

INVESTMENT STRATEGIES FOR BOND PORTFOLIO OPTIMIZATION¹

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Investičné stratégie zamerané na optimalizáciu dlhopisového portfólia

***Abstract:** The debt crisis in Europe has contributed not only to the growth in risk when investing on the bond markets but also to the change of opinions on government bonds as a risk-free investment. The failure of some Eurozone countries to pay off the government bonds has nearly led to bankruptcy of some financial institutions and to their bail out by the state. Today, the asset managers mainly from financial institutions bear the responsibility for the effective business of the institution. Their effort is to model bond portfolios with the aim to bring the best effect also for the clients and at the same time to lower the risk. When constructing portfolios, these asset managers use various strategies, which were applied also in the past. The aim of this working paper is to characterize individual strategies and describe some of them in more details by using relevant methodological tools.*

***Keywords:** bonds, risks, portfolio management, bonds portfolio strategies, passive strategies, active strategies.*

JEL Classification: G 11, G 12

1 Introduction

Portfolio modeling nowadays relates to all parts of financial markets. It relates to commodities, bond and shares markets. Each of these markets has its specifics which the portfolio manager or investor has to take into account during modeling and execution of investment strategies. The aim of this

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working paper is to describe the techniques of bond portfolio modeling based on individual financial attributes and to analyze the most frequently used strategies *Cash Flow Matching* and *Bond Portfolio Immunization* in detail.

The issue of the bond market is currently in the centre of attention not only of financial theory but also of business practice. In the centre of attention, there are analyses of basic attributes of investing on this market: *price, yield, duration of investment – maturity and risks*. Each bond portfolio manager has to take into account these attributes and has to adjust the investment strategy to the current market situation.

2 Literature Review

The most prominent author in this area is Frank J. Fabozzi, who deals with this issue in various works. From our perspective the most important publication is *Bond Markets, Analysis and Strategies* (2009), where the author analyzes not only the impact of various risks on the bond market but also different strategies for modeling individual portfolios based on the requirements of asset managers or investors. The issue of bond market risks and their evaluation based on the portfolio management is also covered by Amswat Damodaran (2014), who highlights the importance of risks quantification.

In the works of the famous economist Moorad Choudhry (2014) we can find the issue of bond pricing and hedging and based on this also some investment strategies on this kind of market.

The bond market is also in the centre of attention of the Czech authors such as Josef Jílek (2009), Petr Musílek (2002) or Jitka Veselá (2007), who mostly deal with the issue of investing on the bond market based on evaluation of particular risks. The bond pricing based on investment risks of this market is covered by the Slovak authors Božena Hrvol'ová (2015) and Peter Arendáš (2013), who deals with particular investment strategies in the commodity markets, which bear a resemblance to the creation of bond portfolios.

In publications portfolio can be defined as a mix of various investments. It is created in order to minimize risks connected with investing and, at the same time, to find the best ratio between revenues and risk.

3 Methodology

Bond portfolio management is a specific type of portfolio management, whose features are based on the properties of bonds as fixed-income financial instruments. Bond portfolio management is based on managing fixed income investments in pursuit of a particular objective, usually maximizing return on investment. This is achieved primarily by minimizing risk and managing interest rates.

This type of portfolio management has to take into account risks connected with bonds. Fabozzi, F., J., Martellini, L., Priaulet, P. (2006) defined and created a comprehensible table of the following bond risks.

Table 1

Summary of Risk Factors of Bonds

Risk Factors	Risk Factor Measurement	Market Changes that Affect Risk Faktor
Market Risk	Duration	Change in Yields Levels Parallel Change in Yield Curve
Yield Curve	Convexity/Distribution of Key Rate Durations (Bullet, Barbell, Ladder, at al.)	Change in Slope and Shape of and Shape of Yield Curve
Exposure to Market Volatility	Convexity • Negatively convex assets (e.g. callables/portfolios are adversely affected by volatility) • Positively convex assets (e.g., putables/portfolios are benefited by volatility)	Market Volatility • Historical based on past actual prices or yields • Expected, as indicated by implied volatility of options
Sector Allocation	Percent allocation to each macrosector, microsector, and security and the option-adjust spread (OAS) of each	Change in option adjusted spreads (OAS) of macrosectors, microsectors, and individual securities
Credit Risk	Average credit rating of portfolio and its sectors	Changes in credit spreads (e.g., spread between Treasuries versus AAA corporates versus BBB corporates), also specific company rating changes

