Mitigating Financial Volatility: The Role of Duration in Interest Rate Risk Management

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Abstract. Duration is a resource that investors can use to lower interest rate risk. The purpose of this research is to analyze the bond market and to join bonds. An investor has many reasons to choose bonds as part of their portfolio and use Duration to value the risk. When choosing to bond, the way to measure whether it suits the portfolio is to balance risks. Therefore, it will be more suitable for investors to join more than two kinds of financial products in a portfolio. The method introduced in this passage is the Duration of the calculation, and the usage will be written clearly. When calculating the Duration, it is important to calculate the yield of maturity and be familiar with the process. It is also essential to list the face and present values in a table to clarify the data when calculating the Duration. Also, when calculating the Duration, it is crucial to look at the view in a portfolio and balance it in a higher position.

Keywords: Fix-income security, interest rate risk, Macaulay duration, portfolio.

1. Introduction

In the financial markets worldwide, bonds are a type of financial product that is well used. They are also one of the major financial markets in most countries, such as America, Germany, the UK, and Japan. Therefore, it is also a financial product found in most developed countries.

Many investors will choose bonds or other fixed-income securities as their financial product or part of the portfolio to add when investing. Fix-income security is a type of security that can receive stable interest income in a specific period, and it could be a government bond with a relatively lower risk compared to the other two types of bonds and with good faith because most of the government bonds are constructed by the country. Businesses usually use corporate bonds to raise capital for operation expansion and typically offer higher yields; however, investors risk receiving a junk bond, so looking through the business's grading system is crucial. Another type of bond that is well used is zero coupon bond, which is a bond that is unique from the other two types of bonds since it can reduce risk in a portfolio. At the same time, it is a convenient tool since it does not pay the coupon interest until maturity, and at the end of the period, the bond will repay the principal at maturity but with no discount rate.

Investing in bonds or other types of financial products defaults investors as risk haters, and most investors will likely reduce their risks as much as possible. Duration, as a valuable form of measuring interest rate risk, can be formed to minimize risk while choosing the bond, and Duration can help investors gauge the sensitivity of a bond price when it changes in market interest and the weighted average time.

This paper will use 22Shangkong (SRTK)02 and 14Tianrui02. These two bonds are examples to explore and analyze how this can be used to reduce interest rate risk by investing in fixed-income security. 22Shangkong (SRTK)02 is issued by Shangrao Investment Holding Group (SRTK). It is a company from the public sector in China and an enterprise that is directly related to the city government. As the second-biggest company in Shangrao City, it used resources to promote the advantages of the business. SRTK issued a bond with a face value of 100 on October 13th, 2022, and the bond will be fully paid on October 13th, 2029, which will go through seven years; the coupon rate of the bond is 4.28%, and the yield to maturity of this bond is 1.45 %. As for 14 Tianrui02, it is an enterprise that focuses on high-tech, manufacturing, and tourism industries; it issued a bond on June 25th, 2014, and ended on June 25th, 2024, with a time value of 10 years. It has a coupon rate of

8.5%, a face value of 100, and a yield to maturity of 10.59%. This research may contribute to using Duration to help investors reduce risk significantly or spread the risks in different forms in a portfolio.

The rest of this paper is structured as follows: Section 2 will briefly explain the method used to measure and reduce the risk in investing bonds, followed by the analysis with the sample selected in Section 3. The final part, Section 4, will summarize this analysis and provide recommendations to investors.

2. Methodology

2.1. Method

The method used in this analysis uses bonds' Duration to reduce the risk of a change of interest in the future. Next, this method will be explained in detail.

2.1.1. The introduction of interest rate risk

The interest rate risk is formed by the fluctuation of the bond price affected by the interest rate and the probability of a decline according to the asset's value. "According to one of the references of the interest rate risk from the textbook, the risk exists when investors are confident enough of the interest in the future level, therefore mainly they will choose a method or a product that with high return, however, if an investors are not confident with the interest then they will be considered the decision in another perspective which is choosing the less risky product." [1]

The interest rate risk shows up when people must distinguish between short-term and long-term interest rates. Interest rate risk measures new debt instruments that increase estimated rates and potential losses from investments. However, adding bonds with different durations or grouping up a portfolio can prevent this risk. If the interest rate rises, the bond prices will fall, which is inversely proportional to each other. Interest rate risk can be calculated by a fixed income security's Duration, with long-term bonds having a more significant price sensitivity to the rate change. "According to the passage of duration definition and its use in fixed income investing it clearly states that the duration can help estimate a bond's fixed income portfolio's price sensitivity relevant to the changes among interest rates." [2]

2.1.2. Duration

Frederick Macaulay first developed Duration in his seminal analysis of interest and bond prices in 1938. It measures the price volatility and average weighted time maturity of the bond's cash flows, which usually show in years. Duration is one of the rules that can be used when measuring risk. By using the future cash flow to calculate the present value by discounting, then using multiplication to each current value and the number of years, a sum of what we get will be the bond duration or number. This tells the amount and the value of time when an investment happens or exists. Present value can help develop the weight of per cash flows in a percentage of the bond's total price. The cash flow includes the bond's repaying value, and the received Duration measures the sensitivity. Duration can be defined as a simple calculation. Equation (1) is the formula of Macaulay Duration.

$$D = \frac{\sum_{t=1}^{N}\left(\frac{CF_t \times t}{(1+r)^t}\right)}{\sum_{t=1}^{N}\left(\frac{CF_t}{(1+r)^t}\right)} \quad (1)$$

Where:

D = The bond's Macaulay duration

t = The number of times

CF_t= the cash flow received at time t

r = The periodic yield to maturity

Duration is the concept of risk management, and it is beneficial when calculating or measuring a bond's interest rate risk, which is also related to a bond's maturity, yield, and coupon. These numbers and factors can be first calculated, showing the bond's features and sensitivity. The potential risk is

due to the time of an investment or business process. Duration can be influenced by factors like time to maturity and coupon rate. The relationship between the Duration and interest rate risk is very tight. They can be affected by each other. If the Duration increases, the bond price might drop, and interest rates will rise. For instance, if the interest rate increases to 6%, the bond fund with an average time value of 6 years duration will lose nearly 6% of its value. When the time to maturity exists longer, then the Duration will be higher due to the time value and the opportunity cost of an investor's decision; different time limits will influence different final prices and affect the Duration and risk.

