ARE EXCESSIVE LEGISLATIVE RESTRICTIONS OF PENSION FUND'S INVESTMENTS REQUIRED TO ENSURE THESE FUNDS' OPERATIONAL STABILITY AND MINIMUM GUARANTED RETURN?

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Abstract

In this paper, it is investigated whether government, when promises pension fund's members a so-called minimum guaranteed return, to reduce the exposure of members to financial risks , should at the same time hinders portfolio diversification process of pension funds. We provide a detailed analysis of the connection between the requirements for providing a minimum guaranteed return and managing financial risks on the one hand and the investment structure of pension funds on the other. We intend to demonstrate with an illustrative case, using the simulation technique and a combination of actual data and some hypothetical one, that by precisely matching the investments' characteristics to the characteristics of the pension fund's liabilities, some important financial risks can even be hedged entirely. We also intend to demonstrate that with the implementation of a proper policy of risk measurement and management, complemented with stress testing practices, excessive legislative restrictions for investments are no longer necessary. At the very least, governments should avoid implementing legislation that hinders the portfolio diversification process and therefore makes pension fund risk management more difficult.

Key words: *pension funds, financial risks, minimum guaranteed return, asset-liability management*
JEL classification: *G11, G23*

1. Introduction

The managers of pension funds are nowadays faced with increasing responsibility for the profitable and – mostly – prudent management of their members' assets. To reduce the exposure of the pension fund's members to financial risks, the legislation in some countries promises a so-called minimum guaranteed return. If the portfolio manager takes excessive risks and earns negative returns, the difference between the actual (negative) return and the minimum guaranteed return must be covered from his own capital. As managers are discouraged to put their solvency at risk, a more conservative approach to investment policy is preferred, which is often associated with relatively poor potential returns and a reduced interest of employed people in participating in supplementary pension savings. This is also the case in Slovenia.

Our intention in this article is therefore a detailed analysis of the connection between the requirement of providing the minimum guaranteed return and managing financial risks on the one hand, and the investment structure of pension funds on the other. We intend to demonstrate on the case study basis, using a combination of empirical data from two Slovenian pension funds and some hypothetical one, that by precisely matching the investments' characteristics to the characteristics of the pension fund's liabilities, i.e. using asset-liability management (ALM) approach, some important financial risks can be mitigated, so excessive legislative restrictions for pension fund's investments are no longer necessary.

The history of ALM models is long, but the importance of ALM strategy increased especially after 2001 when the shocks on the stock exchange due to events connected with September 11 in the U.S. severely reduced numerous pension funds' available resources for covering liabilities. The earliest ALM models in literature were deterministic models and duration matching techniques were applied to find the best portfolio. The stream of future benefit payments was assumed to be known in advance with certainty. Examples of these models are those of Macaulay (developed in 1938), Redington (developed in 1952) and Bierwag et al. (developed in 1983). These models, in which only bonds were considered as possible investments, were used until the mid 1980s. After that,

bond models were used in which the future stream of benefit payments were stochastic. However, alternative portfolios were again found by duration matching techniques. Examples of these models are those by Fabozzi and Fabozzi (1989), Cox et al. (1985), Jacob et al. (1987) and Norris and Epstein (1989). Duration matching techniques have some major drawbacks. One of them is if interest rates change unexpectedly. Then reinvestment risk has to be considered. In addition, these types of models are extremely sensitive to the specific term structure model used.

In the late 1980s the first integrated analyses for ALM problems were made, using simulation models (see for example Van der Meer (1989), Van der Meer et.al. (1990) and Boender et al. (1998)). The added value of these models is the ability to use a lot of scenarios. A major drawback of simulation techniques is, that many choices with respect to policies have to be kept fixed. To overcome the drawbacks of simulation, stochastic linear programming models (SLP) were used for tackle ALM problems. Instead of exogenous variables, as in simulation, decisions become endogenous. While simulation is based on evaluation, SLP is based on optimization (i.e. searches for the best solution). For applications of stochastic programming in ALM for pension funds see for example Consigli and Dempster (1998), Dert (1995), Kouwenberg (2001), Hilli et al. (2003) and Dupacova and Polivka (2009). Even this technique is not without constraint. The major one is its relatively long solution time, which is also the reason why simulation technique is usually used in practice. Simulation technique will be used also in this paper and stress tests in order to evaluate the negative impact of unlikely events on a portfolio.

The paper is organized as follows. In section 2 the theoretical background is given, in section 3 the data are explained and empirical analysis, i.e. simulation is done. Methodological framework is included in section 3 as readers can better follow the steps of simulation. Discussion on results and recommendations are given in section 4. Finally, some concluding remarks are given in section 5.

2. Theoretical background

2.1 Investment and other risks pension funds are exposed to

Pension funds are generally exposed to the following financial risks: the sponsor's insolvency, insufficient funding of the plan because of improper technical and/or investment decisions, misappropriations by managers, or the risk of default by other financial entities involved in the provision of benefits (Laboul, 1998, 3). Here more attention is directed primarily toward investment risks. Regarding the investment risks, following key types should be taken into consideration: market risk or interest-rate risk, reinvestment risk, credit risk or default risk, marketability risk or liquidity risk and exchange rate risk (Fabozzi, 2000, 5).

Market risk or interest-rate risk is the risk of the debt security's price changing as a result of a change in the general level of interest rates or a change in the interest rates of specific securities. For an investor who potentially has to sell a security before its maturity date, an increase in interest rates will mean the realization of a capital loss. This kind of risk is sometimes also called the price risk (Reilly and Norton, 1999, 709). It is possible for an investor to manage interest rate risk with the proper accounting treatment of an investment. With respect to the financial reporting of assets, there are three possible methods: (1) market value, (2) amortized cost or historical cost, and (3) the lower of cost or market value (LCM). In the market value method, an investment is valued at its market value. In the amortized cost method, the value reflects an adjustment of the acquisition cost for debt securities purchased at a discount or premium from their maturity value (Fabozzi, 2000, 452). This method is sometimes referred to as "book value accounting." It is important to note that the real cash flow is the same regardless of the accounting treatment, but there can be substantial differences in financial statements using these three methods.