Liquidity Risk	<p>Typically measured by the bid/ask price spread—that is, the difference between the price at which a security can be bought and sold at a point in time</p> <p>The liquidity of a security refers to both its marketability (the time it takes to sell a security and its market price, e.g., a registered corporate bond takes less time to sell than a private placement) and the stability of the market price</p>	<p>Different securities have inherently different liquidity (e.g., Treasuries are more liquid than corporates)</p> <p>The liquidity of all securities, particularly riskier securities, decreases during periods of market turmoil.</p>
Exchange Rate Risk	Change in the exchange rate between the U.S. dollar and the currency in which the security is denominated (e.g. yen or euro)	Volatility in the exchange rate increases the risk of the security. For a U.S. investor, a strengthening of the other currency (weakening of the U.S. dollar) will be beneficial to a U.S. investor) who holds a security denominated in the other currency

Source: [1].

Each management of a bond portfolio has to take into account and quantify all the risks stated in the table.

Also in the construction of price of a fixed coupon bond there are first two risks stated in the table. If we define the calculation of fixed coupon bond price as follows:

$$P = \frac{C}{1+y} + \frac{C}{(1+y)^2} + \frac{C}{(1+y)^3} + \dots + \frac{C}{(1+y)^n} + \frac{M}{(1+y)^n} \quad (1)$$

or

$$P = \sum_{t=1}^n \frac{C}{(1+y)^t} + \frac{M}{(1+y)^n} \quad (2)$$

After adjustment, we get:

$$P = C \left\{ \frac{1 - \frac{1}{(1+y)^n}}{y} \right\} + \frac{M}{(1+y)^n} \quad (3)$$

Where:

C – coupon payment,

M – value at maturity (face value),

y – yield,

n – time (number of periods to maturity).

From these relations we can define that coupon, yield and maturity are the determining factors for quantification of the market risk. We can simply quantify this risk by using modified duration:

$$MD = \frac{\frac{C}{y^2} \left[1 - \frac{1}{(1+y)^n} \right] + \frac{n \cdot (M - C/y)}{(1+y)^{n+1}}}{P} \quad (4)$$

Modified duration is the best indicator for the investor to simply quantify the change and movement of bond prices in portfolio at the slightest changes in interest rates.

4 Results

Investment strategies on the bond market

Bond portfolio strategies can be classified as either **active strategies** or **passive strategies** (Fabozzi, 2009). Essential to all active strategies is specification of expectations about the factors that influence the performance of an asset class. Passive strategies involve minimal expectational input.

Strategies between the active and passive extremes have sprung up that have elements of both extreme strategies.

a) Passive Bond Strategies

The simplest method of the creation of a bond portfolio is:

- buy and hold strategy;
- modified buy and hold strategy;
- indexing.

Buy and hold – the main feature of this strategy is that the asset manager buys bonds and holds them until they mature.

Sometimes, **modified buy and hold strategy** is used. In this case, specific bonds are bought and held in portfolio until they reach the investment horizon. The manager has the possibility to sell them prematurely and in exchange, he gets bonds with a higher quality.

The next strategy is known as **indexing**. When using this method, the asset manager creates a portfolio whose performance tracks the performance of a selected market index (e.g. JP Morgan EMBI Index), which is also called the **benchmark**. In this method, the portfolio of bonds exactly copies the structure of the market index. The successfulness of this method is evaluated by how exactly the bond portfolio performance tracks the evolution of the index. The difference between them is called as the **tracking error**.

The tracking error is calculated as follows:

Step 1: Compute the total return for a portfolio for each period.

Step 2: Obtain the total return for the benchmark index for each period.

Step 3: Obtain the difference between the values found in Step 1 and Step 2 = active return.

Step 4: Compute the standard deviation of the active returns, which is the tracking error.

Calculations computed for a portfolio based on a portfolio's actual active returns reflect the portfolio manager's decisions during the observation period. We call tracking error calculated from observed active returns for a portfolio **backward-looking tracking error**. It is also called the **ex-post tracking error** and the **actual tracking error**.

Given a manager's current portfolio holdings, the portfolio's current exposure to the various risk factors can be calculated and compared to the benchmark's exposures to the factors. Using the differential factor exposures and the risks of the factors, a **forward-looking tracking error** for the portfolio can be computed. This tracking error is also referred to as **predicted tracking error** and **ex-ante tracking error**.

We can think of active versus passive bond portfolio strategies in terms of forward-looking tracking error. In constructing a portfolio, a manager can estimate its forward-looking tracking error. When a portfolio is constructed to have a forward-looking tracking error of zero, the manager has effectively designed the portfolio to replicate the performance of the benchmark.

