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THE PERFORMANCE OF DYNAMIC AND STATIC INVESTMENT STRATEGIES IN PENSION FUNDS

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The retirement savings process for the members of a pension fund involves regular contribution payments made by a member and/or his employer, and the investment earnings generated by following an investment strategy. After the Global Financial Crisis, the aspect of value preservation has become particularly important to members of a pension fund, thus affecting the selection of an investment strategy. In face of increasing fluctuations on the financial market, static lifecycle strategies have become an unsatisfactory solution for members of a pension fund given the absence of a response to shocks on the financial market. In the paper, a comparative analysis of the performance of dynamic and static lifecycle strategies is carried out using bootstrap resampling in order to simulate investment returns and VaR indicators so as to assess the risk of an adverse financial outcome at retirement. The results of the analysis indicate the fact that dynamic lifecycle strategies generate more favorable financial results than static lifecycle strategies do, with a slightly increased likelihood of generating extremely unfavorable outcomes.

Keywords: dynamic investment strategies, static investment strategies, pension funds, lifecycle strategy, bootstrap resampling

JEL Classification: G11, G17, J26, J32

INTRODUCTION

Members of a pension fund are primarily concerned with the realization of an individual retirement account balance sufficient to finance an adequate living standard in the period after retirement. The retirement account balance at the moment a member of a pension fund decides to retire is partly affected by the amount of the contributions paid during the working career, and mostly affected by the way the accumulated funds are invested on the financial market. If transaction costs and taxation are neglected, most economists concur that an investment strategy is the principal factor that provides portfolio return in the long run.

Static investment strategies have commonly been used by members of a pension fund. The implementation of these strategies implies a lack of the adjustment of a portfolio to short-term fluctuations on the financial market in order to generate value growth over a long period of time, rather than in a short

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term. Consequently, it seems clear why the members of pension funds until the end of the 20th century were those investors who particularly followed these investment strategies. In the first decade of the 21st century, however, the two financial crises significantly influenced a fall in pension savings over a relatively short period of time (the dot.com crisis of 2001 and the Global Financial Crisis of 2008). In that period, the implementation of static strategies resulted in many pension fund members making huge losses without a possibility of a significant correction in the accumulated assets until retirement. The emerging circumstances clearly indicated the need for dynamic investment strategies focused on making multidecade investments and value growth, yet with the built-in flexibility to the changing conditions of the investment framework.

The implementation of dynamic strategies requires the adjustment of a portfolio to changes in asset prices in order to improve the probability of achieving the target amount of assets at retirement. With strictly static investment strategies, this possibility is ruled out since the initial portfolio is shaped according to long-term investment goals and the investor's tolerance to risk, while the adjustment of the portfolio is automatically performed according to a predefined schedule. As for the costs of the implementation of an investment strategy, static strategies are more attractive to individual investors since they do not have to engage themselves in the process of the continuous analysis of market trends and the evaluation of portfolio performance. Simplicity and low implementation costs are the two features that make static investment strategies appealing to individual investors.

In practice, investment strategies with similar targets and conceptual characteristics can be shaped so as to be both static and dynamic, depending on the existence of the financial market feedback. A lifecycle strategy is an investment strategy increasingly followed by members of a pension fund given the fact that such a strategy is oriented towards the generation of wealth in the long run and in the manner that follows the changing profile of the investor's tolerance to risk over time. This strategy can be both static and dynamic in character. The key feature of a lifecycle strategy is the investor's significant exposure to equities in the early years of their working careers, followed by a gradual transition towards less risky securities (corporate bonds, government bonds or money market instruments) as their retirement approaches. If the portfolio adjustments are made according to a predefined rule, the strategy is static; otherwise, if changes are made based on the assessment of market movements and the performance of different asset classes, the strategy becomes dynamic.

Accordingly, the subject matter of the research relates to the performance of dynamic and static investment strategies adhered to by members of pension funds. The starting point of the research study is to examine whether dynamic investment strategies can generate superior financial results in the long run over static investment strategies. Given the growing importance of a lifecycle strategy in pension funds, the question of the effectiveness of the various types of static and dynamic lifecycle strategies in generating enough funds at retirement may be an interesting research area.

