Risk analysis of the proxy life-cycle investments in the second pillar pension scheme in Croatia

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Abstract

In this article we analyze the expected risk of pension funds with different risk profiles in the proxy life-cycle model of investments for the 2nd pillar pension scheme in Croatia. The benefits of implementing proxy life-cycle investments, compared to the previous model of mandatory pension funds investments, are clearly visible in the total expected amount of accumulated savings from the risk/return perspective. However, those benefits are partially diminished by the fact that the expected risk of a pension fund with the lowest risk profile is not substantially different from the expected risk of a pension fund with a medium risk profile, due to the lack of diversification. Additionally, we analyze the robustness of the proxy life-cycle model to a sudden and severe market shock, where we determine the presence of risk for those members who choose to switch to a pension fund with a lower risk profile at an unfavorable moment.

Keywords: defined contribution system, pension funds, life-cycle investing, portfolio risk

1 INTRODUCTION

The design of the pension model in the mandatory pension insurance system (2nd pillar) based on individual investments, i.e. the defined contribution model, has experienced a significant change in recent years in many of the countries in which it has been implemented (Impavido et al., 2010). The basis for such changes is academic studies that have shown that life-cycle investment models of pension fund assets in the accumulation phase, which are based on the change in the allocation of the portfolio of a pension fund as time passes, have a specific benefit to the members (Bodie et al., 2008; Viceira, 2007). The changes that occur in the 2nd pillar are based on the substitution life-cycle investment model (proxy life-cycle), which allows changes in the allocation of portfolios, as time passes, by switching accumulated savings of members from a pension fund of higher expected risk to a pension fund of lower expected risk.

An exact (dynamic) life-cycle model enables the gradual adjustment of asset allocation of members as time passes, i.e. the continuous change in the ratio of investment into equity and bonds in a pension fund portfolio, which is not easily feasible for collective investment schemes. In practice we have discontinuous changes in the allocation of portfolios by a small number of pension funds with different target allocations, which results in different expected returns and expected risk profiles of these funds.

The basic idea of a life-cycle investment model is that at the beginning of the accumulation phase it is easier for members to bear riskier investments while for members with fewer years to retirement, security of investment is more important than high returns. In the beginning of the accumulation phase the members have much lower retirement savings in their personal savings account than at the end of the accumulation phase, so any decrease in the value of assets does not significantly affect the amount of total expected accumulation.

Those members who have been in the pension system for a longer period have large savings, and in that period every fall in the value results in significant losses in the total amount of expected savings. Therefore, within the framework of a life-cycle investment model, for those members with a shorter period of accumulation it is recommended that assets are invested in financial instruments with a higher expected risk (for example, equity), which should bring higher long term returns, while for members with a longer period of accumulation it is recommended that assets are invested in financial instruments with lower expected risks (for example, government bonds).

The 2nd pillar in the pension system of Republic of Croatia started in 2002 and it assumed the same risk profile for all the members of a mandatory pension fund. The only flexibility in asset allocation was in the discretionary decisions of pension fund managers to adjust the structure of investments to market conditions. Given that the minimum share of domestic government bonds in mandatory pension funds in Croatia (till joining the European Union) had to be 50% of the net assets, the maximum allowed investment in financial instruments of higher expected risk (equity and investment funds that invest in equity instruments) was 50% of the net assets of the fund (Mandatory and Voluntary Pension Funds Act, 1999). However, in practice, the maximum level of investment in equity was never able to be achieved due to the investment restrictions of 20% of pension fund assets in foreign markets and the lack of suitable investment opportunities in the domestic equity market. Historical levels of investment in domestic and foreign equity markets fluctuated around the level of 25% of pension fund assets with a greater share in domestic equity than in foreign equity (source: Monthly reports by Croatian Agency for Supervision of Financial Services – HANFA).

The proxy life-cycle model of investments for the Croatian 2nd pillar was introduced in 2014 by the definition of three mandatory pension funds of different risk categories, i.e. different investment strategies: A, B and C (Mandatory Pension Funds Law, 2014). The category A fund has the highest risk profile, with the maximum exposure to equity being 55% of fund assets (theoretically 65%, if all alternative investments create exposure to the equity market) and it can be characterized as a fund with a balanced risk profile. The category B fund has a maximum exposure to equity of 35% of fund assets and it can be considered as a fund with a moderately conservative risk profile. The category C fund may not create exposure to the equity markets and can be considered a fund with a conservative risk profile.

Considering the somewhat surprising lack of research into the risks that mostly derive from the different investment strategies of the proxy life-cycle investment model in 2nd pillar pension funds (with the exception of Scheuenstuhl et al., 2010), we started an analysis of the expected returns and risk of mandatory pension funds of various risk categories. The goal of this research is to determine the efficacy of the model employed in Croatia, i.e. the proxy life-cycle investment model, in comparison to the previous model of the 2nd pillar and to draw certain conclusions able to help with improvement of the newly applied model or possibly help in a future redesign of the 2nd pillar in other countries that have implemented it.

The paper is organized as follows: in the second chapter we describe a life-cycle investment model, its proxy version with reference to its application in the world and to specifics related to Croatia. The third chapter describes the parametric model for the calculation of accumulated savings adjusted for the proxy life-cycle investment model along with the method of calculating the impact of market shocks on the accumulated savings. In the fourth chapter we analyze the expected returns and risks of mandatory pension funds of different risk categories, while in the fifth chapter we analyze the expected accumulated savings in a variety of life-cycle scenarios and the robustness of those scenarios on the occurrence of a market shock. In the sixth chapter we analyze the risk arising from members changing the category of a pension fund at an unfavorable moment. Finally, the last chapter presents an analysis of the research results.

2 LIFE-CYCLE INVESTMENT MODEL

When setting up investment strategies for pension funds in the long term, the question is how to achieve an appropriate return of the fund and at the same time protect the fund's members from the risks associated with investments in the capital market. In the case of a one-time payment to the fund and a very long horizon of investing, the modern portfolio theory clearly states that the optimal allocation of the portfolio between different asset classes is made unambiguously for a defined risk aversion of an investor, as it is defined with a set of parameters such as the expected returns, risks and correlation between different asset classes, risk-free interest rate, in addition to being time-independent.

