

The Importance and Application of Bonds in the Stock Market

Ziqiang Chang^{1, †}, Jingyi Huang^{2, †}, Yanran Zhu^{3, *, †}

¹Faculty of Business and Economics, The University of Hong Kong, Hong Kong, 999077, China.

²School of International Education, Jiangxi Science and Technology Normal University, Jiangxi, 330038, China.

³Bachelor of Commerce, Macau University of Science and Technology, Macau, 999078, China.

*Corresponding author: 2009853wk011002@student.must.edu.mo

†These authors contributed equally.

Abstract. The bond market plays a role in predicting the economy and making portfolio selection for investors. More information can be obtained by analyzing the yield curve. Based on this, this paper mainly describes the role of the bond market and related measurement and analysis methods in detail. This article chooses the relationship between the US benchmark interest rate and the yield of the US 10-year Treasury bond, as well as the relationship between the yield of the US 10-year Treasury bond and its price to analyze interest rate risk. Meanwhile, by quantifying the elements in the portfolio and comparing the data, this paper expounds the management and impact of duration, continuity and cash flow matching on the risk of bond market investment. The results show that the bond market has the function of forecasting and giving investors more choices, and for the risk strategy, the use of a variety of methods will help to reduce risks and increase returns. These help people regard the bond market more effectively and clearly.

Keywords: Finance risk, Indicator, Duration, Convexity, Bond.

1. Introduction

1.1 Research Background and Motivation

Research on bond market has a long tradition. This thesis considers the field of financial market as the main subject of its study. One of the major topics to be investigated in this field is bond market and it is frequently prescribed for investors to make decisions. This thesis will examine the way in which these questions: Why is the bond market so useful? At the same time, what contributions can it make to risk management strategies? This article will focus on these two issues. There are several common kinds of role and contribution, this paper will explain the functionality of indicator and finance alternative. For contributions, this paper will mainly introduce these four aspects: interest rate risk, duration, convexity and cash flow matching.

This study therefore set out to assess the effect of bond market of forecast economy, and the effect of finance alternative. For our first goal, this paper will focus on two aspects: prediction function and finance alternative function of bond market. Existing research recognizes the critical role played by bond market, it is mainly driven by future economic growth. One way to observe future economic performance is the impact of the bond market on the outlook for interest rates. Meanwhile, the best way to use bonds to predict the economy is to look at the yield curve. According to the yield curve, article can judge the economic change trend of the market, so we will give some simple examples to illustrate the curve graphs in general and some special cases. The other effect is the bond market could as a project finance alternative. The bond market provides another source of project financing funds. Compared with the traditional methods of providing funds for projects through bank loans and tax equity, buying and selling bonds to form a reasonable investment portfolio will maximize the return on funds [1].

This study was exploratory and interpretative in nature. This paper will discuss the relationship of the interest rate risk, duration, convexity and cash flow matching. The study was conducted in the form of a survey, with data being gathered via relevant articles and tools. For interest rate risk, when

yields change, bond prices change, Two examples are analysed in order to show the relationships (the relationship between the US benchmark interest rate and the US 10-year treasury yield and the relationship between the yield of the US 10-year treasury bond and its price). So we can see that when interest rates change, bond prices will also change.

A combination of quantitative and qualitative approaches was used in the data analysis. This article put an example to explain the duration. Its main idea is to set up a portfolio such that any capital gains arising from changes in interest rates are offset by reinvested gains. Meanwhile, this paper will also mention some limitations like the cost of duration immunization is too high, immunization is a dynamic process and when interest rates change widely, the duration does not accurately reflect price changes.