Reinvestment risk is the risk that the interest rate, at which interim cash flows can be reinvested (reinvestment rate), will fall. It is assumed that the cash flows received from a debt security are reinvested. The additional income from such a reinvestment, sometimes called interest-on-interest, depends on the prevailing interest-rate levels at the time of reinvestment, as well as on the reinvestment strategy. Reinvestment risk is greater for longer holding periods, as well as for debt securities with large, early, cash flows, such as high-coupon bonds. It should be noted that interest-rate risks and reinvestment risks have offsetting effects. That is, the interest-rate risk is the risk that interest rates will rise, thereby reducing security's price. In contrast, the reinvestment risk is the risk that interest rates will fall, thereby reducing additional revenue from interest-on-interest (Fabozzi, 2000, 6). With the precise matching of the duration of assets and liabilities, both risks can be offset.

Marketability risk, or liquidity risk, is defined as the uncertainty introduced by the secondary market for an investment. The investor expects to be able to convert the security into cash. The more difficult it is to make this conversion, the greater the liquidity risk (Reilly and Norton, 1999, 20). Some authors (Holmes, 2002, 84) relate liquidity risk more generally to the ability (or inability) to buy or sell securities at short notice at a fair or good price. The primary measure for the marketability or liquidity is the size of the spread between the bid price and the ask price as quoted by a dealer. The greater the dealer spread, the greater the liquidity risk (Fabozzi, 2000, 8). Some authors (Kendall, 1998, 83) similarly associate liquidity with price transparency, as the characteristic which enables a price to be easily identifiable and verified at any time.

Credit risk or default risk refers to the risk that the issuer of a security may default, and the exchange rate risk is associated with the value of foreign currency holdings caused by fluctuations in the currency markets.

Managing all types of risks as part of pension saving schemes demands prudent action by pension fund managers in order for them to meet their obligations. As governments are also interested in including as many employees in supplementary pension schemes as possible—the condition for this is also adequate protection of the insured individual—efforts to unify the pension fund market and investment legislation as well as introduce adequate risk measurement and management methods have been stepped up at the international level (i.e., the European Commission and the OECD) in the past decade. In this regard, the asset-liability management (ALM) of pension funds has also become increasingly important.

2.2 Asset-Liability-Management and alternative approaches in portfolio management

Both the asset and liability side of the pension fund balance sheet can contribute to the risk. On the asset side, risks can involve both asset-liability mismatching (where assets are not adequately structured to meet benefits when they become due) and return related risks (where insufficient income is generated to cover liabilities) (OECD, 2007, 3). An institutional investor is concerned with both the amount and timing of liabilities, because its assets must produce cash flow to meet any payments it has promised to make in a timely way.

Portfolio management, when considering assets and liabilities, offers the following alternative approaches to asset allocation: immunization, cash-flow matching, shortfall risk management and asset-liability management (Davis, 2001b, 5).

With immunization, the investor tries to stabilize the value of the investment at the end of the holding period, i.e. to hold an entirely riskless position. This is typically done, in light of interest rate risk, by appropriately adjusting the duration of the assets held to that of the liabilities. It necessitates a constant rebalancing of the portfolio, as well as the existence of assets that have a similar duration as liabilities. Portfolio immunization attempts to balance two components of interest rate risk, i.e. price risk and reinvestment risk. The price risk and the reinvestments caused by a change in interest rates have opposite effects on the ending-wealth position (Reilly and Norton, 1999, 709). An increase in interest rates will cause an ending price below expectations (if the bond is sold before maturity), but the reinvestment rate for interim cash flows will be above expectations. A decline in market interest rates will cause the reverse situation. In an immunized portfolio, whether market rates rise or fall, the value of the portfolio at the end of the time horizon should be close to its target value.

Using cash-flow matching strategy, pension fund managers attempt to immunize their balance sheets by matching the projected payments of pension benefits with cash-flow generated by investments (Laboul, 2006, 8). One way institutions can meet their liabilities is to construct a portfolio of assets – usually bonds – that generate cash flows matching the liability cash flows. Most institutions have rejected this approach because it generally eliminates the opportunity to generate excess returns. Instead, they have established a return target for their assets and then invest in a mix of stocks, bonds and other asset classes with the goal of meeting or beating that return target. With this approach, also known as the asset-driven approach, success is measured by how well the portfolio's investments perform versus market benchmarks (Pacific Investment Management Company, 2007, 1).

Shortfall risk management (or portfolio insurance) approaches put a particular stress on avoiding downward moves in the context of minimum solvency levels for pension funds. Shortfall risk sees the investor as maximizing the return of the portfolio subject to a ceiling on the probability of incurring a loss (e.g. by shifting from equities to bonds as the minimum desired value is approached). Through such means, the value of a portfolio may be prevented from falling below a given value, such as that defined by the value of a guaranteed return, defined benefits, or the minimum funding level of a pension fund (Davis, 2001b, 5).

Asset-Liability-Management (ALM) is an investment technique wherein the long term balance between assets and liabilities is maintained by the choice of a portfolio of assets with similar return, risk and duration characteristics to liabilities. The characteristics of an individual asset may differ from the liabilities, but at the portfolio level they should be matched (Davis, 2002, 6). It can be defined as the ongoing process of formulating, implementing, monitoring, and revising strategies related to assets and liabilities in an attempt to achieve financial objectives for a given set of risk tolerances and constraint (Hess, 2000, 6).

Liability-driven investing shifts the focus of asset allocation back to the real purpose of the assets, which is to meet liabilities. Thus, the defining element of a liability-driven investment approach is that portfolio performance is benchmarked against the institution's liabilities, rather than a benchmark with no direct relation to the liabilities. This is also how the strategy got its name. It is a flexible strategy, so portfolios can take many different forms depending on the institution's desire for excess returns and tolerance for risk (Pacific Investment Management Company, 2007, 1–2). In order to select the right investments we first have to know the characteristics of the liabilities.