However, the time horizon of investments in a pension fund typically ranges from 35-45 years, and payments, which are on average of a slowly increasing intensity, commonly occur at regular intervals. Furthermore, the members' risk aversion, as would be expected, rises towards the end of the savings accumulation phase, when the pension payments phase begins. In such circumstances it is possible that the optimal structure of investment has a time-dependent dynamic. Research shows that the optimal investment strategy of a pension fund should be described with a life-cycle model that allows gradual adjustment of the allocation of a pension fund portfolio in time, i.e. continuous change in the ratio of investment in equity and bonds (for review see, e.g., Bagliano et al., 2009; Potočnjak and Vukorepa, 2012).

Most of the research into life-cycle pension fund investments models (Castañeda et al., 2011) shows that at the beginning of the accumulation phase of investment the fund's assets should be allocated predominantly in equity, with a lower share of bonds in the portfolio (a moderately aggressive investment structure), while at the end of the accumulation phase allocation in equity should be reduced significantly, and assets should mostly be invested in bonds (a moderately conservative investment structure). The basic idea is that at the beginning of entering the pension system it is easier for members to bear a risky investment because they have fewer accumulated funds, have more time to retirement and are more likely to reduce and compensate for any losses. On the other hand, at the end of the accumulation phase members prefer safer investments against returns, given the large amount of funds accumulated and the short term available to offset potential losses.

Therefore, members should have the ability to change the allocation between equity and bonds as time passes and the question is how to perform such a reallocation within the mechanism of collective investment schemes. One of the solutions is life-cycle modeling of investments with a continuous adjustment in allocation. Such a mechanism can be achieved by defining the cohort groups of members with approximately the same retirement date. In practice it means that all members within a range of, e.g. five years until retirement, invested in the same fund in which the allocation throughout the accumulation phase is adjusted continuously according to the life-cycle model of investment. This almost exact life-cycle investment model means a far greater number of pension funds in practice, and consequently, increased management costs.

A solution to the problem of implementing a life-cycle investment model can be found by defining a certain number of pension funds that invest in assets of various risk classes, and the optimal allocation for a member can be achieved by investing his savings in different pension funds in a certain percentage. Here there is the obvious problem of determining the optimal allocation for each member, which can be delegated to the member himself, or on the legislator through an automatic allocation system. Also, the administrative costs of such schemes are increased due to the additional management of members' units register for each of the funds and the complex mechanism for the schedule of contributions for each of the funds.

Finally, a life-cycle investment model can be approximately achieved by forming several pension funds of different risk profiles and by automatically changing the membership from the higher risk profile fund to the lower risk profile fund as members get closer to their retirement date. This alternative life-cycle investment model (proxy life-cycle) simulates the optimal change in asset allocation of the fund in the accumulation phase by introducing several funds with approximately constant risk profiles for a certain phase of the accumulation and pre-defines the moments at which changes to a lower risk profile fund are mandatory. Note that the stability of the risk profile is approximate due to the ability of the fund manager to change the allocation of assets depending on market conditions. Also, it should be possible to allow the members to change funds of different risk profiles themselves at a specific moment, depending on their personal preferences towards risk, which may not be caused by market conditions.

For the purpose of optimizing the cost of the system on the one hand and efforts to approximate the true life-cycle investment model with the proxy model, as far as possible, in practice there are only three to five pension funds of various risk categories. Depending on the number of funds, for a member it is necessary to define the moment of the automatic switch to a lower risk profile fund, and if members are also able to change the risk profile of a fund in general, it is necessary to define the conditions under such change can be done. Note that in both cases the change in the riskiness of a fund induces a risk of switching at an unfavorable moment, i.e. during periods of falling prices in the capital market when a decrease in the value of members' accumulated savings occurs and cannot be compensated for if a member switches to a lower risk profile fund after the fall. In this article we will concentrate especially on such unfavorable scenarios and analyze their impact on the total accumulated funds.

According to the World Bank data, the proxy life-cycle investment model with pension funds of different risk profiles has been introduced in a dozen countries, including Chile, Estonia, Hungary, Mexico, Peru, Slovakia and Poland (Castañeda et al., 2011), while Bulgaria and Colombia are preparing to introduce a proxy life-cycle model (Impavido et al., 2010). Most countries have chosen a system with three different funds of conservative, balanced and aggressive risk profiles, which are mostly defined by the investment limits for the various asset classes, and where the members can only be in one fund at any moment. However, there are exceptions in some countries which have introduced up to five different funds of different expected risks (such as Chile and Mexico), providing great flexibility to the members in selecting those funds.

Chile, for example, allows members to allocate their savings in two funds in an arbitrary ratio, in order to reduce the risk of switching from one fund to another. The Chilean system also allows members to switch from the current fund to a fund of lower or higher expected risk, with the exception of those members who are close to their retirement date and who are not allowed to switch to the most risky fund. Despite the wide selection of funds, as well as the flexibility and ease of selection, about 65% of members in Chile are automatically assigned to a fund, according to the legal restrictions on membership in a particular fund (Impavido et al., 2010).

Table 1 gives us an overview of funds' investment limits into equity for those countries that have adopted the proxy life-cycle pension fund investment model, while table 2 presents the criteria for automatic allocation of members to a specific risk profile fund in each country.

TABLE 1

Investments limits into equity for pension funds in countries with a proxy life-cycle investment model (in terms of % of funds' net asset value)

	Fund A	Fund B	Fund C	Fund D	Fund E
Chile	80	60	40	20	5
Mexico	30	25	20	15	0
Peru	80	45	10	–	–
Hungary	<40,100>	<10,40>	10	–	–
Slovakia	80	50	0	–	–
Estonia	75	25	0	–	–
Poland	75	35	7,5	–	–

Source: Castañeda and Rudolph (2011), except for Poland where the benchmark allocations for funds of different risk profiles are given (Wojcieh, 2011), and Chile (Arthur, 2009).

TABLE 2

The regulatory limits on the duration of membership in a particular fund, considering the age of members

	Fund A	Fund B	Fund C	Fund D	Fund E
Chile	–	Men and women under 35 years of age	Men from 35 to 55 years of age	Men above 55 years of age	–
	–	–	Women from 35 to 50 years of age	Women above 50 years of age	–
Mexico	Men and women 26 years of age	Men and women from 26 to 37 years of age	Men and women from 37 to 45 years of age	Men and women from 45 to 55 years of age	Men and women above 55 years of age
Peru	–	Men and women under 60 years of age	Men and women above 60 years of age	–	–
Hungary	Men and women under 47 years of age	Men and women from 47 to 57 years of age	Men and women above 57 years of age	–	–
Slovakia	Men and women under 47 years of age	Men and women under 55 years of age	–	–	–
Estonia	Default membership in the conservative profile fund (C), no age restrictions	–	–	–	–
Poland	Men and women under 55 years of age	Men and women above 55 years of age – all further payments go to fund C, twice a year the assets are gradually transferred to fund C	–	–	–

Source: Impavido et al. (2010) for Chile, Mexico and Peru; Arthur (2009) for Hungary, Slovakia and Estonia; and Wojcieh (2011) for Poland.