Having in mind the defined subject matter of the research, this paper is aimed at determining the likelihood that a member of a pension fund will achieve superior financial results by following a dynamic investment strategy relative to a static investment strategy, as well as the quantification of a potential surplus and the riskiness of financial results. In accordance with the defined subject matter and the aim of the research study, the two research hypotheses have been defined:

- H1: Members of a pension fund achieve superior financial performance by following dynamic investment strategies relative to static investment strategies.
- H2: Dynamic investment strategies are riskier than static investment strategies in terms of the increased likelihood of extremely adverse outcomes.

The research is predominantly empirically oriented, with the application of the simulation techniques common for this research area to data on stock and bond returns over a period of several decades. In this regard, quantitative research methods used to simulate and quantify financial results, and assess riskiness dominate in the paper.

The contribution of the research study reflects in of its complementing to the existing, mostly international research focused on the implementation of investment strategies in pension funds. According to the available information, no research that deals with the issue of investment strategy selection in pension funds has been conducted in the Republic of Serbia so far. Empirical results may be beneficial for investment managers in pension funds and other entities in companies managing pension funds responsible for creating an investment menu which is at pension fund members' disposal.

In addition to the Introduction and the Conclusion, the paper also consists of the four logically related parts. In the first part of the paper, the theoretical views relevant for the implementation of static and dynamic investment strategies in pension funds are presented. In the second part, the paper provides a review of the results and contributions of previously conducted empirical research studies in this field. The third part of the paper deals with the research methodology. In the fourth part, the results of the empirical research study are presented and discussed.

THEORETICAL BACKGROUND

As is pointed out in the Introduction, the paper focuses on the implementation of static and dynamic lifecycle strategies. A lifecycle strategy ensures the growth of the portfolio in the period that directly follows the enrolment in a pension fund and the preservation of the value of the portfolio in a period immediately prior to retirement. The proponents of this strategy particularly emphasize the value preservation argument as retirement approaches, recognizing that the adverse consequences of the negative rates of return during that period can hardly be eliminated until retirement. B. Malkiel (1990) found that an individual capacity to absorb risk decreased with aging, so the portfolio should become more conservative over time. Younger individuals can absorb a greater level of financial risk due to the fact that they are merely at the beginning of their working careers, and the period until retirement is extremely long. In addition, younger individuals have a greater potential for higher future earnings than older individuals do, which makes an appealing argument for an aggressive asset allocation.

A large body of research has shown that, over a long term, stock returns are superior to bond returns (Jagannathan & Kocherlakota, 1996; Campbell & Viceira, 2002; Siegel, 2008). From this point of view, a younger member of a pension fund should invest more in stocks, since the period until retirement is long, during which time the risk of a significant decline in stock returns in individual years can significantly be reduced (Lukovic & Marinkovic, 2019, 147). Given the fact that older members of pension funds do not have a long period of time at their disposal, stock investment is not adequate for them; an orientation towards government and corporate bonds is preferable instead.

The implementation of a lifecycle strategy in pension funds has been increasing over the last two decades. According to Vanguard (2018), one of the largest companies for the management of pension funds in the world, a total of 92% of the pension funds under their management had some lifecycle strategy in their menus of investment options in 2017. For the sake of comparison, only one-third of the Vanguard-managed pension funds had lifecycle strategies in their menus of investment alternatives offered to members in 2000.

It is important to note that the effects the rates of return have on the retirement account balance are not the same at different stages of an individual lifecycle. A. Basu and M. Drew (2009) pointed out the fact that the magnitude of the impact of the high rates of return on retirement account balance depended on the size of a portfolio. As a portfolio grows with the passage of time not only due to the accumulation of investment returns, but also due to the inflow of contributions, the high rates of return in the period preceding retirement contribute to the final financial result to a higher extent than the same rates of return in the initial period of the working career. Hence, automatic transition from investing in equities in the early stage of working career to investing in bonds in the mid-career and later career stages may be inadequate.

Static Lifecycle Strategies (hereinafter referred to as SLSs) have an automated rule which adjusts a portfolio over time. According to D. Blake, A. Cairns and K. Dowd (2001), SLSs reduce the likelihood of adverse outcomes, as well as fluctuations in the final amount of assets at retirement, rejecting, however, the growth potential offered by aggressive investment strategies. Therefore, SLSs are not adequate for all individual investors, above all for the individuals who want to have a relatively accurate estimate of the amount of assets at their disposal before reaching the retirement age.