Since the duration matching has some limitations so some alternative strategies will be introduced to manage risk. The better measurement method for sensitivity is convexity. The duration strategy it is accurate enough, but for larger changes in yield, it always underestimates the resulting bond prices for non-callable, option-free bonds. It need to consider both duration and convexity to make more accurate prediction. Article will provide examples to show why it can help investors make better decisions, through which investors can better obtain funds and reduce the risks brought by stocks. And another alternative strategy is the cash flow matching. The cash flow matching strategy makes use of cash flows from principal and coupon payments on various bonds that are chosen so that the total cash flows exactly match the liability amounts. There are relevant examples to prove how to better match the relationship between cash flow and liabilities. Through the calculation and analysis of cases, we can see the best distribution method between the two. This paper will compare the advantages and disadvantages of this method to show it more objectively.

This project provided an important opportunity to advance the understanding of bond market. Characteristic of curve is important for our increased understanding of the usefulness and contributions of bond market.

1.2 Literature Review

At present, most scholars mainly carry out the research on the risk management strategy of bond market from the following aspects. First, the impact of the change of convexity on the return, through the analysis of the yield slope and curve, to help maximize the return of the portfolio [2-3]. The second is the problem of cash flow matching, which matches the total cash flow with liabilities through the cash flow paid by bond principal and coupon [4]. These studies can guide the topics we want to study and help form a coherent article. This paper studies from the aspects of interest rate risk, duration, continuity and cash flow matching, which further highlights the significance of our research.

1.3 Research Contents and Framework

Based on the existing research results, this paper analyzes the aspects of interest rate risk, duration, continuity and cash flow matching, and summarizes the corresponding conclusions. The framework of this paper is arranged as follows. The first part is the introduction, including the research background, motivation and literature review. The second part are interest rate risk and duration; The third part is convexity and cash flow matching. The last is the conclusion.

2. The role of bonds in risk management strategies

For a bond, an important factor affecting its price is the yield, which in turn is affected by the interest rate. When interest rates change, bond yields also change, and they usually show a positive correlation. When yields change, bond prices change, like this figure 1, and they are usually negatively correlated.

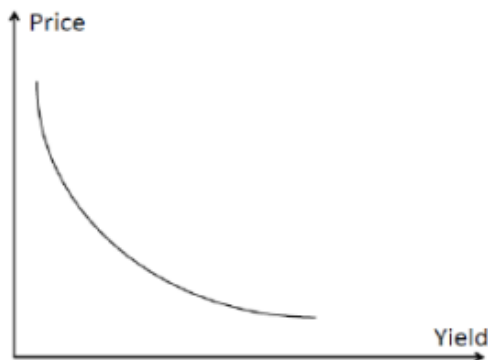


Figure 1 The relationship between price and yield

The figure 2 shows the relationship between the US benchmark interest rate and the US 10-year Treasury yield. The yellow line shows the yield, and the blue line shows the interest rate. It is obvious that as the interest rate increases, the yield increases with it. There is a positive correlation between them [5].

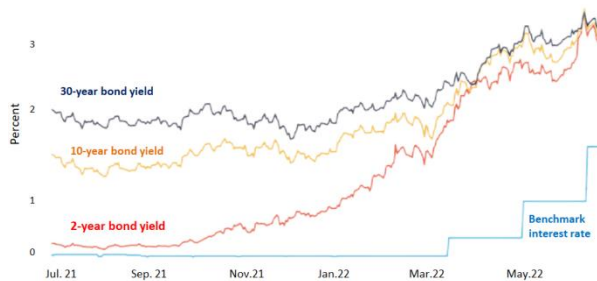


Figure 2 The relationship between the yield and price

The figure 3 shows the relationship between the yield of the US 10-year Treasury bond and its price, the green line is the yield, the red line is the bond price. We can see that they're almost symmetrical along a horizontal line. There is a negative correlation. So we can see that when interest rates change, bond prices will also change [5].



Figure 3 The relationship between the yield and the price

Therefore, there is a risk that investors will suffer losses due to changes in interest rates. This is what we called interest rate risk. However, different bonds have different sensitivity to changes in interest rates. For example, when the yield decreases by 5%, the price of BOND D increases by more than 150%, while the price of bond A only increases by about 25%, which is a very big difference. A risk-averse investor may chooses bonds like BOND A to reduce the interest rate risk faced by the asset.