Automatic allocation of members in Chile, Mexico, Peru, Poland and Hungary is based on some form of life-cycle model, and limitations on the duration of membership in a particular fund depend on the members' age. On the other hand, in Estonia there is no age limit on the duration of membership in a particular fund, and if the member doesn't choose a fund himself, he will be automatically allocated to the conservative fund. Slovakia does not have an automatic selection of funds for the members, and the members themselves must decide in which fund they want to participate, if they want to be in the system (Arthur, 2009).

In Croatia, the proxy life-cycle investment model was introduced in 2014 (The Mandatory Pension Funds Act, 2014), and it is designed through the formation of three pension funds of different risk profiles, i.e. different categories: A, B and C. In table 3 the limitations to exposure to equities and alternative investment funds for pension funds of different categories are given. In accordance with those limits, we can assert that the category A fund has a balanced investment strategy, the category B fund has a moderately conservative investment strategy and the category C fund can be considered a conservative risk profile fund.

Table 3
Maximum exposure to equities and alternative investment funds for category A, B and C pension funds in Croatia

Asset class	A	B	C
Equity	55%	35%	0%
Alternative investment funds	15%	10%	0%

Automatic transfer from category A fund to category B fund occurs when the member has fewer than 10 years to his retirement date, while the next automatic switch occurs when the member has fewer than 5 years to retirement. Also, members can change fund categories only in the years when they reach the age that is a multiple of the number three, and only in the calendar month in which they were born. In a case of a market decline this should prevent the expected switching of a larger number of members to funds with lower risk profiles. However, this mechanism does not prevent the switching of members who do qualify to make a change in their fund category, which raises the risk of switching fund categories in an unfavorable moment.

3 PARAMETRIC MODEL FOR CALCULATION OF ACCUMULATED SAVINGS IN THE PROXY LIFE-CYCLE INVESTMENT MODEL

In this chapter we present the extended parametric model for the calculation of total accumulated savings in the 2nd pillar (Šorić, 2000) which is adapted to the proxy life-cycle investment model. In this approximate model, which assumes payment of contributions at equal time intervals, the total amount of accumulated savings depends on only a few factors: the length of the saving period in a pension fund category, the return of a pension fund category and the income growth rate, which is assumed to be constant as time passes.

In case of savings in the former model of the 2nd pillar, where members contribute n years in the pension fund whose expected long term real return is p and where they have the expected long term real growth of gross wages i, it is shown that the expected total amount of accumulated savings M is equal to (Šorić, 2000):

$$M = R \cdot \frac{r-1}{r^{1/12}-1} \cdot \frac{r^n - s^n}{r-s}, \tag{3.1}$$

where R is the current contribution to the 2nd pillar, paid at the end of the month, and r and s are indices for pension fund return and income growth rate:

$$r = 1+p, \quad s = 1+i. \tag{3.2}$$

We will also assume that the contribution R is equal to one and that it has already been reduced by the entry fee of the pension fund. Detailed analysis of the influence of various parameters on the total accumulated savings from the 2nd pillar is described in the work of Latković and Liker (2009).

Calculation of total savings in the proxy life-cycle model is somewhat more complicated given that there are three saving periods with arbitrary duration and with different expected returns of particular pension funds. Therefore, for the purpose of calculating the total expected accumulated savings we have to obtain accumulated savings in particular categories of funds, and therefore we introduce the following notation:

M_i … accumulated savings from the beginning of the membership period until exit from the category i fund, where i represent the category of the fund (A, B or C),
t_0 … age of a member at the time of entering the pension system,
t_1 … age of a member when switching from category A to category B fund,
t_2 … age of a member when switching from category B to category C fund,
T … age of a member at the time of retirement,
t_A … total participation time in category A fund,
t_B … total participation time in category B fund,
t_C … total participation time in category C fund,
p_i … average annual return of the fund of category i, and
$r_i = 1 + p_l$… index for the annual rate of return of category i fund,
$r_{im} = r_i^{1/12}$… index for the monthly rate of return of category i fund.

According to equation (3.1) the expected accumulated savings in fund A, at the end of the savings period, are:

$$M_A = \frac{r_A - 1}{r_A^{1/12} - 1} \cdot \frac{r_A^{t_A} - s^{t_A}}{r_A - s}. \tag{3.3}$$

When a member reaches t_1 years of age, he switches from fund A to fund B and he begins to pay his contributions into fund B. At the same time, his previously accumulated savings from fund A represent a one-time payment to fund B, and this amount is being capitalized at the rate equal to the expected return of fund B up to the moment of exit from fund B, i.e. until the moment t_2. The expected accumulated savings in fund B at the end of the period of savings in that fund are:

$$M_B = M_A \cdot r_B^{t_B} + s^{t_A} \cdot \frac{r_B - 1}{r_B^{1/12} - 1} \cdot \frac{r_B^{t_B} - s^{t_B}}{r_B - s}. \tag{3.4}$$

Accordingly, the expected accumulated savings in fund C at the end of the period of savings in that fund are:

$$M_C = M_B \cdot r_C^{t_C} + s^{(t_2 - t_0)} \cdot \frac{r_C - 1}{r_C^{1/12} - 1} \cdot \frac{r_C^{t_C} - s^{t_C}}{r_C - s}. \tag{3.5}$$

After including equations (3.3) and (3.4) into the equation (3.5), we get the following expression for the total expected amount of accumulated savings, M_{PLC}, in the proxy life-cycle investment model:

$$\begin{aligned} M_{PLC} = {} & \frac{r_A - 1}{r_A^{1/12} - 1} \cdot \frac{r_A^{t_A} - s^{t_A}}{r_A - s} \cdot r_B^{t_B} \cdot r_C^{t_C} + s^{t_A} \cdot \frac{r_B - 1}{r_B^{1/12} - 1} \cdot \frac{r_B^{t_B} - s^{t_B}}{r_B - s} \cdot r_C^{t_C} \\ & + s^{(t_2 - t_0)} \cdot \frac{r_C - 1}{r_C^{1/12} - 1} \cdot \frac{r_C^{t_C} - s^{t_C}}{r_C - s}. \end{aligned} \tag{3.6}$$