The major disadvantage of the implementation of SLSs lies in the aforementioned automatic path of the portfolio adjustment. In simpler terms, the investor may face the falling stock market that lasts for a very long time, causing the value of the portfolio to become significantly lower than expected. Simultaneously, a static strategy demands transferring to the conservative assets that generate low returns. In this manner, the investor cannot accumulate the expected amount of funds at the moment of reaching the projected retirement age. The only way for an investor to increase the value of the portfolio in the years immediately before retirement is to aggressively invest in the stock market, which is restricted by accepting SLSs.

Dynamic Lifecycle Strategies (hereinafter referred to as DLSs) suggest a built-in flexibility in adjusting a portfolio, depending on the level of the realization of the target retirement balance at the observed time. Thus, investment decision-making in the future is sensitive to the performance of the financial market in the past. Aggressiveness in investing at the beginning of the working career is common to both dynamic and static lifecycle strategies. However, transition to conservative assets at a later stage in the lifecycle is not automatic, as is the case with static strategies, but occurs provided that an individual has accumulated an amount greater than or equal to the target amount up to that moment instead. If the amount of assets is lower than expected, a member of a pension fund will continue to aggressively allocate until the next period of the assessment of the performance of the investment strategy. It should be emphasized that the adjustment of a portfolio is not permanent, i.e. there is a possibility of repeated transition to exposure in stocks if the amount of assets in any subsequent period is lower than the target amount.

OVERVIEW OF THE EMPIRICAL RESEARCH

Research work in analyzing the performance of dynamic and static investment strategies in pension funds has become particularly evident following the 2009 Global Financial Crisis, which has resulted in a significant decline in the amount of assets in retirement accounts. An increasing implementation of lifecycle strategies has just stemmed from the growing need of members of pension funds to protect themselves from the risk of the occurrence of adverse outcomes.

A large body of research studies indicate the fact that SLSs can reduce the risk of adverse outcomes and fluctuations in retirement savings (Blake, Cairns & Dowd, 2001; Poterba, Rauh, Venti & Wise, 2006; Antolin, Payet & Yermo, 2010). On the other hand, there are studies showing that, under the conditions of the increased fluctuations of the financial market, SLSs may be inadequate for members of pension funds (Basu & Drew, 2010; Basu, Byrne & Drew, 2011).

Most scientific efforts having dealt with the efficiency of lifecycle strategies were carried out in the United States (Poterba *et al*, 2006; Viceira, 2008; Basu & Drew, 2009; Pfau, 2010; Basu, Byrne & Drew, 2011). Given the growing importance of a lifecycle strategy in the international context, however, there are an increasing number of the studies analyzing the implementation of this strategy in other countries (Louw, Schalkwyk & Reyers, 2017; Manor, 2017; Medaiskis, Gudaitis &

Mechkovski, 2018). E. Louw, C. van Schalkwyk & M. Reyers (2017) analyzed the effectiveness of a lifecycle strategy in South African pension funds compared to more conservative balanced funds. The results of the analysis reveal that a lifecycle strategy can achieve more favorable financial results compared to balanced funds and that a higher level of protection against risk can be provided, yet with a significant loss in the potential growth of the final retirement balance. Also, the authors showed that a high stock exposure in the initial portfolio leads to a lifecycle strategy being superior to such balanced funds.

M. Manor (2017) analyzed the implementation of a lifecycle strategy in pension funds in Israel. The author used CVaR risk indicators, which are more suitable for measuring the risk of extremely adverse outcomes than standard VaR indicators. The Monte Carlo technique was used to simulate investment returns and other variables. The paper compared 15 investment strategies for 6 different representative agent profiles. The results of the analysis showed that SLSs were superior to a static constant mixed investment strategy. On the other hand, DLSs generated more favorable financial results than SLSs with a lower exposure to equity in the initial portfolio. The author concluded that static investment strategies with a low exposure to equity most commonly implemented in Israel should be replaced with the DLSs that provided high rates of return with a slight increase in risk.

The studies comparing the financial performance of static and dynamic lifecycle strategies are rare. In one of more important studies, A. Basu, A. Byrne and M. Drew (2011) conducted a comparative analysis of the two static (defined by the authors as conventional) strategies and two dynamic lifecycle strategies. The authors used a representative agent model to simulate investment returns by conducting bootstrap resampling. The analysis showed that dynamic strategies were superior to conventional lifecycle strategies in terms of the amount of accumulated assets at the moment of retirement. On the other hand, conventional strategies suffer from a less severe problem of the occurrence of extremely adverse outcomes than dynamic strategies.

