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A new index for bond management in an uncertain environment

Jose M. Brotons [a,*], Antonio Terceño [b], M. Glòria Barberà-Mariné [b]

[a] Department of Economic and Financial Studies, Miguel Hernández University, Avda. Ferrocarril s/n. 03202 Elche, Spain
[b] Department of Business Administration, Rovira i Virgili University, Avda. de la Universidad, 1. 43204 Reus, Spain

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Abstract

Within the framework of Assets Liability Management, we understand that immunization is the main method to assure a certain yield in a future date departing from an initial portfolio. Although the objective of passive strategies is to design a portfolio that will achieve the performance of a predetermined benchmark, active bond management strategies rely on expectations of interest rate movements or changes in yield–spread relationships. However, the variation of the duration increases the risk of a portfolio, that why the decision maker will have to choose the combination of expected return and risk which provides the higher utility. Finally, the construction of a fuzzy return risk map will allow the decision maker to know the over risk and the over return as regards immunization strategy for each duration and for each risk aversion of the decision maker. The construction of a risk return map presents the results in an appropriate way. It will help the decision maker to choose the best duration for the decision maker interest rate forecast. Finally, this methodology is applied to the Spanish debt so that the decision maker can select the duration that brings him a greater preference.

Keywords: Finance; Active strategies; Duration; Immunization; Portfolio; Passive strategies

1. Introduction

One of the most important research fields in modern finance theory [1] has been the mean-variance methodology for the portfolio selection problem proposed by Markowitz [2], in which the investor is averse to risk. This model considers, for a given return that is multivariate distributed, the decision maker (DM) has a quadratic utility function [3]. In contrast, Konno and Yamazaki [4] proposed the first linear model for portfolio selection, the L_1 risk model.

Asset-Liability Management can be traced back to Redington [5] who suggests a parallel treatment to the assets and liabilities in actuarial valuation. This topic has been broadly dealt with in financial literature. In Van Der Meer and Smink [6] an extensive revision of these techniques is considered. It divides them in static methods (cash flow

* Corresponding author. Tel.: +34 96 665 89 67.
E-mail addresses: jm.brotons@umh.es (J.M. Brotons), antonio.terceno@urv.cat (A. Terceño), gloria.barbera@urv.cat (M. Glòria Barberà-Mariné).

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payment, gap analysis, segmentation and cash floor matching) and dynamic ones (passive, such as immunization or active, such as contingent immunization).

However, some authors, like Gerber [7], point out that the use of stochastic models is not suitable for the prediction of long term interest rates. They consider it is much more realistic the use of discount rates based on fuzzy numbers (FN), since only data available is the one facilitated by experts. For applications of the theory of the fuzzy sets in finance, the following can be considered: Kaufmann [8], Li Calzi [9], Gil [10], Ostaszewski [11], Terceño et al. [12,13], De Andrés and Terceño [14–16] and Terceño and Brotons [17].

However, the bibliography on immunization in a fuzzy environment is very scarce. Derrig and Ostaszewski [18] uses fuzzy mathematics to estimate the effective tax rate and the tax-free discount rate in an insurance company with a portfolio formed with assets and liabilities. In our opinion, the use of FN presents important advantages: as bond prices oscillate between a maximum and a minimum price, we consider much more appropriate to consider the price, and thus, the corresponding internal rate return (IRR), as fuzzy magnitudes. Considering this, we can use all the information that the market provides. When the problem to investigate is economic or social, the observations are consequence of the interaction among the expectations and the opinions of the economic agents, which are highly vague and imprecise.

Terceño et al. [19], Brotons and Terceño [20,21] and Brotons [22] apply immunization strategy in a fuzzy environment. However, our goal is to design active bond management in a fuzzy environment, in order to anticipate changes in interest rates. From a starting immunized portfolio, the DM will have to decide whether to increase the expectation return (modifying portfolio duration), increasing the risk as well, or not. The use of utility functions and the building of risk return maps will improve decision-making.

One reasonable function that is commonly employed by financial theorists [23] assigns a risky portfolio P with risky rate of return r_p, an expected rate of return $E(r_p)$ and a variance of the rate of return $\sigma^2(r_p)$ the utility score $U(P) = E(r_p) - 0.005 \cdot A \cdot \sigma^2(r_p)$ where A is an index of the DM's risk aversion. Carlsson et al. [24], in a fuzzy environment, uses $E(\cdot)$ as a measure of return and $\sigma^2(\cdot)$ as a measure of risk.

In practical applications, the use of utility theory has proved to be problematic, which should be more serious than having axiomatic problems: (i) utility measures cannot be validated inter-subjectively, (ii) the consistency of utility measures cannot be validated across events or contexts for the same subject, (iii) utility measures show discontinuities in empirical tests (as shown by [25]), which should not happen with rational DMs if the axiomatic foundation is correct, and (iv) utility measures are artificial and thus hard to use on an intuitive basis.

Because of the limitations of probability assessment and utility theory we deal with fuzzy interest and we propose the use of possibility theory. In literature, in the works of fuzzy utility [26–30] fuzzy parameters are assumed to be known membership functions. However, it is actually not always easy for a DM to specify the membership function or probability distribution in an inexact environment [24]. At least in some of the cases, the use of interval coefficients may serve the purpose better.

Consequently, the main goal of the present work is to design active management strategies in a fuzzy environment, using Sengupta's methodology to get the return and the risk of a portfolio. Vercher et al. [31] uses this methodology to optimize a fuzzy portfolio under downside risk measures. Interest rate will have to be forecast by the DM, and as a result, the portfolio duration will have to be modified in order to increase the portfolio return, in exchange for a higher risk (wrong estimation will decrease portfolio return).

This way of proceed does not allow to choose the risk in a suitable way, so one of the major points of the present paper is the construction of return risk maps in a fuzzy environment, using fuzzy utility functions that allows DMs to choose the most appropriate combination of risk and return, modifying portfolio duration. In order to allow that DM can choose between different portfolios, we propose the construction of an index that allows him to set the preference of one option over another when, because of uncertainty, both are represented through Triangular Fuzzy Numbers (TFN), and we will use their α-cuts. That is, we will propose an index that allows DM to order intervals (α-cuts) to a certain level of presumption.

The structure of the paper is as follows. Section 2 is devoted to describing the preliminary concepts. In Section 3, we introduce the concept of bond and portfolio's duration that we extend to the fuzzy environment. Then, in Section 4 we expose the passive management. Risk and return of a portfolio using active bond management are obtained in Section 5. The next section presents the construction of a new index of preference for portfolio selection investment. We illustrate our approach with an application to the Spanish Public Debt market using numerical examples in Section 7.