We mention some special cases of equation (3.6) when a member spends the entire time in category A fund ($t_1 = t_2 = T$):

$$M_{PLC}^{A} = \frac{r_A - 1}{r_A^{1/12} - 1} \cdot \frac{r_A^{(T - t_0)} - s^{(T - t_0)}}{r_A - s}, \tag{3.7}$$

or in category B fund ($t_0 = t_1$; $t_2 = T$):

$$M_{PLC}^{B} = \frac{r_B - 1}{r_B^{1/12} - 1} \cdot \frac{r_B^{(T - t_0)} - s^{(T - t_0)}}{r_B - s}, \tag{3.8}$$

or in category C fund ($t_0 = t_1 = t_2$):

$$M_{PLC}^{C} = \frac{r_C - 1}{r_C^{1/12} - 1} \cdot \frac{r_C^{(T - t_0)} - s^{(T - t_0)}}{r_C - s}. \tag{3.9}$$

For simplicity, we assume that there is no real growth of gross wages, which further simplifies the equation for the expected amount of accumulated savings given by the equations (3.3) to (3.9). This assumption can be justified by the fact that, in the event of a positive real rate of income growth, which corresponds to the range of average historical real rate of gross salary growth in Croatia, the results of the analysis presented are analogous.

4 THE EXPECTED RETURNS AND RISKS OF PENSION FUNDS OF VARIOUS CATEGORIES

In order to compare the calculations for total accumulated savings under the previous and the new law and to determine the expected risks, below we will define the expected long term returns of basic asset classes that are part of the pension funds' portfolios of different risk profiles, their expected risks and mutual correlations.

The expected long term returns of pension funds mostly depend on the strategic asset allocation of their portfolios, i.e. the ratio between debt securities (bonds) and equity securities (shares) in their portfolios. With the help of the average realized returns over the long term for these two basic asset classes, it is possible to set expectations for their future values. The same applies to the expected risks and correlations.

By analyzing historical returns of bonds and equities in developed markets (Dimson et al., 2014), it is possible to estimate the expected returns and risks for those markets, as well as to provide an estimate of the expected returns and risks for the Croatian capital market (table 4). Due to the short history of the domestic equity market and the unreliability of statistical estimates of its average historical returns, for the Croatian equity market we use estimates for expected returns (Latković and Liker, 2009) that are based on the spreads in historical returns between emerging markets (12.5%) and developed markets (10.8%) achieved since World War II (Dimson et al., 2014). Therefore, for the expected real return of equity in the domestic market, we use the historical real rate of return for foreign equity markets plus a premium of 2 percentage points.

Since it is not possible to give an estimate of the spread in premium for bonds in emerging markets and developed markets on a longer time scale (the history of debt issuing for emerging markets, in foreign currencies, starts at the beginning of the 1990s), we assume that the spread should be less than the difference between the equity premium due to the generally lower risk of bonds versus equity. Therefore, for the sake of simplicity, we estimate that the real return of bonds in the foreign (outside Croatia) market should be increased by 1 percentage point to get the expected real return on the domestic (Croatian) bond market.

The results of the analysis presented in this paper depend only on specific quantitative estimates of expected returns for the Croatian capital market, but not qualitatively as long as the premiums for the Croatian market are larger than the corresponding premiums for developed markets. Expected risks for foreign equity and bond markets are estimated based on historical volatility (Dimson et al., 2014) while for the Croatian market the historical volatility for emerging markets was taken. Assumptions about the correlations we use in the analysis are given in table 5, and they are estimated by observing the trends in the movement of correlation of returns on various asset classes.

Table 4

The expected returns and risks for basic asset classes in the domestic (HR) and international (INO) capital markets (in %, annualized)

Asset class	Expected real return	Expected risk
HR bond market	2.8	10
HR equity market	7.2	27
INO bond market	1.8	7
INO equity market	5.2	18

Source: Dimson et al. (2014) and calculations by the authors.

Table 5

*Assumptions for correlations of basic asset classes in the domestic and international capital markets**

Correlations	HR O	HR D	INO O	INO D
HR O	1	0.25	0.3	0.2
HR D	0.25	1	0.1	0.6
INO O	0.3	0.1	1	0.2
INO D	0.2	0.6	0.2	1

** HR O, HR D, INO O and INO D respectively denote Croatian bond market, Croatian equity market, foreign bond market and foreign equity market.*

Source: Calculations by the authors.

Taking into account the legal restrictions on the exposure to equity for pension funds of various categories (table 3), we assume the targeted asset allocation in equity and bonds for funds A, B and C and define the targeted allocation for a pension fund that operated by the previous law (based on historical asset allocation in equities and bonds of mandatory pension funds in Croatia in the period from late 2006 to the end of 2013; source: HANFA). Assumptions about the asset allocations are shown in table 6.

Table 6

Assumed asset allocation of pension funds in stocks and bonds (in % of the net asset value of a fund)

	Previous law	A	B	C
Equity market	25	50	25	0
Bond market	75	50	75	100

Note that the moderately conservative asset allocation of category B fund is identical to the asset allocation of the pension fund operated under the previous law. For category A fund we have selected a balanced asset allocation, while the allocation for the category C fund is completely conservative. Furthermore, we assume that funds invest their assets in Croatian and foreign markets, according to the allocation shown in table 7.

Table 7
Assumed asset allocation of pension funds (in % of the net asset value of a fund)

	Previous law	A	B	C
HR bond market	65	40	65	90
HR equity market	15	30	15	0
INO bond market	10	10	10	10
INO stock market	10	20	10	0

Based on the assumptions on expected real returns, risks, correlations and the asset allocations of pension funds portfolios, shown in tables 4 to 7, and by using the equation for portfolio total return, R_P, and portfolio risk, σ_P:

$$R_p = \Sigma_i w_i R_i, \tag{4.1}$$

$$\sigma_P^2 = \Sigma_{i,j} w_i\, w_j \sigma_i \sigma_j \rho_{ij}, \tag{4.2}$$

where w_i represents the share of an asset class in the portfolio, R_i and σ_i are its expected return and expected risk respectively, while ρ_{ij} is the expected correlation between the ith and jth asset classes, we calculate the expected real returns and risks for a particular fund. Table 8 shows the results obtained.