On a sample of 17 countries, K. Wang (2012) conducted a comparative analysis of the financial performance of a number of different investment strategies, including one type of static lifecycle strategies and two types of dynamic lifecycle strategies. The author proved that dynamic strategies were superior to static strategies in terms of accumulated assets. Interestingly, the risk of an adverse outcome is lower for dynamic strategies than for static strategies, suggesting that a dynamic strategy represents an improvement over the implementation of traditional strategies.

DATA AND METHODOLOGY

The representative agent model previously used in A. Basu and M. Drew (2009), A. Basu, A. Byrne and M. Drew (2011) and K. Wang (2012) was used in the analysis. The representative agent has predefined economic and demographic characteristics. As far as the demographic profile is concerned, the focus of the analysis is on the individual who remains a member of the same pension fund during the entire working career. The individual's initial age at the time of joining the pension fund, retirement age and, therefore, working career length are predefined.

For the purpose of calculating the financial inflows into the retirement account, the following characteristics are of significance:

- the salary at the time of registration with the pension fund - Z_0;
- the salary growth rate during the working career - s;
- the length of the working career expressed in years - N;
- the assumed contribution rate - d.

the salary growth rate is fixed, which means that an increase in the salary of the member of a pension fund happens at the same rate throughout his/her working career. The length of his/her working career is fixed, assuming that the member of the pension fund spent his working career in the same company, that he/she became a member of the pension fund immediately after starting employment and that he/she was continuously paying contributions until reaching the retirement age.

The contribution rate is constant over time. Contributions are credited to the retirement account balance at the end of each month, while investment returns are credited at the end of each year. This means that twelve monthly contributions are paid in each year, after which assets are invested in the portfolio of financial instruments, with the realization of investment returns at the end of the year. In the next year, the assets are again increased by contributions and investment returns, and so forth. Hence, Table 1 provides the values of the parameters that will be used in the further analysis.

The following formula is used for the salary calculation:

$$Z_t = Z_{(t-1)}\,(1+s),$$

where Z_t is the salary in the year t, Z_{t-1} is the salary in the year t-1, and s is the constant growth rate of the salary.

In order to calculate the retirement account balance at the end of the year, the following formula is used:

$$B_t = (B_{(t-1)} + Z_t\, d_t)(1+r_t) = (B_{(t-1)} + Z0\,(1+s)^{(t-1)}\, d_t)(1+r_t),$$

where B_t and B_{t-1} are the retirement account balances at the end of the years t and t-1, respectively, Z_t is the member's salary in the year t, while r_t is the return of the portfolio in the year t and can be either positive or negative. The contribution rate d_t is expressed as a percentage. Since the working career length is 40 years, the retirement account balance at the time of reaching the retirement age equals as follows:

$$B_{40} = (B_{39} + Z_0\,(1+s)^{39}\, d_{40})(1+r_{40}).$$

In the further analysis, the portfolio consists of the two asset classes: stocks as risky assets and long-term government bonds as risk-free assets. In line with the previously said, the four investment strategies are designed.

Table 1 The values of the parameter for the simulation of the financial result

Parameter	Label	Initial value
Initial retirement account balance	Bo	0
Initial salary	Zo	40000 monetary units
Salary growth	s	3%
Working career length	N	40 years
Contribution rate	d	10%

Source: Author

Following the static lifecycle strategy 30-10 (SLS 30-10), the portfolio is fully invested in equities for the first 30 years. After such 30 years, the exposure of the portfolio to stocks linearly decreases by 10% every year in the following period, whereas exposure to bonds increases by the same percentage. In the year preceding retirement, the portfolio is entirely invested in bonds.

The static lifecycle strategy 20-20 (SLS 20-20) suggests that the portfolio is fully invested in equities for the first 20 years. After such 20 years, in each of the following years stock exposure decreases by 5%, with a simultaneous linear increase in bond exposure in the same percentage.

According to the dynamic life-cycle strategy 30-10 (DLS 30-10), the portfolio is fully invested in stocks in the first 30 years. After such 30 years, instead of automatic gradual portfolio transition to conservative assets, the adjustment of the portfolio depends on the performance of the portfolio from the previous year. If the stock market return from the previous year is higher than 10%, the portfolio remains invested in stocks. On the other hand, if the stock market return from the previous year is negative and below -10%, the portfolio is entirely invested in bonds. Finally, if the stock market return in the previous year is in the range from -10% to 10%, the portfolio is invested 50% in bonds and the remaining 50% is invested in stocks.