No two institution's liabilities are the same, but virtually all liabilities have one characteristic in common: falling interest rates cause liabilities to increase, while rising rates cause liabilities to decline (the market value is the present value of future liabilities, discounted at proper interest rate; when interest rates rise,

the present (or the market) value falls).. Therefore, falling interest rates may be the single largest risk that institutions face in relation to their liabilities (Pacific Investment Management Company, 2007, 2). To hedge this risk, many institutions implementing a liability-driven approach turn to bonds. Bonds typically appreciate in value when interest rates decline, and therefore tend to be among the most common ingredients in a liability-driven portfolio. A second common characteristic is that most liabilities are long-term. The longer-term the liabilities are, the more sensitive they are to changes in interest rates. For example, a drop in interest rates will cause liabilities owed 30 years in the future to increase more than liabilities owed 10 years in the future. Similarly, longer-term bonds are also more sensitive to changes in interest rates. Therefore, another common element in liability-driven investing is that bonds held in the portfolio tend to be long-term bonds. Aside from the common use of long-term bonds, liability-driven portfolios can vary significantly from institution to institution. Some institutions, for example, can have liabilities that are sensitive to inflation and may employ inflation-linked bonds to hedge inflation risk. Other institutions may have a higher tolerance for volatility in the portfolio relative to liabilities, and may therefore employ alternative asset classes.

Pension fund investment and risk management practices, as previously mentioned, have often focused more on asset returns instead of the actual liability structure of the pension balance sheet. In part, this is because assets are more easily adjusted in the short term to meet changing circumstances than pension liabilities. In practice, many pension funds have pursued investment strategies measured relative to broad market indices (OECD, 2005, 36,71).

Several factors drive institutions towards liability-driven investing. The most significant of these factors is probably the fact that asset-driven strategies leave many pension plans and other institutions with deficits relative to their liabilities. As data shows, the pension funds' projected benefit obligation (PBO) funding declined globally in 2001 and 2002 due to a combination of falling interest rates and modest or negative equity returns. The euro zone PBO funding ratio went from more than 120% at the beginning of 2001 to less than 80%[1] in just two years (a PBO ratio of 80% means that a pension fund has 0.80 EUR of assets available to cover 1 EUR of projected pension liabilities). The U.S. and U.K. experienced a similar shift from surplus to deficit during the same period. The PBO ratio of Japanese pension funds was already below 60% in 2003 (Pacific Investment Management Company, 2007, 2-3).

Pension funding ratios have improved in subsequent years as the result of the combination of rising interest rates and higher equity market returns but even more as the result of sound management of pension funds assets as well as taking more into account the characteristics of pension fund liabilities. Those pension funds that did not adapt their investment strategy were hit again by the appearance of the global financial crisis in 2008.

As noted by Davis (2001a, 7) minimum funding levels and limits on overfunding provide tolerance limits to the variation of assets around the value of liabilities. If the assets are selected in such a way that their risk, return and duration characteristics match those of liabilities, there is a "liability immunizing portfolio". This protects the portfolio against risks of variation in interest rates, real earnings growth and inflation in pension liabilities.

In the following section our intention is therefore to demonstrate, using the simulation technique and actual data from two Slovenian pension funds and some hypothetical one, that by precisely matching the investments' characteristics to the characteristics of the pension fund's liabilities and with the implementation of a proper policy of risk measurement and management, excessive legislative restrictions for investments are no longer necessary.

3 The data and results of the analysis

A practical example of a pension fund investment policy taking into account the requirement to achieve the minimum guaranteed return and managing risk using the asset-liability management strategy is shown here. Because pension fund managers in Slovenia usually do not disclose their data to the public, a combination of accessible data from two Slovenian pension funds is used; other data are hypothetical or invented. The number and structure of insured individuals is taken from the Capital Mutual Pension Fund (Kapitalski vzajemni pokojninski sklad), managed by *Kapitalska druzba* (2008 data), and the data on the investment and liabilities structure is taken from the insurance fund of the pension investment company *Moja nalozba* (2008 data).

The effect of the risk of abnormal events on the portfolio will be verified using stress tests (i.e., sensitivity and scenario tests). The majority of investment risks that the manager is exposed to while managing the portfolio will be defined; in addition, suitable methods of measuring these risks will be identified and suggestions for their management will be presented.

The process of asset-liability management will be based on a synthetic defined contribution (DC) pension fund with 100 million EUR of assets and 30,000 pension plan members. Assets and liabilities will be matched through risk, return and duration characteristics. As previously indicated, asset-liability management

helps the manager hedge, or at least limit, the negative impact of financial risks that they are exposed to when managing a pension fund.

In the first step, we estimated the average duration of a pension fund's liabilities while considering the pension plan members' structure. A more accurate calculation of duration can be prepared by actuaries, based on different mathematical assumptions: members' age and gender structure, mortality tables, projected returns, selected discount rates, pension benefits promised, the probability of exiting pension insurance or switching to another pension plan, etc.

To simplify the calculation of the average duration, the following assumptions can be stated:

- the number of pension plan members structured by age and gender is sufficient to calculate the duration of liabilities (other parameters can be disregarded),
- the distribution of pension plan members within an individual age group is even,
- retired pension plan members will receive pension benefits in a lump-sum (instead of a monthly annuity).