Table 8
The expected real returns and risks of pension funds under the previous and the new law (in %, annualized)

	Previous law	A	B	C
Expected real return	3.60	4.50	3.60	2.70
Expected risk	9.63	12.48	9.63	9.23

The results presented in table 8 show that the expected real returns and risks are the highest for category A fund, and by decreasing the share of equity in the portfolios of category B and C funds their expected real returns and risks decline. Note that the expected real returns and risks of the pension fund operated by the previous law and for category B fund are identical given the same assumed asset allocation. However, note that the expected reduction of risk in category C fund with respect to category B fund is not in proportion to the reduction of the expected risk of category B fund versus category A fund, despite the proportional reduction in the allocation of equity. The expected risk of category B fund decreases by 22.8% compared to the expected risk of category A fund, while the expected risk of category C fund decreases by only 4.1% compared to the expected risk of category B fund.

The reason lies primarily in the insufficient diversification of investments in the category C fund which is caused by the large, 90%, proportion of Croatian bonds in the portfolio. If we reduce the share of Croatian bonds to 80% and increase the share of foreign bonds to 20% in the category C fund, the reduction of expected risk is 11.5% while the expected real return is reduced by only a tenth of a percentage point. If we allow investments into equities in the category C fund and assume a targeted asset allocation in this segment in the amount of 10% (5% in Croatian equity and 5% in foreign equity), with an appropriate reallocation of investments in bonds in the amount of 75% for Croatian bonds and 15% for foreign bonds, the expected risk would be slightly higher than in the previous case, with a reduction of 10.3% compared to the risk of category C fund with a 90/10 allocation to domestic and foreign bonds. Also, the expected real return increases to 3%, which is 0.3 percentage point higher than the expected real return of the category C fund with 90/10 allocation in bonds.

From the analysis above we can conclude that the diversification potential of different asset classes is probably not fully utilized in category C fund and that with a slight increase in the exposure to equity markets it would be possible to obtain a larger reduction of portfolio risk while increasing returns. However, the portfolio risk depends primarily on the assumed asset allocation of a pension fund, the expected risks of individual asset classes as well as their mutual correlations and therefore the resulting reduction of portfolio risk has to be viewed as an indication (not quantification) of diversification insufficiency in category C fund.

5 EXPECTED TOTAL ACCUMULATED SAVINGS AND THE IMPACT OF MARKET SHOCKS

Next, we analyze the expected total accumulated savings in the proxy life-cycle investment model obtained on the basis of expected returns of pension funds of various categories and make a comparison with expected returns of a pension fund operated under the previous law.

Furthermore, we have to assume the total duration of the accumulation phase and the savings period in a particular fund category (A, B and C). We assume that a member enters the pension scheme at 25 years of age and retires at 65 years of age, i.e. the total working period is 40 years. We are interested in changes of the total expected accumulated savings, M_{PLC}, as we change the age of a member at the moment of switching from fund A to fund B, t_1, i.e. from fund B to fund C, t_2, and how it differs from the expected total accumulated savings under the previous law, M.

Also, we are interested in the impact of a market shock on the total expected accumulated savings for A, B and C funds at the end of the accumulation phase, i.e. we calculate the worst losses in which the probability of observations of a larger loss is less than the pre-defined probability (Scheuenstuhl et al., 2010). This concept is called the Value-at-Risk (VaR) of the portfolio, and is defined as:

$$P\left(L > VaR\right) \leq 1 - c, \tag{5.1}$$

where c is the confidence level and L is the expected loss of the fund. For simplicity we assume that returns of a pension fund are independent and identically distributed normal random variables.

Based on the assumption that the accumulation phase lasts 40 years and assuming an isolated market shock in those 40 years, we define a confidence level c = 1-1/40 = 97.5%, i.e. we determine the probability of 2.5% for the occurrence of a greater loss than VaR. An example of such an event in the capital markets occurred in 2008, when the decline in foreign equity markets, measured by the MSCI World index (including dividend yield), was 37.25% measured in Croatian currency kuna, while the decline in domestic stock markets, measured by the CROBEX index, was 63.74%. The average decline in the returns of Croatian mandatory pension funds in 2008, as measured by the MIREX index, was 12.50%. According to the assumptions in tables 7 and 8 the worst loss defined by formula (5.1) for the fund under the previous law amounts to 15.28% and is comparable to the average realized decline of MIREX in 2008.

For the case of normally distributed pension fund returns and a confidence level of 97.5%, the expected VaR of a fund is:

$$\text{VaR} = M \cdot (1.96 \cdot \sigma_P - R_P), \tag{5.2}$$

where R_P and σ_P represent the expected return and risk of a fund, and M is the total amount of expected accumulated savings. This expression allows us to determine the loss that would arrive from a market shock at the time of retirement.

We consider the case when a member spends the entire employment period in the pension fund operated under the previous law, in funds of particular categories in the proxy life-cycle model with age-dependent constraints of switching between funds starting with the category A fund at the beginning of employment (A-B-C scheme: the transition from fund A to fund B in 10 years before retirement and from fund B to fund C in 5 years before retirement), and starting with fund B at the beginning of employment (B-C scheme: the transition from fund B to fund C in 5 years before retirement). The results for the total expected accumulated savings and the corresponding VaR are shown in table 9.

Table 9

The calculation of total expected accumulated savings and VaR for one unit of contribution

	Expected real return (%)	Expected risk (%)	Expected accumulated savings (kn)	VaR (kn)
Previous law	3.6	9.63	1,055.4	161.3
Only fund A	4.5	12.48	1,310.6	261.7
Only fund B	3.6	9.63	1,055.4	161.3
Only fund C	2.7	9.23	856.1	131.8
A-B-C scheme*	4.16	9.23	1,157.6	161.4
B-C scheme**	3.49	9.23	1,011.7	147.8
Life-cycle model	3.01	8.51	1,139.3	155.7

**Average expected real return in accordance with the period of participating in fund A, B and C and the expected risk for fund C.*
*** Average expected real return in accordance with the period of participating in fund B and C and the expected risk for fund C.*

Note that the total expected accumulated savings would be the largest if a member could spend his total accumulation phase in fund A, however, he would also have the largest expected risk and expected VaR. Nevertheless, a member is free to choose to spend all of his employment period in fund C where the expected risk is the smallest, although with significant penalization of total expected accumulated savings. The proxy life-cycle investment model allows a member to achieve an average return that is higher than the return of the fund under the previous law, and the return in the case of membership only in fund B or only in fund C. However, the expected risk at the time of his retirement is the risk of fund C while VaR is almost identical to VaR of the fund under the previous law. Therefore, even in the case of a market shock at the time of retirement, a member is better off in the proxy life-cycle investment model (A-B-C scheme) than in the case of investment under the previous law.