The dynamic 20-20 life cycle strategy (DLS 20-20) suggests that the portfolio remains fully invested in equities in the first 20 years. In the next 20 years, the adjustment of the portfolio in the current year depends on the stock market return from the previous year. If the stock market return from the previous year is higher than 10%, the portfolio remains invested in stocks, and if the stock market return from the previous year is negative and lower than -10%, the portfolio is invested in bonds. Finally, in a situation where the stock market return in the previous year ranges from -10% to 10%, the portfolio is invested 50% in bonds and 50% in stocks.

Given the fact that a portfolio consists of two asset classes, i.e. stocks and long-term government bonds, the data on the annual returns of these securities is required. S&P 500 annual returns are used to capture the stock market movements, and US 10-year government bond returns are used to capture the movements of government bonds in the market. The data on the annual returns of the S&P 500 index and the US long-term government bonds were collected by using an electronic database of U.S. stocks, bonds and treasury bills, periodically updated by Aswath Damodaran. The data are available for the period from 1928 to 2017, which means that a total of 89 observations on the annual returns of stocks and government bonds are available. The length of the investment period for the representative agent is 40 years. Hence, two non-overlapping 40-year time series of successive annual returns can be formed from the available data about annual return. No conclusion based on the two independent series of annual returns can be sufficiently reliable.

Past performance is not indicative of future results. Hence, series of returns over a specified period of time must be constructed in a different manner. The approach used to simulate investment returns is the bootstrap resampling method, previously applied in a number of papers dealing with the investment process in pension funds (Basu, Byrne & Drew, 2011; Wang, 2012; Wang, Li & Liu, 2017). A random selection of a large number of samples out of the 40 observations is performed for each asset class based on the existing data on the annual returns of different asset classes by using bootstrap resampling. The assumption is that the returns of different asset classes are independently distributed over time. Random sampling is performed with replacement, which means that the data from the basic population can appear more than once in the same sample. The return vectors obtained for the asset classes are multiplied by the appropriate portfolio weightings so as to generate portfolio returns for each year over the 40-year horizon. The simulated investment return series are credited to the retirement account at the end of each year, and the balance at retirement is ultimately calculated. The procedure is repeated a thousand times for each of the static and dynamic strategies and a population of thousands of simulated results is obtained.

A comparative analysis of the static and dynamic strategies is performed by comparing the corresponding pairs of investment strategies, i.e. the static and dynamic type 20-20 strategies, and the static and dynamic type 30-10 strategies. For each of the thousands of simulations, the retirement account balance is compared for both pairs of investment strategies. If the difference is positive, it means that the DLS is superior to the SLS, and vice versa. After thousands of simulations, the total number of the simulations in which the DLS generated larger accumulated assets at retirement than the SLS is recorded. The share of successful simulations represents the success rate, which is the basic criterion for comparing dynamic and static lifecycle strategies.

Assuming the target retirement account balance set by a member of a pension fund, it can be determined that a particular strategy will generate the same or more favorable financial outcome. Considering the fact that not only the balance at retirement is important for a member of a pension fund, the uncertainty of its realization also being of importance, the indicators of the risk of the occurrence of a loss will be used in the performance analysis of SLSs and DLSs. In this case, the loss represents the amount of the funds lacking realization of the target at retirement. Traditional risk indicators are used to measure the risk of the occurrence of a loss: Value-at-Risk (VaR) and Expected Tail-Loss (ETL) for a given confidence level. By calculating these indicators, a more accurate picture can be provided of the magnitude of adverse outcomes for each strategy.

The VaR analysis involves choosing the confidence interval used to compare the financial results of different investment strategies. The basis for the comparison will be the investment goal achieved by applying the fixed 10% annual rate of return. By investing in any of Vanguard's index funds tracking Standard&Poor's 500, the investor can earn an average annual rate of return ranging between 11.30% and 16.64% over the previous 10 years (Vanguard, 2020). Taking into account the fact that the investment process in the pension fund is oriented towards a greater certainty, the target rate of return is set at a slightly lower 10% level. By using the target annual rate of return of 10%, the expected amount of assets at retirement is calculated. After the 40 years of investment, the final retirement account balance is calculated. The amount calculated by using the fixed 10% rate of return is subtracted from the simulated results and the difference represents a surplus or a shortfall relative to the target amount.