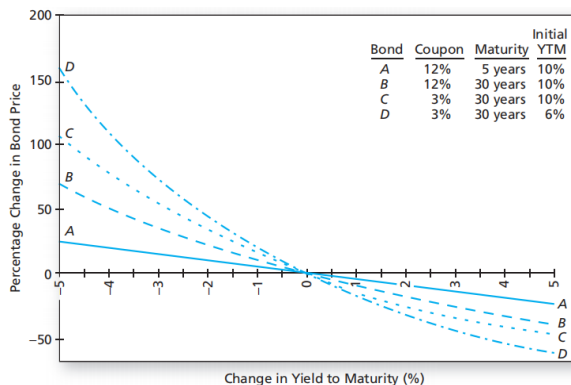


Figure 4 Change in Yield to Maturity

The sensitivity of bond prices to interest rates is not well judged from Figure 4 [6]. Further, this article will cover duration. The definition of the duration is the weighted average of the maturity of individual cash flow, with the weights be proportional to their present values. It is designed to measure, on average, how long you have to wait, in order to enjoy the cash flow benefits of a bond. The longer the duration, the more the percentage of price changes when the interest rate changes, then the greater interest rate risk.

There is an example. The bond P has the cash flow as the red line, five dollars in each of the first three years and 100 dollars in the fourth year and bond Q is blue line, five dollars in the first year, 100 dollars in the fourth year. We can calculate that the duration of bond P is 3.68 and that of bond Q is 3.5. You can see from the graph that the red line of bond P is more curved. When the interest rate increases from 10% to 15%, the price of P will decrease by 17.7%, while the price of Q will only decrease by 16.6%, which is less. The higher the duration, the greater the change in bond price for a given change in interest rates.

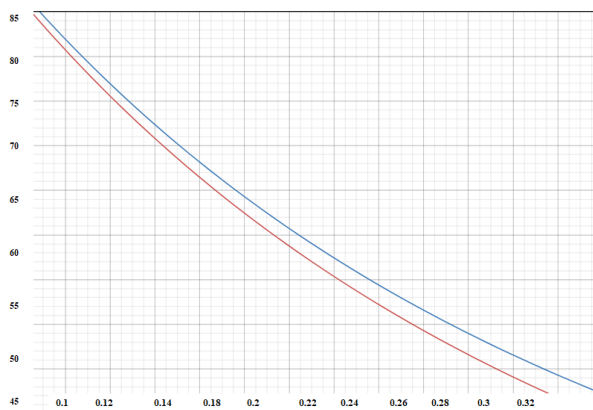


Figure 5 Price-yield about bond P and bond Q

This paper introduced one important method to manage the interest rate risk and duration immunization. Its main idea is to Set up a portfolio such that any capital gains arising from changes in interest rates are offset by reinvested gains. Immunization means that: you lock in the interest rate and you will have the expected amount of money at the end. Duration immunization works on the principle that a coupon bond with a given duration can approximate a zero-coupon bond with the same duration[7,8].

There is an example: Company A have a cash obligation to be made at the end of year 5. And there is a coupon bond like this. We can calculate that the PV of the obligation is 9000 and the duration of the bond is 5 years, which is the same as your due date. Therefore, it can hold 9 units of the bond to achieve the immunization. If 1 year later , the interest rate decrease to 7.9%, if you don't construct the portfolio ,you'll still need about \$50 to make that payment, and if interest rates fall faster, you'll have to pay more. If you build this portfolio, at the end of five years, you'll have just enough money

to cover what you owe. After that, you have achieved the duration immunization, we can fix the interest rate. But this method has its limitation. The first limitation is follows: firstly, the cost of duration immunization is too high. It is hard to find bonds with the suitable duration. Secondly, immunization is a dynamic process. A portfolio should be restructured to maintain its original expectations when market interest rates change significantly. Meanwhile, when interest rates change widely, the duration does not accurately reflect price changes. The duration rule is only an approximation of bond prices regard the interest rate impact, and it is only a tangent line to the price-yield curve at the calculated point. But the actual price change is a curve line.