If a member who participates in the proxy life-cycle investment model decides not to participate in fund A at all, i.e. he chooses or is assigned by law to fund B and remains a member of fund B up until the membership age restriction (B-C scheme; transition from fund B to fund C 5 in years before retirement), he can expect a smaller amount of total accumulated savings and a lower VaR than in the pension scheme under the previous law. In the event of a market shock at the time of retirement, a member would (in this case) have been better off in the model of investments under the previous law.

Next, we analyze one of the exact life-cycle investment models and compare it with the proxy life-cycle model in Croatia. In the second chapter we mentioned that there are multiple ways of implementing life-cycle portfolio modeling. Studies show that there is an age span at which a member should be almost fully exposed to equity markets, and after that age the exposure to equity should be gradually reduced until the time of retirement (Schiller, 2006). Some of the possible scenarios for life-cycle portfolio modeling provide the following investment ratios in equity and bond markets:

- *basic portfolio*: the initial allocation of equity is equal to 85% of fund assets and is fixed until a member reaches 29 years of age, after which the exposure to equities is gradually reduced to 15% by the time of retirement,
- *conservative bond portfolio*: similar to the basic portfolio, only the initial exposure to equity is 70% and the final is 10%,
- *aggressive portfolio*: similar to the basic portfolio, only the initial exposure to equity is 90% and the final is 40%.

Of these three scenarios we select the conservative bond portfolio for further analysis, given that it best describes the A-B-C scheme of investments in Croatia. Due to the simplicity of calculating the allocation of equity and bonds over time, we decrease exposure to equity linearly from the moment when a member reaches 29 years of age until the time of his retirement. Also, we assume a fixed ratio of 4:1 for bonds and 3:2 for equity between investment in Croatian and foreign markets for the entire period of investment (the initial allocation is 42% in Croatian equities, 28% in foreign equities, 24% in Croatian bonds and 6% in foreign bonds). The result of this selected exact life-cycle investment model is shown in table 9. From the results we see that the proxy life-cycle investment model in Croatia is comparable with the selected exact model of life-cycle investment both in terms of accumulated savings and by the amount of VaR.

6 THE RISK OF CHANGING A FUND CATEGORY IN AN UNFAVORABLE MOMENT

As we mentioned in the introduction, the proper selection of the moment of switching from a pension fund of higher risk to a fund of lower risk is an important factor in determining the expected total accumulated savings in the proxy life-cycle model in the 2nd pillar. In this article we do not optimize this process in order to achieve the maximum amount of accumulated savings in relation to risk at retirement, and we focus on the analysis of scenarios of voluntary transition to a fund of lower risk in an unfavorable time.

Below, an unfavorable moment of transition to a lower risk fund presents a scenario where, after a market shock, a member can change fund categories and decide to transfer his previously accumulated savings to a lower risk fund, immediately after the occurrence of a market shock. The expectation for the realization of such a scenario is based on the large number of membership terminations from voluntary pension funds after the collapse of the market at the end of 2008 (according to HANFA's monthly reports on the status of membership in voluntary pension funds). Furthermore, in all of the following examples we use legal age restrictions on the membership duration in fund A and the minimum duration in fund B and C. The reason for this inert transition dynamics from one fund category to another fund category is found in the previous inertness of choosing a pension fund in the first place, i.e. when members enter the pension scheme, as well as in the inertness of members about changing pension funds because of their performance.

In the following analysis we continue to use the expectations for a market shock occurrence once in 40 years, i.e. we consider the VaR with a confidence level of 97.5%. Market shock of a portfolio P is defined as:

$$S^P = 1.96 \cdot \sigma_P - R_P, \tag{6.1}$$

where R_P and σ_P are the expected return and risk of a fund. We apply a market shock on accumulated savings in fund A or B and observe how these savings behave at retirement, depending on the moment of the transition from fund A to B or from B to C (depending on which fund the member is in at that moment).

The equation for the total expected accumulated savings in the proxy life-cycle investment model can be expressed as:

$$M_{PLC} = M^A + M^B + M^C, \tag{6.2}$$

where:

$$M^A = R \cdot \frac{r_A - 1}{r_A^{1/12} - 1} \cdot \frac{r_A^{t_A} - s^{t_A}}{r_A - s} \cdot r_B^{t_B} \cdot r_C^{t_C}, \tag{6.3}$$

$$M^B = R \cdot s^{t_A} \cdot \frac{r_B - 1}{r_B^{1/12} - 1} \cdot \frac{r_B^{t_B} - s^{t_B}}{r_B - s} \cdot r_C^{t_C}, \tag{6.4}$$

$$M^C = R \cdot s^{(t_2 - t_0)} \cdot \frac{r_C - 1}{r_C^{1/12} - 1} \cdot \frac{r_C^{t_C} - s^{t_C}}{r_C - s}. \tag{6.5}$$

If a member of fund A decides to switch to fund B at an unfavorable moment, then equation (6.3) becomes:

$$M_S^A = R \cdot \frac{r_A - 1}{r_A^{1/12} - 1} \cdot \frac{r_A^{t_A} - s^{t_A}}{r_A - s} \cdot (1 - S^A) \cdot r_B^{t_B} \cdot r_C^{t_C}, \tag{6.6}$$

and the expression for his expected total accumulated savings becomes:

$$M_{PLC}^{S,A} = M_S^A + M^B + M^C. \tag{6.7}$$

Analogously, if a member of fund B decides to switch to fund C at an unfavorable moment, then equation (6.4) becomes:

$$M_S^B = R \cdot s^{t_A} \cdot \frac{r_B - 1}{r_B^{1/12} - 1} \cdot \frac{r_B^{t_B} - s^{t_B}}{r_B - s} \cdot (1 - S^B) \cdot r_C^{t_C}, \tag{6.8}$$