The VaR indicators for the given confidence level (90%, 95% and 99%) provide an estimate of a possible shortfall faced by a member of a pension fund. Consequently, VaR can be defined as potentially the largest loss over a period of time with the low probability that the actual loss will be greater than that value (Jorion, 2007, 17). In order to calculate VaR for the given confidence level (90%, 95% or 99%), all the data are ranked from the smallest to the highest. Then, with the confidence level ($1-\alpha$) selected, it is necessary to find the simulated loss that will not be overcome in $1-\alpha$ cases, namely the loss in comparison to which the simulated loss is greater in α cases. Selecting a higher confidence level provides fewer cases where losses are greater than VaR value, since VaR value increases.

In addition to VaR, the ETL is calculated. The ETL is calculated based on the previously calculated VaR for the confidence levels of 90%, 95% and 99%. Given the fact that VaR represents the outcome of the worst case for the given confidence level and the period of time, the ETL represents the expected loss after exceeding the VaR threshold, i.e. the average of the losses greater than VaR for the given confidence level weighted by the corresponding probabilities of realization. Given the fact that it is calculated for the losses greater than VaR, the ETL is always greater than VaR.

EMPIRICAL RESULTS

In Table 2, the descriptive statistics for the annual returns of the S&P 500 and the US long-term government bonds over a 40-year period are presented. Average return on stock investments is higher than the average government bond return accompanied by an increased risk, i.e. a standard deviation, which means that there is an equity risk premium. This return series is used as a sample to conduct bootstrap resampling. The simulation is performed a thousand times, resulting in a thousand simulated 40-year series of stock and bond returns.

The comparison of the performance of the DLS 20-20 and the SLS 20-20 involves the calculation of the surplus (shortfall) of the funds in the retirement account at the moment of retirement which in each simulation is realized by implementing a dynamic strategy versus a static strategy. The results of the simulation of the surplus of the DLS 20-20 against the SLS 20-20 are presented in Table 3.

As can be noted, the average and the median surpluses speak in favor of the superiority of the DLS 20-20 over the SLS 20-20, and of the 65.7% success rate as well. Simply said, a member of a pension fund is faced with the choice to achieve a superior result in 66 out of every 100 simulation cases by adhering to the DLS 20-20 than to the SLS 20-20. The kurtosis coefficient of approximately 13 indicates the tail data exceeding the tails of the normal distribution (fat tails), while the positive coefficient of asymmetry indicates a heavier

Table 2 The descriptive statistics for the stock and bond annual returns in the period 1979-2018

	Stocks (annual returns of S&P 500)	Government bonds (the annual return of the U.S. 10-year government bonds)
Mean	12.94%	7.61%
Median	15.22%	7.22%
Max	37.20%	32.81%
Min	-36.55%	-11.12%
Standard deviation	15.879%	10.132%
Asymmetry	-0.9334	0.3052
Kurtosis	1.2643	-0.1487
Number of observations	40	40

Source: Author

right tail than the left tail of the distribution. Hence, the probability of realizing outliers is significantly higher than in a normal probability distribution.

Table 4 shows the success rate of the DLS 30-10 versus the SLS 30-10. The success rate is high and approximately 64%. The average and the median surpluses speak in favor of the superiority of the DLS 30-10 over the SLS 30-10. The high value of the coefficient of variation of 259% suggests that it is a scattered probability distribution. In addition, based on the values of the kurtosis coefficient, it can be concluded that the distribution of the simulated surplus of the DLS 30-10 over the SLS 30-10 suffers from the problem of more extreme adverse outcomes.

The success rate for each of the observed strategies in the realization of the target amount is given in Table 5, from which it can be seen that the strategy with the highest success rate is the DLS 30-10 (approximately 74.3%), whereas the second most successful strategy is the DLS 20-20, with a slightly lower success rate of 73.7%. Both static strategies, the SLS 30-10 and the SLS 20-20 have lower success rates of 67.1% and 66.6%, respectively. In addition, the dynamic lifecycle strategies achieve more favorable average and median results than the static strategies. Based on these results, it can be said that there is sufficient evidence to support Hypothesis 1, i.e. that dynamic lifecycle strategies generate superior financial results compared to static lifecycle strategies.