Passive strategies require no forecast of future market changes – both the portfolio and benchmark respond identically to market changes. The scale of tracking errors is mentioned in the following table.

Table 2

Magnitude of Tracking Errors

TE	Strategy
0%	Passive Portfolio (Indexed)
1% - 2%	“Index plus” strategy
2% - 4%	Moderate risk strategy
4% - 7%	Fairly active strategy
Over 8%	Very aggressive strategy

Note: TE measured in terms of the number of standard deviations.

Source: [1].

b) Active Bond Strategies

While a buy-and-hold strategy can provide income from a bond portfolio, the strategy for getting the optimal potential out of any bond portfolio is active management. Active strategies are based on a forecast, because the portfolio and benchmark will respond differently to market changes. In an active strategy, the portfolio manager has to decide in which direction and by how much the risk factor value of the portfolio will deviate from the risk factor value of the benchmark on the basis of expected market changes. The main aim of an actively managed portfolio is to achieve greater risk-adjusted returns than a buy-and-hold strategy. As bonds have become an even more important asset class, associated with reducing overall portfolio risk, the technological advances, modeling techniques and rapid data dissemination have grown in the business.

The techniques of active bond-portfolio management have evolved, and the styles of management have become more sophisticated. The main difference between passive and active strategy is the assumption that the portfolio manager, whether it is a large institution or an individual, has the ability to either predict the direction of interest rates or exploit mispriced securities.

Types of active bond strategies:

- valuation strategy,
- interest rates anticipation,
- yield spreads,
- Bond swaps.

- ***Valuation Strategy***

This type of strategy is based on the portfolio manager's ability to identify and buy *undervalued* securities and avoid those that appear to be *overvalued*. This technique necessitates some experience and in-depth knowledge of bond markets.

- ***Interest Rates Anticipation***

Interest rate anticipation is one of the most common – and probably riskiest – strategies, since it relies on forecasting. The aim is to achieve a profit based on a good prediction of evolution of interest rates. When forecasting interest rates, the portfolio manager buys bonds if he expects the decline in interest rates, because the price of bonds will go up and, vice versa, the investor sells the bonds when he expects the rise in interest rates and thus the price of bonds goes down.

Since *duration* is a more accurate metric to measure volatility, it is used to adjust the portfolio. Duration is lengthened in an effort to capture an increase in value when the prediction is that interest rates will fall. Conversely, if interest rates are expected to rise, the move would be to shorten the duration of the portfolio to preserve capital and potentially reinvest in shorter-term bonds when rates are presumed to be higher.

This technique is based on a close monitoring of the monetary policy of central bank and fiscal policy of government, based on which it is possible to anticipate the future evolution of inflation and changes of the interest rates environment.

- ***Yield Spreads***

This is an active bond strategy that is based on the correction in temporarily abnormal spreads. Yield spread strategies involve positioning a portfolio to capitalize on expected changes in yield spreads between sectors of the bond market. Swapping (or exchanging) one bond for another when the manager believes that the prevailing yield spread between the two bonds in the market is out of line with their historical yield spread, and that the yield spread will

realign by the end of the investment horizon, are called intermarket spread swaps (Fabozzi, 2009). Credit or quality spreads change because of expected changes in economic prospects. Yields are determined by the pricing of bonds in various segments of the market. The unique characteristics of the bonds relate to the varying prices and related yields.

- ***Bond Swaps***

The key to a bond-swap strategy is to simultaneously sell one bond and purchase another for the sole purpose of improving the portfolio's return. Investors engage in bond swapping with the goal of improving their financial positions. Bond swapping can reduce an investor's tax liability, give an investor a higher rate of return or help an investor to diversify a portfolio.

- ***Leverage Bond Strategies***

The asset manager can use this type of strategy in order to enhance and extend portfolio returns. A portfolio manager can create leverage by borrowing funds in order to acquire a position in the market that is greater than if only cash were invested (Fabozzi, 2009). The funds available to invest without borrowing are referred to as the "equity." A portfolio that does not contain any leverage is called an unlevered portfolio. A levered portfolio is a portfolio in which a manager has created leverage.

The basic principle when using leverage is that a manager wants to earn a return on the borrowed funds that is greater than the cost of the borrowed funds. The return from borrowing funds is produced from a higher income and/or greater price appreciation relative to a scenario in which no funds are borrowed.