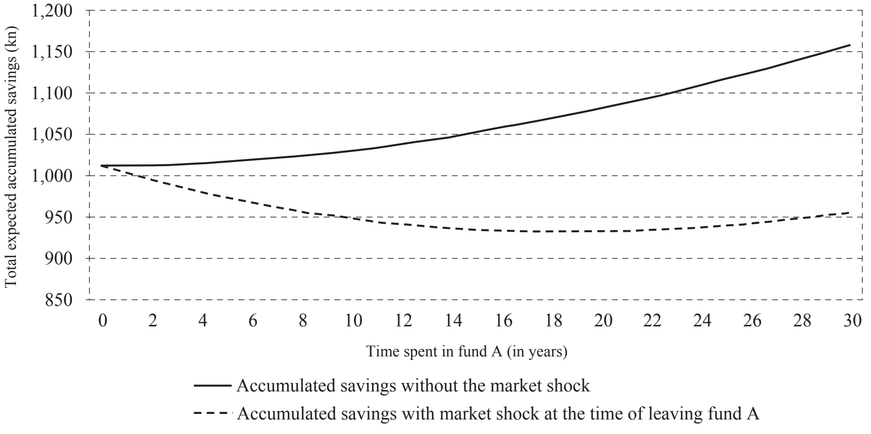
and the expression for his expected total accumulated savings becomes:

$$M_{PLC}^{S,B} = M^{A} \cdot (1 - S^{B}) + M_{S}^{B} + M^{C}. \tag{6.9}$$

Next, we calculate the expected total accumulated savings in the event of an unfavorable moment of changing the fund and in a case when the shock does not happen. Consider the situation where a shock occurs at the moment of transition from fund A to B. Suppose that the change from fund A to B is possible at any time.

Figure 1

The total expected accumulated savings (for a one unit of contribution) without shock and with the shock in fund A

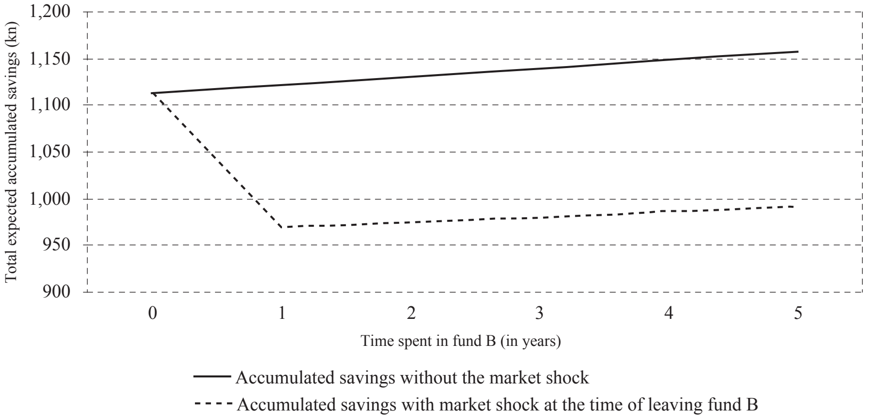


It is evident that a shock at the time of transition from fund A highly affects the expected total accumulated savings and that the difference between the accumulated savings without a shock and with a shock after which a member decides to change the fund, grows according to the time spent in fund A. If the shock occurs in the initial years of membership in fund A, and a member decides to switch to the lower risk fund, there is an opportunity cost, i.e. the risk of missed earnings that would be realized if he remained in fund A. This opportunity cost increases in the initial years of the accumulation phase as the time remaining until retirement, in which a member is no longer a member of the fund A, is significant. In this case, at about half of the maximum legally expected time of membership in fund A, there is a mutual influence of opportunity cost and previously accumulated savings which results in the lowest amount of total expected accumulated savings in a case in which a member leaves the fund immediately after the market shock.

Furthermore, we study the situation when a shock occurs at the moment of transition from fund B to C. Suppose that the change from fund B to C is possible at any time.

FIGURE 2

Total expected accumulated savings (for one unit of contribution) without shock and with the shock in fund B



As mentioned earlier, after a period of membership in fund A, the accumulated savings in fund A are transferred to fund B and this amount increases at the rate of the expected return of fund B. In this example, we assume that a market shock occurred at a moment when a member is in fund B, i.e. when he has a significant amount of savings on his personal account. In figure 2 we see a significant and sudden loss of previously accumulated savings. Also, it is evident that the difference between the accumulated savings without a shock and with a shock, after which a member decides to change the fund, grows according to the time spent in fund B.

Consider the situation when a market shock occurs and the member decides not to change funds, i.e. he remains in the fund until the age restrictions for membership in a particular fund apply. Let m be the moment when a shock occurs and a member decides to stay in a fund until he switches automatically to the next fund. If a shock occurs during the membership in fund A then instead of equation (6.3) we have:

$$M_{S,m}^{A} = R \cdot \frac{r_A - 1}{r_A^{1/12} - 1} \cdot \left(\frac{r_A^{(m-t_0)} - s^{(m-t_0)}}{r_A - s} \cdot (1 - S^A) \cdot r_A^{(t_1 - m)} + s^{(m-t_0)} \cdot \frac{r_A^{(t_1-m)} - s^{(t_1-m)}}{r_A - s} \right) \cdot r_B^{(t_2-t_1)} \cdot r_C^{(T-t_2)}, \tag{6.10}$$

and the expression for the total expected accumulated savings are:

$$M_{PLC,m}^{S^A} = M_{S,m}^{A} + M^B + M^C. \tag{6.11}$$

If the shock occurs during the membership in fund B, then instead of equation (6.4) we have:

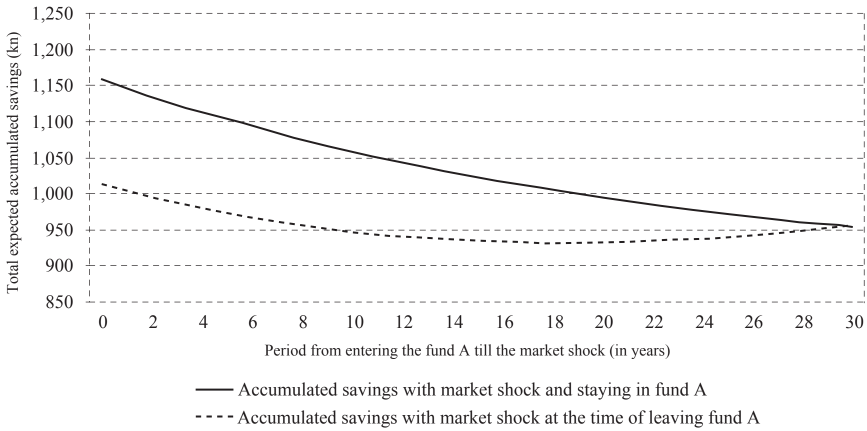
$$M^{B}_{S,m} = R \cdot s^{t_A} \cdot \frac{r_B - 1}{r_B^{1/12} - 1} \cdot \left(\frac{r_B^{(m-t_1)} - s^{(m-t_1)}}{r_B - s} \cdot \left(1 - S^B\right) \cdot r_B^{(t_2-m)} + s^{(t_2-m)} \cdot \frac{r_B^{(t_2-m)} - s^{(t_2-m)}}{r_B - s} \right) \cdot r_C^{t_C}, \tag{6.12}$$

and the expression for the total expected accumulated savings are:

$$M^{S^B}_{PLC,m} = M^A \cdot \left(1 - S^B\right) + M^B_{S,m} + M^C. \tag{6.13}$$

Let us observe the situation when a shock occurs during membership in fund A. We are interested in how this affects the total expected accumulated savings if a member remains in fund A after the market shock, and in relation to the scenario in which he chooses to switch from fund A to fund B at an unfavorable moment.