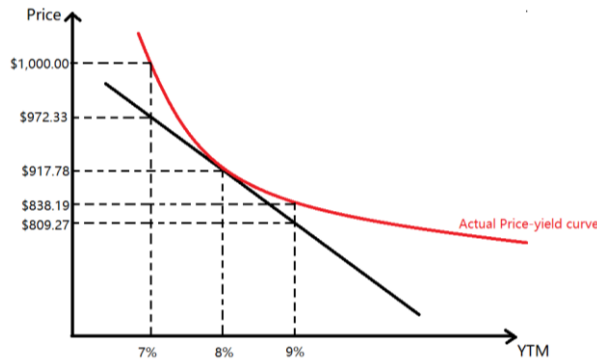


Figure 6 Price-yield curve

In Figure 6, the straight line is predicted by the duration strategy. When the yield decrease from 8% to 7%, when only see from the duration line, the bond price rise to \$972.33. And when taking the actual price-yield curve into account, the bond price actually rise to \$1000, which is higher than \$972.33. When the yield increase from 8% to 9%, see from the tangent line, the price falls to \$809.27. But see from the actual curve, the price falls to \$838.19, which is higher than \$809.27. In this case, when consider the actual curve, the bond prices rise more and fall less regard the change of interest rate. So this kind of relationship between the bond price and the yield rate is convexity.

The main reason for choosing this strategy is that the duration strategy is accurate enough for small changes in yield, but it always underestimates the final bond price of non-callable and option-free bonds for large changes in yield. Therefore, when the yield changes greatly, this paper needs to consider both duration and convexity in order to make a more accurate forecast. Meanwhile, it can help the investors to make better decisions.

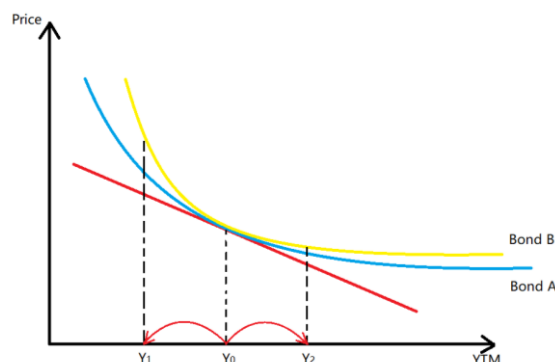


Figure 7 Price-yield curve of bond A and bond B

In Figure 7, the price-yield curve of bond B is more curved than Bond A. If yields rise, the bond B will fall less than bond A. If yields fall, bond B will rise more than bond A. Therefore, if yields change from Y_0 , bond B will always be worth more than bond A. As a result, it can definitely help the investors to decide which bond to pay for[9].

Meanwhile, another alternative strategy is the cash flow matching. The cash flow matching strategy use cash flow from principal and coupon payments on chosen bonds to match the total cash flow with the liability amounts. In order to do cash flow matching, the cost of funds required to do cash flow matching would be significantly higher compared to the total debt amount, and a large amount of initial funds would be required to purchase bonds for matching repayment. Therefore, cash flow matching costs will increase. In addition, the difference between the bond maturing date and debt repayment date expose the risk of reflection. Without a suitable short-term investment, this part of the money will waste time and cost. If the last liability maturity date is later than the date that bond can be matched, then the bond needs to be sold early, and selling the bond early will face the market price risk. In addition, if the liquidity of the bond is not high, it will also pay a liquidity premium cost at this time, which is one of the reasons for the high cost of cash flow matching.

The cash flow matching also has benefits. It is simple to calculate and not affected by the structural risk of interest rates, because it does not involve the calculation of PV, and naturally there is no repricing of its valuation. Since the time and amount of cash flow is known, it is also less difficult to manage.