Given a large number of the arguments in favor of the view that members of pension funds are more oriented towards the certainty of an outcome and that they are more willing to accept the lower rates of return, it is useful to consider the likelihood and size of adverse outcomes, i.e. the negative difference between the financial result and the target amount for each investment strategy (Table 6). As can be observed, the dynamic strategies are in this respect also superior to the static strategies, since the probabilities of a shortfall for the DLS 20-20 and the

Table 3 The simulation results of the DLS 20-20 surplus against the SLS 20-20

	Success rate	Average surplus	Maximum surplus	Maximum shortfall	Median surplus
DLS 20-20 vs. SLS 20-20	65.7%	13751223	305962619	-86034025	7081240
	oefficient of variation	Asymmetry	Kurtosis		
	237.05%	2.476	12.959		
	Percentiles				
	5th	10th	90th	95th	
	-22054614	-13775947	50255785	69553026	

Source: Author

Table 4 The DLS 30-10 surplus over the SLS 30-10 surplus

	Success rate	Average surplus	Maximum surplus	Maximum deficit	Median surplus
DLS 30-10 vs. SLS 30-10	64.1%	11865847	261026859	-81288035	5706873
	Coefficient of variation	Asymmetry	Kurtosis		
	259.590	2.163	10.865		
	Percentiles				
	5th	10th	90th	95th	
	-23991879	-14368908	45458802	67860100	

Source: Author

DLS 30-10 are 26.3% and 25.7%, respectively, whereas for the SLS 20-20 and the SLS 30-10, the probabilities of a shortfall are 33.4% and 32.9%, respectively.

In addition to the likelihood of the occurrence of negative outcomes, it is necessary to consider the size of potentially realized shortfalls. In this respect, the average deficit is greater for the dynamic strategies (14 mil. for the DLS 20-20 and 14.2 mil. for the DLS 30-10) than for the static strategies (12.5 mil. for the SLS 20-20 and 13 mil. for the SLS 30-10).

In order to more adequately analyze the potential shortfall that a member of a pension fund may experience, the VaR and ETL indicators for investment strategy shortfalls are calculated (Table 7). The VaR indicators are calculated for the 90%, 95% and 99% confidence levels. It can be observed that the values at risk differ for every given confidence level. VaR (90%) is the greatest for the DLS 30-10 (17.2 mil. monetary units) and the lowest for the DLS 20-20 (at approximately 16.57 mil. monetary units). For the static strategies, VaR is greater than in the case of the DLS 20-20, but lower than in the case of the DLS 30-10. The ETL (90%) is the greatest for the DLS 30-10 (23.6 mil.) and the lowest for the SLS 20-20 (22.4 mil.). The SLS 30-10 and the DLS 20-20 have a similar expected tail-loss, standing at 23.1 million. For this confidence level, VaR and the ETL do not provide sufficient evidence that dynamic strategies suffer from a more severe problem of the occurrence of an extreme adverse outcome compared to the static strategies.

For the 95% confidence level, the VaR differences are less noticeable. The DLS 20-20 has the greatest VaR (95%) and the SLS 20-20 has the lowest VaR (95%). The difference between the lowest and the greatest values is approximately 800 thousand monetary units. However, the SLS 20-20 strategy has the lowest ETL (95%) of approximately 25.6 million, followed by the SLS 30-10 (26.6 mil.), while the ETL for the dynamic strategies exceeds 27 million. The difference between

Table 5 The success rate of the static and dynamic lifecycle strategies in the realization of the target amount (the annual return rate of 10%)

	Success rate	Average surplus	Maximum surplus	Maximum shortfall	Median surplus
DLS 30-10	74.3%	40047972	546772373	-36847423	25083507
DLS 20-20	73.7%	39784410	551330151	-36133482	22535144
SLS 30-10	67.1%	27225561	295942691	-35691018	16025856
SLS 20-20	66.6%	28157148	453377902	-33336216	14497766

Source: Author

Table 6 The probability of the realization of a shortfall (compared to the target amount at the 10% annual return rate)

	Probability	Average shortfall
SLS 20-20	33.4%	-12549251
SLS 30-10	32.9%	-13052301
DLS 20-20	26.3%	-14022451
DLS 30-10	25.7%	-14262626

Source: Author

the highest and the lowest ETLs is almost 2 million monetary units, which clearly indicates the fact that the dynamic strategies show more extreme adverse outcomes than the static strategies.