Figure 3
Total expected accumulated savings (for one unit of contribution) in the event of staying in fund A after the shock and of leaving the fund A after the shock



It is evident that for any moment that the shock occurs m, $t_0 \leq m < t_1$, it is better to stay in fund A than to move to fund B in the year when the shock occurred. If the moment of shock corresponds to the moment of mandatory transition from fund A to B, $m = t_1$, the total expected accumulated savings is equal for both cases.

Let us observe the situation when a shock occurs during membership in the fund B. We are interested in how this affects the total expected accumulated savings in a case in which a member remains in fund B after a shock as compared to the scenario in which he chooses to switch from fund B to fund C, at an unfavorable moment.

It is evident that for any moment of shock m, $t_1 \leq m < t_2$ it is better to stay in fund B than to switch to fund C in the year when the shock occurred. If the moment of

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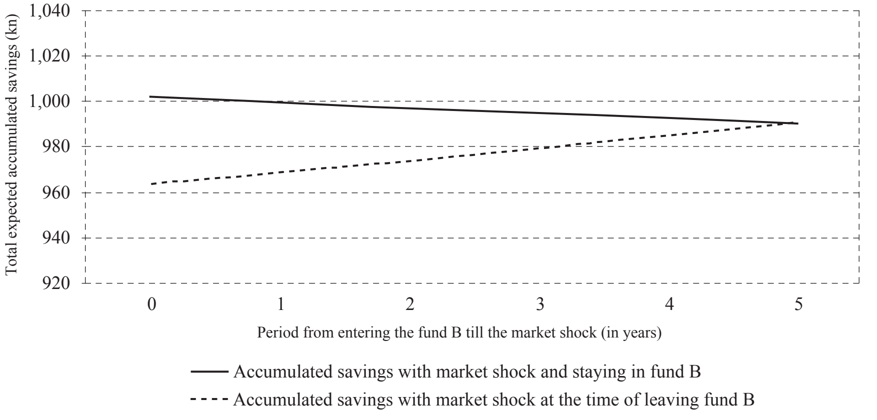
shock corresponds to the moment of mandatory transition from fund B to C, $m = t_2$, the total expected accumulated savings is equal for both cases.

FIGURE 4

Total expected accumulated savings (for one unit of contribution) in the event of staying in fund B after the shock and of leaving fund B after the shock



7 CONCLUSION

This article offers a brief overview of the new model of the 2nd pillar pension scheme in Croatia, which, for the first time, introduces a proxy life-cycle model of investment in the portfolios of mandatory pension funds, where members have the opportunity to choose funds of different risk profiles with specific age restrictions on membership.

Given the assumptions on the expected returns, risks and correlations between different asset classes and allocations of pension fund portfolios, we calculated the expected real return and risk for category A, B and C funds and gave a comparison with the results obtained on the basis of the investment structure under the previous law. The results were in line with expectations that life-cycle investment models would perform better than other models in terms of expected return and risk.

However, the analysis shows that the expected risk for fund C as compared to that of fund B is not proportionally smaller, given the reduction in the exposure to equity. The reason for this is primarily the lack of diversification of investments in the category C fund. In case of a minimal change in asset allocation in the category C fund, in terms of the possibility of a low exposure to equity and increasing limits on exposure to foreign markets, the expected real return of the fund would have increased, while the expected risk, due to the increase of diversification, is expected to be reduced. Since the magnitude of the reduction of risk depends on the estimates of several key factors, the amount of risk reduction should be seen only as an indication of lack of diversification in the category C fund.

In this article we analyze the total expected accumulated savings for different models of proxy life-cycle investment and for one possible exact model of life-cycle investment. In addition to the total expected accumulated savings, we calculated the value of the worst loss, which we do not expect to be exceeded in more than 2.5% cases, i.e. the amount of loss that we expect to achieve once in 40 years. The length of membership in the category A fund has proved to be the most important factor in determining the total expected accumulated savings, even in case of a market shock, i.e. in of the event of the realization of the worst loss. We show that for the case of investments based on the maximum duration of membership in the category A, B and C fund, with the age restrictions on membership in a particular fund (A-B-C scheme), the member is better off in the proxy life-cycle investment model than in the model of the previous law, even in the event of a market shock at the time of retirement.

As the right choice of the moment of transition from a higher risk pension fund to a lower risk pension fund is a very important factor in determining the total expected accumulated savings in the proxy life-cycle model of investments in the 2nd pillar, we show the effect of a market shock on the total expected accumulated savings in cases in which the shock occurs at moments when a member is in category A fund and when he is in category B fund. Our result is that a member is better off if he does not make a decision to change the fund and instead decides to remain in the fund in which he is currently a member, until he reaches the age limit for membership of that fund.

The results of this study show that there are possible further improvements of the 2nd pillar of pension funds in Croatia, especially in the final phase of accumulation, primarily in setting investment limits for category C fund, which should result in a mandatory pension fund with a better risk/return ratio and a further reduction in VaR. Also, it is necessary to consider the conditions for the transitions from a fund of higher risk to a fund of a lower risk at an arbitrary moment, given the identified risk of changing funds at an unfavorable moment, i.e. in the occurrence of a market shock that could discourage the members from staying in the higher risk fund. For the purpose of further research of the risk of changing funds of various categories, it is necessary to explore the opportunity of the members to change the funds in the opposite direction from that here analyzed, i.e. a change from the lower risk fund to the higher risk fund. If a member decides to change the fund in such a way and if at some point a market shock occurs, it is possible that there will not be enough time to cover the losses until the next legal possibility of switching to the lower risk fund. The risk analysis of such transition from the lower risk fund to the higher risk fund is a logical extension of the overall analysis of the proxy life-cycle model of pension fund investments. The analysis made above of all the risks identified in the new proxy life-cycle model of investments in the 2nd pillar pension scheme in Republic of Croatia can only be applied within the legislative framework for possible changes that might result in further improvements of the Croatian pension system.

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