3. Results and Discussion

The bond market is not only significant for serve as the indicator and the financial alternative, but the huge impact on risk management is important as well. To manage interest risk, the bond market plays the major role of the bond immunization that any capital gains arising from changes in interest rates are offset by reinvested gains. The duration matching, which serve as an important tool of bond immunization, is able to manage price sensitivity. Owing to the fact that there are several limitations due to the uncontrollable date, the convexity and cash flow matching can help to cover the shortages. In this essay, the concept of convexity and the advantages are discussed. The vulnerabilities and strengths of cash flow matching are also introduced.

4. Conclusion

To begin with, the usefulness of the bond market is discussed. The bond market plays an critical role in predicting the future changes of economy, which can clearly tell from the yield curve. So some simple examples are given to illustrate the curve graphs in some cases. In addition, the bond market can serve as the financial alternative to provide another source of project financing funds.

The bond market's contribution to the risk management is primarily discussed. Firstly, this paper discusses the relationship between bond prices, yields and interest rates from the perspective of risks that need to be managed. It takes the curve of yield, price, and interest rate of US 10-year treasury to explore their relationship, and thus illustrate what is interest rate risk. Next, this paper explains that different bonds have different sensitivity to interest rate and face different interest rate risk. Thus, it introduces the index describing interest rate risk, duration. And then it explains the definition of duration and cites two bonds with different duration to illustrate the relationship between duration and the sensitivity of bonds to interest rate changes. Next, this paper introduces an important method of managing risk, duration immunization. It talks about the definition, how to implement it. And illustrate how to use this method to manage risk using an example. Finally, it discusses three limitations of this approach and pave the way for the discussion of convexity and other approaches later. The convexity and cash flow matching are serve as the alternative strategies of duration matching. In this essay, a graph with specific data is used to discuss the differences between the impact of yield rate changes on bond prices in convexity and duration strategies. At the same time, it also introduces the most suitable cases for convexity and duration strategies. In addition, the benefits and strengths are introduced by a graph of two bonds contrast, which illustrate the convexity's function that is able to help the investors to make better decision. Moreover, the usage of cash flow matching is introduced. The vulnerabilities and strengths of cash flow matching are discussed. Owing

to the fact that the present value is not included in the calculation, the cash flow matching is simple and easy to understand. However, the cash flow matching may have high cost at most of time and some risk may face due to the differences between the bond maturing date and debt repayment date.

References

- [1] G.M. Soto, "Immunization derived from a polynomial duration vector in the Spanish bond market." *Journal of Banking & Finance* ,2001,DOI: 10.1016/s0378-4266(00)00112-6
- [2] B. C.Kumar, R. Ramasamy , and Z. Mohamed . "Probability Approach in Estimating Value at Risk of Bond Portfolios for Effective Hedging." *Asian Economic and Financial Review*,2020.
- [3] G., Iyengar, and A. Ma . "Cash Flow Matching: A Risk Management Approach." *North American Actuarial Journal*,2008, pp. 370-384. DOI:http://dx.doi.org/
- [4] MacroMicro. HRL: <https://sc.macromicro.me>,Access:2022-7-22.
- [5] B., KANE, MARCUS, (2011). *Investment* (9th ed). Douglas Reiner. DOI: 10.4236/ojbm.2022.102054
- [6] N.J. Jan, and R.W. Werner. "Mathematical analysis of replication by cash flow matching." *Risks* 5.1 (2017): 13. DOI: 10.3390/risks5010013
- [7] B.J., Grantier. "Convexity and bond performance: The benter the better." *Financial Analysts Journal* 44.6 (1988): 79-81. DOI: 10.2139/ssrn.983316
- [8] G.R. Robin, A. J. Marcus, and A.W. Woodhams. "Delivery options and convexity in Treasury bond and note futures." *Review of Financial Economics* 19.1 (2010): 1-7. DOI: 10.2139/ssrn.1159562
- [9] L.Z. Zhewen, et al. "A Network Approach to the Study of the Dynamics of Risk Spillover in China's Bond Market." *Entropy* 23.7 (2021): 920. DOI: 10.3390/e23070920