Average age of pension plan members can be calculated using the following equation:

$$\overline{AGE} = \frac{1}{A} * \sum_{i=1}^{7} (age_i * a_i), \quad (1)$$

where: $\overline{AGE}$ *- average age of pension plan members (in years), A - sum of pension fund's assets (in EUR),* age_i *- average age at group i (in years),* a_i *- assets at group i (in EUR).*

Table 1: Age and gender distribution of pension plan members

Age group (in years)	Average (in years)	Female members		Male members	
		Number	Assets (in EUR)	Number	Assets (in EUR)
From 11 to 20	15	1	778.54	24	11,973.75
From 21 to 30	25	915	1,536,030.42	1,973	3,656,188.81
From 31 to 40	35	3,392	10,276,903.36	5,955	21,506,814.48
From 41 to 50	45	4,042	11,979,749.27	7,355	27,432,604.87
From 51 to 60	55	1,918	6,361,231.16	4,145	15,955,766.35
From 61 to 70	65	28	92,572.18	251	1,167,168.93
From 71 to 80	75	0	0.00	1	22,217.88
	Sum	10.296	30,247,264.93	19,704	69,752,735.07

Data source: Kapitalska druzba (2008)

Using the information about the pension plan members' age, gender and the sum of assets saved, we were able to calculate that the average plan member will retire and exit the pension plan after 21.13 years.

Table 2: Calculation of average liabilities duration

	Females	Males	Average
Average age	42.75 years	43.49 years	
Retirement age	63.00 years	65.00 years	
Duration of liabilities	20.25 years	21.51 years	21.13 years

Source: author's own calculation

If we are to match the duration of assets to duration of pension liabilities, we have to select investments with similar interest rate sensitivity as that of liabilities. Most of the funds were invested in long-term government and corporate bonds. It is also possible to invest a part of assets in shares and mutual funds, as they are considered to have no maturity. By precisely matching the duration of assets to the duration of liabilities, the interest-rate risk and reinvestment risk get perfectly hedged. The manager of the fund can also afford a smaller deviation from a perfect match with the intent of earning higher returns. The pension fund would then be more vulnerable to financial risks.

The second step has been to match assets and liabilities from the required return point of view. The pension fund's liabilities can be divided into three components:

- net premiums received (sum of gross premiums received, net of the front-end fee),
- guaranteed return earned (minimum guaranteed return added to net premiums received, as promised by the manager in the pension fund's plan),

- a return above the guarantee or provisions (the positive difference between actual returns earned and guaranteed returns promised).

We supposed for our pension fund that the minimum guaranteed return promised by the pension plan is 60% of the average annual return on Slovenian government securities with a term to maturity above one year. For the year 2008, this was 2.37%. The management fee is 1.20% p.a., deducted from the pension fund's return. The minimum guaranteed return is added only to net premiums received, increased by the guaranteed return already earned. The manager of the pension fund does not promise a guaranteed return on provisions (return in excess of the guarantee). Should a pension fund's assets fall below the guaranteed value (sum of net premiums received and the guaranteed return already earned), the manager is not allowed to charge his management fee. Until the provisions are formed again, the manager's goal should be to earn a return, above the guaranteed return, for at least the amount of the management fee.

Table 3: The pension fund's liabilities structure and the required rate of return

Liability	Min.guaranteed return	Management fee	Required rate of return
Provisions	–	–	–
Guaranteed return	2.37%	1.20%	3.57%
Net premiums received	2.37%	1.20%	3.57%

Source: author's own calculation

Before we select the investments that are to be matched to our pension liabilities, we have to structure the fund's liabilities from a risk point of view. Let us keep our liabilities structured to net premium received, a guaranteed return and provisions formed. Asset-liability management can also be called a surplus management (see Fabozzi, 2000, 450). It is actually a tradeoff between managing shortfall risk and taking an acceptable risk to earn a sufficient return on the assets invested.

Table 4: Pension fund's liabilities structure and risk

Liability	Share	Risk allowed
Provisions	7.50%	High
Guaranteed return	6.50%	Moderate
Net premiums received	86.00%	Low

Source: author's own calculation

For every gross premium received, only front-end fees can be charged by the manager. The net premium will then fall into the net premiums received category. As this category may never drop below the sum of all premiums paid to the fund, the manager can only afford a minimum risk. At the end of every month, the guaranteed return is calculated on net premiums received, as a percentage, as promised in the pension plan. If the actual return falls below the guaranteed return, provisions may be used by the manager of the fund to cover the difference. It is possible that the actual return falls below 0 within a certain period. For the amount of the guaranteed return earned, the manager is allowed to take moderate risks. Because there is no guaranteed return promised on a pension fund's provisions, the manager can be allowed to expose this share of the pension fund's liabilities to maximum risk. But he must keep in mind not to let the fund's provisions fall below 0. This would be the case if the actual return would fall below the guaranteed return, and the provisions would not be sufficient to cover the deficit. The manager would then have to form additional provisions from his own capital.

To estimate how unfavourable events affect a pension fund's capitalization, stress tests can be performed. In our case, we used two fundamental techniques. To study the impact of exchange rate risk and stock exchange decline on a pension fund's portfolio return, sensitivity tests were used. Since the impact of interest-rate risk is more difficult to comprehend, a scenario test was used with the minimum guaranteed return as the key financial driver. In the following tables, we have summarized the characteristics of the pension fund's liabilities, as defined in the beginning of this chapter. The characteristics of a pension fund's assets are hypothetical and not precisely matched to liabilities. Stress tests help us understand how a mismatch between assets and liabilities can affect the return. To simplify the case we assumed that there are no new premiums paid to the pension fund during the observation period. In our asset-liability management case, currency risk, price risk and interest-rate risk were put into focus.