Leveraging is a necessity for depository institutions (such as banks and savings and loan associations) because the spread over the cost of borrowed funds is typically small. The magnitude of the borrowing (i.e., the degree of leverage) is what produces an acceptable return for the institution.

- ***Matching Strategies (Match-Funding Strategies)***

These strategies represent a combination of active and passive bond strategies. They are used in order to create a bond portfolio that will finance specific funding needs. If the timing and cash flow amounts of these needs can be predicted, then a matching strategy can be used to support them. The main aim of the strategy is to minimize the effect of interest rates volatility. This strategy involves matching a "liability" with an asset, a bond investment. The two most commonly used matching

strategies are *cash flow matching (dedicated portfolio)* and *immunization*.

- ***Cash Flow Matching and Bond Portfolio Immunization***

This strategy is used to secure a particular group of liabilities. The cash flow of bond portfolio is timed so as to cover these liabilities. There are two types of this strategy: *accurately timed dedicated portfolio* and *reinvesting dedicated portfolio*. An accurately timed dedicated portfolio is a portfolio whose cash flow of coupons and principal repayments cover the volume of liabilities. A reinvesting dedicated portfolio is also balanced with the maturity of liabilities, but not as strictly as in the previous case. Bond cash flow due before the maturity of liabilities is reinvested (e.g. coupon payments).

Table 3

Example of a Cash Flow Matching Strategy

Time (year)	1	2	3	4
Liability	5 000	9 000	8 000	11 000
Principals	3 000	7 000	6 700	10 000
C4	1 000	1 000	1 000	1 000
C3	300	300	300	0
C2	700	700	0	0
Total Cash flow	5 000	9 000	8 000	11 000

Source: [15].

The table above displays a liability stream for 4 years. To fund these liabilities with cash flow matching, we start with funding the last liability with a 4-year \$10,000 face-value bond with annual coupon payments of \$1000 (Row C4). The principal and coupon payments together satisfy the liability of \$11,000 at year 4. Next, we look at the second to last liability, Liability 3 of \$8000, and fund it with a 3-year \$6700 face-value bond with annual coupon payments of \$300. Next, we look at Liability 2 of \$9000 and fund it with a 2-year \$7000 face-value bond with annual coupon payments of \$700. Finally, investing in a 1-year zero-coupon bond with face value of \$3000, we can fund Liability 1 of \$5000.

- ***Bond Portfolio Immunization***

This strategy matches the durations of assets and liabilities in order to minimize the impact of interest rates on the net worth. In simple terms, to immunize a portfolio, we have to match the duration of portfolio assets with the duration of future liabilities (or with the investment horizon). When interest

rates increase, the price of a coupon bond falls, whereas the reinvestment return on the coupon rises. The main aim of immunization is to establish a portfolio in which these two components of total return – price return and the reinvestment return (coupons being constant) – exactly offset each other in case of a parallel interest rate shift once the portfolio is set up. This is achieved by matching the duration of the portfolio with that of the investment horizon of the future liability. When a bond portfolio is immunized, the investor receives a specific rate of return over a given time period regardless of what happens to interest rates during that time.

A specific rule is applied: when the modified duration is equal to the investment horizon, then the portfolio value is immune to interest risk during the whole time of the investment horizon.

Fong and Vasicek (1984) identified these conditions of immunization as follows:

- the present value of assets (portfolio) should equal the present value of liabilities;
- the duration of the portfolio should equal that of liabilities;
- The range of durations of individual bonds in the portfolio must have a span that extends beyond the range of durations of individual liabilities, i.e. the portfolio must contain individual bonds each with duration less than that of the first liability and duration greater than that of the last liability.

One should bear in mind that these conditions assure an immunized rate of return only in case of a parallel rate shift. If the interest rates shift are in an arbitrary fashion, which is mostly the case in the real world, techniques such as optimization and linear programming may be used to construct a minimum-risk immunized portfolio.

- ***Special Immunization Techniques***

After taking into account risks which were mentioned before, within immunization techniques of bond portfolio modeling we can deal with these strategies: Bond Ladders, Barbells and Bullets.