For the 99% confidence level, the SLS 20-20 strategy has the lowest VaR (29.05 mil.), only to be followed by the DLS 20-20 (29.7 million), whereas the remaining two strategies (the SLS 30-10 and the DLS 30-10) have a VaR that exceeds 30 million. The difference between the highest and the lowest VaR is not negligible and amounts to approximately 1.6 million monetary units. As for the ETL, the lowest level refers to the SLS 20-20 (27.8 mil.), only to be followed by the SLS 30-10 (31.7 mil.), while the ETL is significantly higher for the dynamic strategies (32.1 and 33.5 million, respectively). At this confidence level, it seems that the dynamic strategies generate more extreme adverse outcomes compared to the static strategies.

Based on the calculated VaR and ETL risk indicators, it appears that at the 90% confidence level dynamic strategies do not demonstrate more extreme negative outcomes in comparison with static strategies. However, at higher confidence levels, when the analysis focuses on the most extreme adverse outcomes with a low probability of realization, static strategies become less risky than dynamic strategies, for which reason the most extreme results are significantly less favorable. Consequently, Hypothesis 2 can only be partly validated if riskiness is viewed from the point of view of rare, but extremely unfavorable financial results.

CONCLUSION

Based on the empirical results, it can be concluded that the amount of the assets produced by adhering to dynamic lifecycle strategies exceeds the amount obtained by adhering to static lifecycle strategies with a relatively high probability level. On the sample of the 1000 simulated financial results of the two corresponding pairs of static - dynamic lifecycle strategies, the approximately 66% and 64% probabilities were computed, showing that a dynamic strategy would generate results superior to a static strategy. The analysis also shows a higher probability that dynamic strategies will meet the requirement for the target amount compared to static strategies (74.3% and 73.7%, versus 67.1% and 66.6%). The average shortfall in terms of the funds lacking to reach the target amount is approximately the same

Table 7 VaR and the ETL for the 90%, 95% and 99% confidence levels

	VaR (90%)	ETL (90%)	VaR (95%)	ETL (95%)	VaR (99%)	ETL (99%)
SLS 20-20	16790873	22438830	22091216	25618711	29058691	27801338
SLS 30-10	17119000	23154552	22138414	26629800	30258657	31789598
DLS 20-20	16570058	23140558	22916031	27087658	29746585	32141383
DLS 30-10	17267245	23636473	22590397	27622495	30781384	33522190

Source: Author

for all the observed strategies. In this respect, there seems to be sufficient evidence to support the further affirmation of dynamic lifecycle strategies in pension funds. Given the fact that members of a pension fund may be deterred by the magnitude of the potential losses they may face, the VaR and ETL risk indicators are compared for the selected strategies. For both criteria, dynamic lifecycle strategies do not generate extremely unfavorable outcomes in comparison with static lifecycle strategies for a 90% confidence level. However, for higher confidence levels (95% and 99%), when the most extreme adverse outcomes with a low probability of occurrence are analyzed, dynamic lifecycle strategies generate riskier results than static lifecycle strategies.

It should be pointed out that the empirical results do not deviate from the findings of similar research studies conducted throughout the world (Basu, Byrne & Drew, 2011; Wang, 2012; Manor, 2017). Regarding the first hypothesis, there is sufficient evidence in favor of its validation, whereas the second hypothesis is partly validated, since dynamic lifecycle strategies do not generate more extreme adverse outcomes relative to static ones for a 90% confidence level, but this problem does become more evident for higher confidence levels. If riskiness is analyzed solely by comparing the magnitude of losses with an extremely low frequency of occurrence (5% and 1% of the observed cases), it could be said that dynamic strategies are riskier than static strategies.

The research results may have theoretical and practical implications. Taking into consideration a small number of the research studies in this area in the region, as well as in the Republic of Serbia, the paper contributes to filling gaps in the literature, highlighting the importance of investment decision-making in pension funds. As far as practical contributions are concerned, some guidelines for managers of pension funds can be derived in the sense of facilitating the investment process by linking the empirical results with the previously published research results.

The basic research limitation relates to the omission of the implementation costs of different investment strategies. Although the paper points out the advantages of adherence to dynamic investment strategies over static investment strategies, the analysis has neglected the increased costs of the implementation of dynamic strategies. The incorporation of the implementation costs in the analysis, as well as the benefits-to-costs ratio, would provide complete information about which investment strategy is the most suitable solution for members of pension funds. In addition, the analysis has focused on the profile of a single member of a pension fund, with the predetermined demographic and economic characteristics. Future research could provide more useful results by simulating the various aspects of the demographic profile of a member of a pension fund, which could answer the question of which investment strategy is best suited for members of a pension fund at different lifecycle stages and at the different levels of risk aversion.

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