level – Part 1

		$U = 0$	$U = 1$	$U = 0 - U = 1$	$U = 1/U0 - 1$
	Contributions $\sum_{t=1}^T C_{j,t}$	110,493.03€ (33,512.97€)*	107,763.60€ (32,738.60€)*	-2,569.30€ (-800.39€)*	-2.39%
	Last wage $w_{j,T}^*$	5,749.10€ (1,722.42€)	5,615.91€ (1,686.39€)	-113.54€ (-36.03€)	-2.09%
	Months of unemployment	-	21 (4.46)**	-	-
Stock (Strategy I)	Saving $S_{ij,T}$	332,114.25€ (99,684.43€)*	311,421.26€ (93,490.40€)*	-19,351.24€ (-5,863.50€)*	-6.09%
	Pension benefit $PB_{ij,T}$	1,323.59€ (397.28€)*	1,241.12€ (372.59€)*	-77.12€ (-23.37€)*	-6.09%
	Saving performance $SP_{ij,T}$	2.05 (1.56)**	1.93 (1.50)**	-0.11	-3.77%
	$IRR_{ij,T}$	0.23 (0.12)**	0.22 (0.12)**	-0.01	-4.06%
	$MRI_{ij,T}$	57.87 (31.31)**	55.46 (30.04)**	-2.29	-4.06%
	Unemployment effect $UE_{ij,T}$	-	596.53€ (363,24€)**	-	-
Bond (Strategy II)	Saving $S_{ij,T}$	231,200.12€ (70,167.32€)*	217,229.53€ (65,900.40€)*	-13,781.01€ (-4,231.60€)*	-6.07%
	Pension benefit $PB_{ij,T}$	921.41€ (279.64€)*	865.73€ (262.64€)*	-54.92€ (-16.86€)*	-6.07%
	Saving performance $SP_{ij,T}$	1.08 (0.46)**	0.99 (0.44)**	-0.08	-3.75%
	$IRR_{ij,T}$	0.16 (0.04)**	0.15 (0.04)**	-0.01	-4.04%
	$MRI_{ij,T}$	40.74 (10.28)**	39.07 (9.88)**	-1.64	-4.04%
	Unemployment effect $UE_{ij,T}$	-	415.04€ (138.09€)**	-	-
Aging I. (Strategy III)	Saving $S_{ij,T}$	278,715.33€ (85,087.01€)*	261,172.90€ (79,992.50€)*	-16,647.95€ (-5,136.70€)*	-6.08%
	Pension benefit $PB_{ij,T}$	1,110.77€ (339.10€)*	1,040.86€ (318.80 €)*	-66.35€ (-20.47€)*	-6.08%
	Saving performance $SP_{ij,T}$	1.56 (0.80)**	1.46 (0.77)**	-0.10	-3.77%
	$IRR_{ij,T}$	0.20 (0.06)**	0.19 (0.06)**	-0.01	-4.06%
	$MRI_{ij,T}$	49.4 (16.23)**	47.46 (15.58)**	-2.00	-4.06%
	Unemployment effect $UE_{ij,T}$	-	509.04€ (213.42€)**	-	-

Tab. 4: Average results for each strategy for an individual with master's degree education level – Part 2

		$U = 0$	$U = 1$	$U = 0 - U = 1$	$U = 1/U0 - 1$
Aging II. (Strategy IV)	Saving $S_{ij,T}$	270,849.33€ (80,160.78€)*	254,105.97€ (75,124.50€)*	-16,011.48€ (-4,840.50€)*	-6.09%
	Pension benefit $PB_{ij,T}$	1,079.43€ (319.47€)*	1,012.70€ (299.40€)*	-63.81€ (-19.29€)*	-6.09%
	Saving performance $SP_{ij,T}$	1.37 (0.67)**	1.28 (0.64)**	-0.09	-3.78%
	$IRR_{ij,T}$	0.19 (0.06)**	0.18 (0.05)**	-0.01	-4.07%
	$MRI_{ij,T}$	46.54 (14.32)**	44.62 (13.73)**	-1.89	-4.07%
	Unemployment effect $UE_{ij,T}$	-	490.17€ (193.47€)**	-	-

Source: own in R

Note: * presented in real terms (discounted by inflation);

** represents a standard deviation (StdDev) from the average.

on the terminal value of pension savings and thus our paper provides more insight into the future research in the area of searching for an optimal saving strategy under the existence of unemployment of fragmented contributions under modern employment contracts (freelancers, part-time jobs, etc).