Table 5.1: Currency structure of assets and liabilities – assets side

Assets	Value	Share
Other currencies (USD, GBP)	7,500,000.00	7.50%
Local currency (EUR)	92,500,000.00	92.50%

Total	100,000,000.00	100.00%

Source: author's own calculation

Table 5.2: Currency structure of assets and liabilities – liabilities side

Liabilities	Value	Share
Technical provisions	7,500,000.00	7.50%
Guaranteed return	6,500,000.00	6.50%
Net premiums received	86,000,000.00	86.00%
Total	100,000,000.00	100.00%

Source: author's own calculation

Table 6.1: Risk, return and duration structure of assets and liabilities – assets side

Assets	Duration	Return	Share	Risk
Shares	–	–	7.50%	High
Mutual funds	–	–	6.50%	Moderate
Liquidity reserve	0.01	3.90%	6.00%	Low
Other debt securities	3.50	7.40%	10.00%	
Bonds – corporate	5.50	5.30%	20.00%	
Bonds – government	6.00	4.50%	50.00%	
Average	5.18	4.98%	100.00%	

Source: author's own calculation

Table 6.2: Risk, return and duration structure of assets and liabilities – liabilities side

Liabilities	Return	Duration	Share	Risk
Technical provisions	–		7.50%	High
Guaranteed return	2.37%		6.50%	Moderate
Net premiums received	2.37%		86.00%	Low
Average	2.37%	21.13	100.00%	

Source: author's own calculation

Table 7: Debt securities structure with duration and return ratios

Investment	Average maturity	Average yield	Average duration	Modified duration
Liquidity reserve	0.01	3.90%	0.01	0.01
Other debt securities	3.50	7.40%	3.15	2.93
Bonds – corporate	5.50	5.30%	4.83	4.59
Bonds – government	6.00	4.50%	5.37	5.14
Average	5.18	4.98%	4.61	4.40

Source: author's own calculation

Stress Test I.: a -10% decline of a basket of foreign currencies against the EUR

Euro-denominated investments represent 92.5% of a pension fund's assets. The other 7.5% is invested into securities, denominated in currencies, like USD, GBP or JPY. Our debt securities, which represent the entire euro portfolio, have an average annual return of 4.98%.

Table 8: The impact of a decline of foreign currencies on the portfolio (in euros)

Assets	Value (t)	Return (in %)	Value (t + 1)
Other currencies (USD, GBP)	7,500,000.00	–10.00%	6,750,000.00
Local currency (EUR)	92,500,000.00	4.98%	97,107,790.70
Total	100,000,000.00	3.86%	103,857,790.70

Source: author's own calculation

As shown in Table 8, a -10% decline of equity investments, denominated in other currencies, would lead to a -750,000.00 EUR loss. On the other hand, debt securities, denominated in euros, would yield 4,607,790.70 EUR of positive return. Together, the pension fund's assets would rise by 3,857,790.70 EUR or 3.86%. As calculated in Table 3, the required return on a pension fund's liabilities is 3.57%. With the return actually earned, the pension fund's manager is able to cover the minimum guaranteed return and charge a 1.20% management fee. An additional return of 0.29% (3.86% - 3.57%) would increase the fund's technical provisions.

Since the share of the fund's investments in foreign currencies is small, the exchange rate risk is not that important. The manager can afford small currency mismatches between assets and liabilities to increase the diversification of the fund's assets, and therefore decrease the price risk, which represents a much greater threat.

Stress Test II.: a -20% decline in the stock market

Our pension fund is exposed to equity directly and indirectly with the investments in mutual funds. Because the mutual funds can also diversify their assets in the investment with less risk (bonds, treasury bills or bank deposits), we assumed that their decline could only reach 75% of the stock market decline. We also assumed that the volatility of the stock market had no effect on the bond market. Our focus remained on the impact of the stock market decline with other factors constant.

Table 9: The impact of stock market decline on the portfolio (in EUR)

Assets	Value (t)	Return (in %)	Value (t + 1)
Stocks	7,500,000.00	–20.00%	6,000,000.00
Mutual funds	6,500,000.00	–15.00%	5,525,000.00
Liquidity reserve	6,000,000.00	3.90%	6,234,000.00
Other debt securities	10,000,000.00	7.40%	10,740,000.00
Bonds – corporate	20,000,000.00	5.30%	21,060,000.00
Bonds – government	50,000,000.00	4.50%	52,250,000.00
Total	100,000,000.00	1.81%	101,809,000.00

Source: author's own calculation

A -20% decline in stock prices would represent a capital loss of -1,500,000.00 EUR, and a -15% (20% × 0.75) decline in mutual funds would mean another -975,000.00 EUR negative return to the pension fund. Other investments would add 4,284,000.00 EUR of positive return. In total, the pension fund's assets would increase by 1,809,000.00 EUR or 1.81%.

Table 10: Impact of stock market decline on a fund's liabilities (in EUR)

Liabilities	Value (t)	Return (in %)	Value (t + 1)
Technical provisions	7,500,000.00	–	5,905,896.00
Guaranteed return	6,500,000.00	2.37%	8,692,250.00
Net premiums received	86,000,000.00	2.37%	86,000,000.00
Management fee	0.00	1.20%	1,210,854.00
Total	100,000,000.00	1.81%	101,809,000.00
Guaranteed value of the fund	92,500,000.00	2.37%	94,692,250.00

Source: author's own calculation

The guaranteed value of the fund is the sum of net premiums received and the guaranteed returns already earned. At the end of the year, the pension fund's manager must be able to increase the guaranteed value of the fund by at least the guaranteed return, which is 2.37%. As the net premiums received can only be increased by new premiums paid to the fund, the sum will be added only to the guaranteed returns already earned. Because the pension fund's assets are still above the guaranteed value, the manager is allowed to charge the fund for the management fee, which is deducted from technical provisions. The management fee is calculated as 1.20% of the average pension fund's value. Pension fund's net return, following the deduction of the management fee, is 0.61% (1.81% - 1.20%).

Should the negative trend in the stock market continue and the manager would already decrease the technical provisions to 0, the difference between the actual return and the minimum guaranteed return would have to be covered by his own capital. He would also lose the right to charge his management fee. Using "goal seek" in our model, it is possible to calculate the maximum percentage of the stock market decline, where the manager would still be entitled to charge the management fee without decreasing technical provisions or the percentage where he would lose all technical provisions.