- ***Bond ladders***

The investment strategy of laddering maturities with a normal upward sloping yield curve attempts to balance and blend the principal stability inherent in shorter-term bonds with the yield advantage available on longer-term bonds. The resulting diversification helps to potentially mitigate interest rate risk,

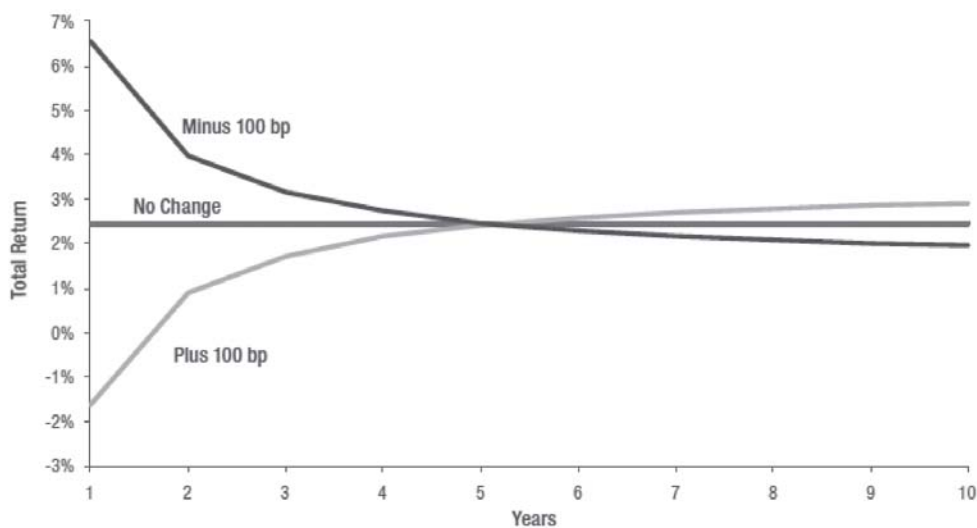
improve returns and allow for reinvestment flexibility, while also providing periodic liquidity and predictable cash flows. Additionally, laddering a portfolio of bonds provides a way to partially hedge against rising yields in the future.

A laddered portfolio is structured by purchasing several bonds with differing maturities, such as three, five, seven and ten years. As each bond matures, proceeds are reinvested in a new bond at the longer-term end of the ladder, which often is the highest yield within the desired maturity range. If interest rates are rising, the maturing principal will be invested at higher rates. If rates are falling, the reinvestment of proceeds will be at lower rates but the remaining ladder will still be locked-in and earning higher yields, helping to keep a blended advantageous overall portfolio return.

The income stream will stay relatively constant because only a small portion of the portfolio will mature and be replaced each year. Over time, the portfolio should include bonds purchased in periods of both high and low interest rates. Figure 1 illustrates how a laddered portfolio can be expected to react to three interest rate scenarios.

Figure 1

Effect of Interest Rate Changes on a Hypothetical Laddered Bond Portfolio



Source: http://www.thornburg.com/pdf/TH084_laddering_full.pdf

- **Steady interest rates:** a very steady return is generated each year in the laddered portfolio. The return will be fairly close to the highest-yielding bond in the portfolio;

- **Rising interest rates:** bond values initially fall down, but recover value as they move toward their maturity at par. Unlike owning an individual bond, the ladder has maturing bonds each year, which gives the portfolio a stream of cash flow to reinvest in new, higher-yielding bonds. As proceeds from maturing bonds are reinvested in higher-yielding bonds at the far end of the ladder, the portfolio's yield gradually increases. The built-in reinvestment feature works to offset some of the price depreciation that occurred throughout the ladder when interest rates rose. It also results in a rising income stream: after a few years, the portfolio's total return first equals its original return, then surpasses it;

- **Declining interest rates:** the portfolio's return rises as bond prices are marked up. Finally, as those bonds mature and proceeds are reinvested in lower-yielding bonds, the portfolio's long-term return is lower than it would have been under the first two scenarios. The income stream also decreases, but only gradually, because the longer-term higher-yielding bonds continue to be held in the portfolio and the income generated continues to be the average of all bonds.

Advantages of bond ladders:

- The periodic return of principal provides additional investing flexibility;
- The proceeds received from principal and interest payments can be invested in additional bonds if interest rates are relatively high or in other securities if they are relatively low;
- Exposure to interest rate volatility is reduced because bond portfolio is now spread across different coupons and maturities.

Barbells

Barbells are a bond investment strategy similar to laddering, except that purchases are concentrated in the short-term and long-term maturities. This allows the investor to potentially gain high yields from longer maturities in one portion of their portfolio, while using the shorter maturities to minimize risk. Barbells can provide opportunity in both rising and declining interest rate environments: if interest rates decrease, the long end of the barbell provides potential for capital gain, however, the asset manager would be reinvesting the proceeds into potentially lower yielding bonds. If interest rates increase, the shorter end of the barbell can be reinvested at the new higher rates, however, the current market value of existing long term bonds could go down. Barbells do not need to be composed of equal balances as an investor can weight the short or long end heavier to take advantage of what the curve is offering.