Conclusion

The aim of the paper was to show, on the example of three individuals with different education levels, the expected performance of applying two strategies using a passive approach to saving and investing (Stock (I) and Bond (II)) and two life-cycle strategies (Aging I. (III) and Aging II. (IV)), which are based on a dynamic determination of the savings ratio between shares and bonds over time. Only few authors have analyzed the impact of unemployment on the level of savings under various investment strategies. Our approach enriches the existing research by estimating the expected life-cycle income and unemployment trajectories for three different educational and income cohorts. The first educational cohort is represented by an individual with an elementary education, who over the life-cycle receives the minimum wage, which is close to 60% of an average wage, and is exposed to the high probabilities of being unemployed over the working career. The second individual is represented by a high school education and his life-cycle income

starts below the average wage, while during the productivity peak reaches a higher wage than the economy average and later in a career prefers job stability and thus accept lower increases of wages. Overall, during the entire working career, his wage stood at the average. The last individual holds the master's degree, while his life-cycle income is on average at 1.25 the average wage. Again, his wage starts below the average and has a steeper growth during the first two thirds of his career. Later on, he prefers job stability and accepts lower wage increases. Both higher education level individuals face lower unemployment risks over the life-cycle, which turned into smaller differences in the savings performance for both scenarios (with and without unemployment risk).

We have formulated three research questions and following conclusions can be drawn based on the performed simulation and research. Of the 4 selected strategies, an individual, regardless of his/her education, can expect the highest pension pot by applying the Stock (I) strategy that invests all contributions into the equity fund. Intuitively and in the line with many previous papers, this risky strategy delivers high dispersion of expected returns. Life-cycle strategies, Aging I. (III) and Aging II. (IV), are a compromise between the performance and associated down-side risk represented by the standard deviation of returns. These strategies require an active

approach, however the activity is required on an annual basis. A slightly higher performance for all three individuals was achieved by applying the Aging I. (III) strategy compared to the Aging II. (IV) strategy. The advantage of life-cycle strategies is that they are less aggressive with significantly less dispersion of returns. The lowest performance has been observed by applying the Bond (II) strategy, which uses a passive allocation of contributions exclusively to the least volatile financial instruments such as bonds.

Life-cycle strategies failed to provide a single individual with a higher performance than the Stock (I) strategy, but both have achieved higher performance than the second Bond (II) strategy. Histograms of performance distribution at the end of a saving horizon provides the evidence that the life-cycle strategies bring less volatility to an individual than the Stock (I) strategy, while the Bond (II) strategy is the least volatile strategy. Looking at the results of all the strategies applied for all three individuals, one can observe the right skewed distribution, which indicates that in all strategies, an individual can expect below average results with a chance of achieving abnormal savings performance in a few (extremes), cases especially for Stock (I) strategy.

The third and perhaps the most valuable question, we tried to answer, is how the risk of unemployment affects the accumulated value of saving for individuals with different life-cycle income paths. Based on the results of our model, we can conclude that the impact of unemployment is the greater the longer an individual is unemployed. However, the impact is greater when the unemployment occurs at the beginning of the working career. This is due to the lost effect of compound interest, which is in line with many previous research findings. As the unemployment risk is U-shaped over the working career, we can expect direct nonlinear relation between the final value of savings and the length of unemployment. When trying to understand the impact of unemployment risk on the final value of savings, one should carefully consider the periods of working career, when unemployment occurs. If a person is unemployed at the beginning of the saving horizon, he does not contribute to the pension system and therefore he loses the compound interest effect on initial contributions even if

the value of initial contributions is small due to the lower wage at the beginning of the working career. The impact of unemployment on final value of savings decreases when the unemployment risk occurs later in the career. If individuals contribute regularly for 30 years, especially over the last 10 years, and would have been unemployed for some time, then this would have had a significantly lower impact on his final value of savings than the non-contribution period that occurs early in his career. However, we realize that the paper has not specifically focused on the impact of unemployment with regard to the period of unemployment, and therefore we leave this interesting question open for further research.

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Appendixes:

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