Table 11: Impact of stock market decline on management fee and provisions (in EUR)

Scenario		Fund's value (t + 1)	Tech. provisions (t + 1)	Management fee (t + 1)
% decrease:	–7.04%	103,412,726.36	7,500,000.00	1,220,476.36
% decrease:	–20.00%	101,809,000.00	5,905,896.00	1,210,854.00

% decrease:	–77.51%	94,692,250.00	0.00	0.00

Source: author's own calculation

If the stock market declined by -7.04% (and therefore mutual funds by -5.28%), the return on other investments would still be sufficient to cover both the guaranteed return and the management fee. Technical provisions would remain intact. On the contrary, in the case of a -77.51% decline in stock prices (and a -58.13% decline in mutual funds), the manager would lose all technical provisions and earn no management fee. The pension fund's value at the end of the year would only be equal to the guaranteed value of the fund. Any further decline in the pension fund's investments would require the manager to cover the loss from his own capital. To avoid such a risk, he would have to adjust the structure of investments to a new structure of liabilities. The share of equity investments should be reduced to match the level of technical provisions. If a pension fund's technical provisions are reduced to 0, it would be prudent to reduce equity investments to 0 as well. Their share can be increased again, when the actual returns exceed the guaranteed return.

Stress Test III.: **A** 100-Basis Point Increase Across the Yield Curve

The most important risk that the pension fund manager is exposed to is interest rate risk. We tested the scenario of an increase across the yield curve by 100 basis points. At the same time, we assumed that the yield curve was flat and that there was a parallel shift upward on all durations at the beginning of the observation. Until the end of the year, the yield curve remains unchanged. The influence of the stock market was disregarded. We used the information about debt security diversification, duration and return ratios from Table 7. But before we discuss the stress test results, let us explain how the ratios were calculated and how to interpret them. The price (market value) of a bond at a new required return was calculated using the following equation (Reilly and Norton, 1999, 567):

$$P = \sum_{t=1}^{n} \frac{C_t}{(1+y)^t} + \frac{M}{(1+y)^n}, \tag{2}$$

where: *P - price of a bond, y - interest rate (required annual yield),* C_t *- coupon payment in year t, M - maturity value, n - number of years to maturity (term to maturity).*

As shown by the equation, the price of a bond equals the present value of the cash flows, discounted at the required annual yield. The price of a bond changes inversely with the change in the required yield. As the required yield increases (decreases), the present value of the cash flows decreases (increases). However, the relationship is not linear. For a given change in basis points, the percentage price increase is greater than the percentage price decrease (Fabozzi, 2000, 23).

The volatility of a bond's price is dependent on its maturity. With all other factors remaining constant, the longer the maturity of a bond, the greater the price volatility resulting from a change in market yields.

The duration of a bond is a more appropriate measure for time characteristics than the term to maturity, because it considers both the repayment of capital at maturity, and the size and timing of coupon payments prior to final maturity. Duration is defined as the weighted average time to full recovery of principal and interest payments (Reilly and Norton, 1999, 587–588):

$$Dur\ (in\ years) = \frac{\sum_{t=1}^{n} \frac{t \times C_t}{(1+y)^t} + \frac{n \times M}{(1+y)^n}}{P}, \tag{3}$$

where: *Dur - duration,* C_t *- interest payment that occurs in period t, M - maturity value, P - bond price, t - time period in which the payment occurs (t = 1,…, n), n - number of time periods to maturity, y - yield to maturity.*

Modified duration is a measure of the sensitivity of a bond's price to interest-rate changes, assuming that the expected cash flow does not change with interest rates. It can be used as a measure of interest-rate risks. The modified duration shows the approximated change of a bond's, or a bond portfolio's, market value when the interest rates change. It can be calculated using the equation (Fabozzi, 2000, 62):

$$Dur_{mod} = \frac{Dur}{(1+y)}, \tag{4}$$

where: Dur_{mod} *- modified duration, Dur - duration, y - yield to maturity.*

An investor who purchases a bond can expect to receive a return from one or more of these sources: the periodic coupon interest payments made by the issuer, any capital gains (or capital losses) when the bond either matures, is called, or is sold, and interest income generated from reinvestment of the periodic cash flows (interest-on-interest). If an investor has received coupon payments prior to the bond's maturity, they should be reinvested in order to earn additional income. Interest-on-interest can be calculated using the equation for the

future value of an ordinary annuity (an ordinary annuity involves the (re)investment of equal sums at equal intervals at an equal interest rate) (Fabozzi, 2000, 14, 44):

$$P_n = A\left[\frac{(1+r)^n - 1}{r}\right], \quad (5)$$

where: P_n - *interest on interest, A - amount of the annuity, r - rate of return, n - number of years to maturity.*

The reason we are using this equation, is that we are reinvesting fixed periodical coupon payments at a fixed rate of return. The future value can then be calculated using the expected reinvestment rate of return. The data calculated from these equations are summarized in Table 12 and 13. The key financial driver for stress testing is the minimum guaranteed return that affects both sides of a pension fund's balance sheet.

Table 12: Investment portfolio at the beginning of the investment horizon (in EUR)

Assets	Value (t)	Coupon (in %)	New yield	Coupon payments
Shares	7,500,000.00	–	–	–
Mutual funds	6,500,000.00	–	–	–
Liquidity reserve	6,000,000.00	3.90%	4.90%	–
Other debt securities	10,000,000.00	7.40%	8.40%	semiannual
Bonds – corporate	20,000,000.00	5.30%	6.30%	semiannual
Bonds – government	50,000,000.00	4.50%	5.50%	annual
Total	100,000,000.00	4.98%	5.98%	

Source: author's own calculation

The rise of interest rates would increase the required yield of our debt securities by 100 basis points. Each group of investments can be considered as a single debt security with a fixed (average) coupon and annual or semiannual coupon payments.