Advantages of barbells:

- this strategy allows to take advantage of rates when they are high, without limiting financial flexibility;
- because a portion of assets are invested in securities that mature every few years, the investor has the necessary liquidity to make large purchases or respond to emergencies;
- Allocating only part of fixed-income portfolio in longer-term bonds can help reduce the risk associated with rising rates, which tend to have a greater impact on the value of longer maturities.

Bullets

The bullet strategy is based on the acquisition of a number of different types of securities over an extended period of time, but with all the securities maturing around the same target date. One of the main benefits of the bullet strategy is that it allows the investor to minimize the impact of fluctuations in the interest rate, while still realizing excellent returns on the investments.

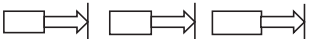





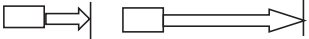
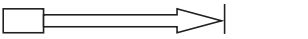
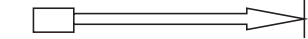

Advantages of bullets:

- All bond maturities coincide with the date of a future financial need. Return of principal is, of course, subject to issuer credit risk;
- By buying bonds at different times and during different interest rate environments, the investor is hedging interest rate risk.

The following figure shows the comparison of ladders, barbells and bullets strategies:

Figure 2

Ladders, Barbells and Bullets

Ladders	Barbells	Bullets
Bonds mature at different times and you continually reinvest them	Sets of bonds mature in the long term and short term, but not in the mid term	Bonds invested at different times, have the same target maturity date
		
		
		
		

Source: own processing based on www.fidelity.com

It is obvious from this table that a particular strategy represents a combination of bonds with different maturities. It is necessary to realize that the quality of bond issue will be an important moment.

5 Conclusion

The main aim of the bond portfolio management is to achieve high revenues or low risk. The asset manager has to take into account risks connected with bonds: credit risk, interest rate risk, liquidity risk and exchange rate risk. There are many strategies for investing in bonds that investors can employ. The buy-and-hold approach appeals to investors who are looking for income and are not willing to make predictions. The “middle-of-the-road” strategies include indexation and immunization, both of which offer some security and predictability. Then there is a range of active techniques, which is intended for advanced asset managers since they have to be able to foresee the future market conditions.

Passive strategies are suitable for investors who are not willing to predict future market conditions or are not that skilled and advanced. They create a portfolio that copies the construction of a chosen market index. The deviation of the performance of their portfolio from the yield of a market index is called the tracking error. Even more simple method is buy & hold strategy, when the investor buys bonds and holds them until they mature.

Active strategies are suitable for advanced bond portfolio managers with the ability to predict future evolution of market rates, inflation and other conditions. They have to follow the decisions within monetary and fiscal policy since these affect economic conditions.

Immunization techniques and match funding strategies are a combination of active and passive strategies. Their aim is to create a bond portfolio in order to secure future liabilities. These portfolios generate stable interest cash flow and are formed in such manner that they are secured against market interest rates volatility. The technique is based on the fact that if interest rates rise, the price of bond falls but the reinvestment revenues grow. These two opposing tendencies offset one another. One of the most used techniques is called bond laddering. The essential part of this technique is to create a portfolio that is a combination of bonds with different maturities. The proceeds from expiring maturities are constantly reinvested into new bonds. Based on the maturity

bond laddering has other modifications: barbells and bullets. They provide stable yield and at the same time the necessary liquidity in order to swiftly respond to a changed market situation. These strategies, like most of the duration-based techniques, work most effectively in case of a parallel interest rate shift.

The selection of a particular strategy will also depend on current market conditions (interest rates and their volatility) and on type of institution which implements the strategy (e.g. the investment horizon of banks and insurance companies are different). Each strategy has its place and when implemented correctly, it can achieve the goals for which it was intended.

Currently, the market interest rates are low and investors are expecting their rise. Changing interest rates can be a concern to bond investors because as rates rise, the price of existing bonds declines. Under these circumstances, individual bondholders and bond fund shareholders can lessen the effect of rising interest rates by reducing the maturities of the bonds. They can also reduce portfolio's exposure to interest rate risk by shifting the mix to bonds and funds with shorter durations. That would be especially important if the portfolio consists largely of long-term bonds. Another useful technique in this case might be bond laddering: as each bond in portfolio matures, the investor can reinvest the proceeds at higher yields should the market rates rise.

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