Table 13: The impact of an interest rate increase on investment portfolio (in EUR)

Assets	Coupon payment	Interest-on-interest	Market value	Sum
Shares	–	–	–	7.500.000,00
Mutual funds	–	–	–	6.500.000,00
Liquidity reserve	234.000,00	0,00	6.000.000,00	6.234.000,00
Other debt securities	740.000,00	15.540,00	9.702.000,00	10.457.540,00
Bonds – corporate	1.060.000,00	16.695,00	19.082.000,00	20.158.695,00
Bonds – government	2.250.000,00	0,00	47.500.000,00	49.750.000,00
Total	4.284.000,00	32.235,00	82.284.000,00	100.600.235,00
Guaranteed value				95.154.750,00

Source: author's own calculation

The parallel shift in the yield curve has no effect on coupon payments (as coupons are fixed), but it does alter the returns from interest on interest. The coupons from corporate bonds and other debt securities, maturing after the first 6 months (semi-annually), have already been reinvested at a higher reinvestment rate. The coupons from government bonds that mature at the end of the year (annually) have not yet been reinvested. Because the required yield has increased, the market value of all debt securities has decreased. If the modified duration of a pension fund's assets was perfectly matched to the modified duration of a pension fund's liabilities, the change in interest on interest would be offset by the change in price. Because this is not the case, the reinvestment risk and interest rate risk are not perfectly hedged. The pension fund's total annual return is therefore only 660,235 EUR or 0.66%.

The minimum guaranteed return was calculated as the average yield to maturity of all Slovenian government bonds, with a term to maturity of 1 year or more. As the average yield to maturity of government bonds increases, the minimum guaranteed return increases. However, because the guaranteed return is calculated every 6 months (and remains fixed for the following 6 months), it will only affect the required rate of return on the pension fund's liabilities in the second half of the year. On an annual level, the minimum guaranteed return will therefore increase only by half, i.e. 50 basis points to 2.87%. The new guaranteed value of the fund would be 95,154,750.00 EUR**.**

Table 14: Impact of an upward shift of the yield curve on pension liabilities (in EUR)

Liabilities	Value	Return	Value

	(t)	(in %)	(t + 1)
Technical provisions	7,500,000.00	–	4,241,883.59
Guaranteed return earned	6,500,000.00	2.87%	9,154,750.00
Net premiums received	86,000,000.00	2.87%	86,000,000.00
Management fee	0.00	1.20%	1,203,601.41
Total	100,000,000.00	0.60%	100,600,235.00
Guaranteed Value of the Fund	92,500,000.00	2.87%	95,154,750.00

Source: author's own calculation

Thus higher guaranteed return must be added on top of the pension fund's guaranteed value. Since the actual return is below the minimum guaranteed return, the difference must be covered by technical provisions. The management fee will also be deducted from technical provisions. Their total reduction is greater than 3 million EUR. If we were testing the impact of a stock market decline, the reduction of technical provisions would be the same at a -33.53% decline in stock prices and a -25.15% decline in mutual funds. Because debt securities represent most of the pension fund's portfolio, interest rate risk has the largest effect on the capitalization of the pension fund. Interest rate risk can be managed with the more accurate (modified) duration matching of assets and liabilities. It is also possible to hedge interest rate risk using the amortized cost valuation method.

For the selected pension fund it has been estimated that the average duration of liabilities is 21.13 years. In order to determine the liabilities' sensitivity to changes in the general level of interest rates, the modified duration of liabilities also has to be calculated. The pension fund manager has to attribute at least the minimum guaranteed return of 2.37% to liabilities every year. At the same time, the actual return must also suffice to cover the management fee of 1.20%. The required return on liabilities thus amounts to a total of 3.57%. Based on these data, the following can be calculated:

future value of liabilities = 100,000,000.00 * $(1 + 3.57\ \%)^{21.13}$ = 209,842,725 EUR
modified duration of liabilities = 21.13 / (1 + 3.75%) = 20.40

The estimated modified duration of liabilities thus equals 20.40. If the manager seeks to eliminate interest-rate risk and reinvestment risk at the same time, he or she has to invest the pension fund's assets in investments whose modified duration matches the liabilities. In this case, the manager could purchase a government bond with a maturity of 37 years and a 3.57% rate of return. The modified duration of this bond equals 20.36, which almost completely matches the liabilities.

Table 15: The basic data on the selected government bond

Date of issue	Maturity date	Return	Value (in EUR)	Duration	Average duration
1 Jan 2008	1 Jan 2045	3.57%	100,000,000.00	21.09	20.36

Source: author's own calculation

The bond will be held for 21.13 years, which corresponds to the duration of our liabilities, and will then be sold at the market price valid at that time. In addition to interest payments, the total return of the bond is thus also affected by changes in the market price (interest-rate risk) and the return generated from the reinvestment of the interest payments already received (reinvestment risk). The estimate takes into account the presumption that the required return changes immediately after the purchase of the government bond and remains the same until it is sold. In addition, it is also presumed that the yield curve is flat and that it shifts upward or downward evenly for all maturities when the required return changes.

Table 16: Total return of the bond at various levels of required return (in EUR)

New return	Coupon payments	Interest on interes	Market value	Sum	The difference
2.07 %	75,434,100	18,000,110	120,250,000	213,684,210	3,841,485
2.57 %	75,434,100	23,117,987	112,980,000	211,532,087	1,689,362
3.07 %	75,434,100	28,579,426	106,250,000	210,263.526	420,801
3.57 %	75,434,100	34,408,625	100,000,000	209.842,725	0
4.07 %	75,434,100	40,631,483	94,200,000	210,265,583	422,858
4.57 %	75,434,100	47,275,713	88,820,000	211,529,813	1,687,088
5.07 %	75,434,100	54,370,967	83,820,000	213,625,067	3,782,342

Source: author's own calculation

The table shows that if the required return remains unchanged (i.e., 3.57%), the manager will generate a total return of EUR 209,842,725 from the bond, which is exactly the same as the estimated sum of future

liabilities. Any change in the general level of interest rates does not affect the amount of interest payments; however, interest on interest does change. If the required return is reduced, the manager will have to reinvest the interest already paid in new investments following the new, lower return. At the same time, due to the lower required return the manager will be able to sell the bond at a higher market price. The generated capital profit more than covers the loss of interest. The opposite applies when the interest rate increases. Due to reinvesting paid-out interest in more profitable investments, the income from interest on interest increases. However, with higher required return the bond has to be sold below its nominal value. Nonetheless, the additional income from interest more than covers the capital loss generated by selling the bond.

4. Discussion

To sum up, a great advantage of this strategy is that a change in the general level of interest rates never has a negative impact on the pension fund return. In fact, if the required return is changed significantly in either the positive or negative direction, the manager can generate a greater surplus of the actual return over the required return. The risk of a decrease in the investment market value due to an increase in the general level of interest rates (interest rate risk) and the risk of a decrease in the income from interest on interest due to a decrease in the general level of interest rates (reinvestment risk) cancel each another out. With precise matching of the duration of assets with the duration of liabilities, the actual pension fund return is never lower than the required return.

On the other hand, there are also some disadvantages to this strategy. In the long term, the actual return will never significantly exceed the required return. That is, the strategy limits the return that could be generated by investing in bonds with a duration that does not equal the duration of liabilities. In case of low interest rates, the manager can intentionally invest in short-term bonds and thus expose the pension fund to reinvestment risk. Anticipating that the interest rates will rise in the future, the manager will be able to reinvest the matured bonds and principals in more profitable investments, and thus boost the total return of the portfolio.

A further weakness of this strategy is also the fact that it demands constant adjustment of assets and liabilities. In our case, a one-off change in the general level of interest rates was presupposed, but in real life market interest rates change constantly. Changes in the required return cause changes in the duration of the portfolio. At the same time, the closer to the maturity date, the shorter the investment durations become. Due to these two factors the portfolio has to be constantly adjusted to the pension fund's liabilities, which incurs transaction costs.

In matching the duration of assets and liabilities one should also not forget the model of estimating the minimum guaranteed return. With greater changes in the general level of interest rates, the amount of guaranteed return will also change. The manager will have to find new investments that will correspond to the changed characteristics of the liabilities. Using the estimation method, a manager in Slovenia can do this in six months time. However, if the manager does not take action, due to the mismatch he or she will expose the fund's assets to interest-rate risk or reinvestment risk with all its positive and negative consequences.

It is possible for the manager of the fund to completely eliminate currency risk by only selecting investments that are denominated in the same currency as the pension liabilities are denominated in. Other investments would then only be included if they increase portfolio diversification and decrease price risk. Because there is no guaranteed return on technical provisions, this portion of the liabilities can be matched with equity investments that have a higher price risk. As long as the actual return is below the minimum guaranteed return, the manager will be forced to reduce the fund's exposure to riskier investments. As soon as the actual return exceeds the guaranteed return, technical provisions will rise and the manager will be able to increase the share of equity investments. With an accurate (modified) duration matching of assets and liabilities, the interest rate risk and reinvestment risk can be completely offset. Short-term interest rate volatility can be hedged with the amortized cost valuation method. The manager can also use the market value valuation, adjusting the duration of investments to expected interest rate movements. If interest rates are expected to rise, the manager can shorten the average duration of the portfolio. The manager will increase reinvestment risk and reduce the price risk of the debt securities portfolio. Returns (or interest on interest) from the reinvestment of matured bonds and coupon payments will more than offset the loss of the portfolio's market value. If interest rates are expected to fall, the manager will buy bonds with a longer duration than the duration of pension liabilities. This will increase the portfolio's price risk. Because the required returns will fall, bond prices will rise. The capital gain from the increased portfolio's market value will more than offset the reduced income from interest on interest.

As the interest rates rise or fall, the minimum guaranteed return changes. The manager can avoid the risk of underperforming the guaranteed return with partial portfolio indexation, where the guaranteed return is considered as a benchmark. He can invest a part of the pension fund's assets into reference government bonds, used in the minimum guaranteed return calculation. Additional returns can be made investing in bonds of similar duration and credit risk, but with a higher yield to maturity. Allocating entire net premiums received in government bonds and prime corporate bonds will significantly reduce a pension fund's credit risk exposure. More risk can be avoided by investing the guaranteed return already earned in mutual funds with a properly diversified investment policy, with no significant restrictions to an individual industry or region. Technical

provisions can be matched with investments in blue chip shares of companies with sound financial statements and high market capitalization. A fund's assets should be allocated only in those investments with a high turnover ratio (shares) or a market maker (bonds). For pension plan members at the age of 55 or above, the liquidity reserve should be formed from investments in bank deposits and short-term debt securities (treasury bills, certificates of deposit, commercial papers). In this way, the liquidity risk and biometric risks will be much easier to hedge. A pension fund's assets should also be managed in such a way that they retain their purchasing power. The risk of real asset value depreciation can be hedged with investments in bonds that are linked to inflation. This will help the manager earn a real rate of return regardless of the actual inflation rate in the future. During the asset allocation process, the regulative and pension plan investment restriction should always be obeyed.

5 Conclusions

Asset-liability matching considerably eases the portfolio and risk management of a pension fund. Using the information about plan members by age and gender and the structure of pension liabilities with the required rate of return, it is possible for the manager to determine the average duration, required rate of return and proper level of risk that would be suitable for liabilities. This information should help the manager select investments that are best fitted to the above-mentioned criteria. Once the investments that are matched to liabilities by duration, return and risk are allocated, a portfolio sensitivity analysis can be run. It helps the manager to define the risks that pose the greatest threat to a pension fund and take additional measures to protect the investments of pension plan members from financial market shocks. With such a policy, it is possible to limit some of the financial risks, while others can even be hedged entirely**.**

We intended to demonstrate in our paper, using empirical data from two Slovenian pension funds and some hypothetical one, that after the pension fund's manager is able to implement the proper method of risk measurement and management, excessive regulative restrictions on investments are no longer needed. Moreover, governments should never impose investment restrictions that would limit pension funds to the domestic market (i.e. restricting investments in foreign capital markets), forbid investments in shares or mutual funds or set a minimum limit of government securities in portfolio. Some restrictions can even hinder portfolio diversification of the pension fund's assets and therefore make risk management more difficult. Therefore, governments should instead establish proper supervision over pension fund managers and keep today's active population appropriately informed about expected future pension benefits.

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