When using Duration to measure and quantify the sensitivity of a bond or debt from a change in the interest rate. From equation (1), it is easy to get the Duration. It concludes that if the bond's price decreases, then the interest rate will rise, and the interest rate will become more significant. Duration is the remaining continuous period of a bond and is a tool we use to pay the interest rate. According to the Principles of Corporate Finance, "They are influenced by the duration since it estimates the exposure of bond's price to fluctuations in interest rate" (1). We know that we, the investors, focus on lowering the risk, and if the interest rate for the bond is stable, the interest rate for the market might be changeable.

2.1.3. Bond Valuation

When investors want to compare bonds, they usually use the concept of yield to maturity since different bonds have different yields. The yield to maturity (YTM), which tells us the single fixed interest, explains the bond's price; it is a coupon and maturity. [3] " According to the quote of yield to maturity, it is a compound return of the level that the investors seeks according to the bond buyer in the current market. It can describe the return that is updated to the maturity date."

A bond's yield to maturity (YTM), denoted by y, is obtained by equation (2).

$$P = \sum_{t=1}^{T} \frac{C \times N}{(1+y)^T} + \frac{N}{(1+y)^T} \tag{2}$$

T= time until maturity

y= YTM

$C \times N$= coupon payment

N = principle and the coupon payment

If the bond's coupon rate equals YTM, it sells at a par rate, and its price will match its share value.

2.2. Sample

2.2.1. Bond 22Shangkong02

The bond 22Shangkong02 was set up in 2022, which is the sample that will be used in this article. It is a typical corporate bond from a limited company constructed based on the Shangrao city government and the integration of state-owned assets and urban resources allocated in June 2015 as a large wholly state-owned enterprise [4]. From now on, the SRTK group has paid in registered capital 10.459 billion and a total asset of more than 30 million yuan and raked ninth place in the top hundred asset scale of urban investment companies in China. Contains a grade of AAA in the China bond grading system and BBB in the International Bond grading system. Using the face value and the time value of the bond, we can get the Macaulay duration according to the calculation and get 3.948 years, and it tells the investors to repay the bond price by the bond's total cash flow.

2.2.2. Bond 14Tianrui02

Tianrui Group is a private enterprise in Henan Province, China, founded in 1982 [5]. One of the joint-stock enterprises that contains green building materials, casting (intelligent manufacturing), internet technology, cultural tourism, and other industries. It ranks 380th among the top 500 enterprises in China. The Tianrui group has been involved in cloud computing, databases, artificial intelligence, and the leading technology in every part of its core manufacturing process. Tianrui Group set the bond 14Tianrui02 in 2014 and ended in 2024 on June 25th; it is a typical corporate

bond, and the bond has a grade of A and A* in the China bond grading system, according to the calculation of the Macaulay duration.

3. Analysis and discussion

3.1. Investment background

Assume A company is considering using financial instruments to reduce the interest rate risk. A Co. needs to make a payment of 10,000 RMB, and the risk of this payment will be the uncertainty of the interest rate. To solve this problem, the company decided to use fixed-income securities to reduce the risk. The fixed-income securities have a lower cost than the equity investment and are less risky than the derivatives. Thus, two bonds issued by Shangrao and Tianrui Group were selected for this investment. However, the amount and weights of these two bonds in this portfolio need to be decided, and this analysis will use the Macaulay Duration to solve this question.

The bond issued by Shangri is named22Shangkong02 (sh184590), and it is constructed by the Shangrao Investment Holding Group (SRTK); it has a face value of 100, and the time to maturity is seven years, and the yield to maturity is 1.45%. The bond 22Shangkong 02 is traded on the Shanghai Stock Exchange, and the issuer will pay the interest once a year, and the principal will be paid back to the buyer at the end of the interest rate, October 13th, 2029. According to the annual report of Shangri Investment Holding Group, the contract of the bond investors and the protection clause can be found.

3.2.Using Duration to Reduce Interest Rate Risk

The two bonds that are chosen in this analysis the 14Trianrui02 and 22Shangkong02, to find the liability payment and to achieve the purpose of Duration, which is reducing risk and exploring the sensitivity of the price in a bond and to find the relations of the increase of Duration and the interest rate risk.

The basic terms of the bond and the procedure are to match the Duration of the two bonds with the duration ability, and the durations are addictive. When investors are making decisions, not only do they need to consider the discount rate, but also, for bonds (fixed income securities), it is more important to claim the “fixed” set of cashflows at “fixed” dates for debt financing. Therefore, when considering the duration goal, in this case, both bonds are coupon bonds, so they will pay periodic interest payments to the bondholder. Bonds can pay coupons more often than once per year. When holding a coupon bond, the investor can use the cashflows of coupon bonds to calculate the spot rates through bootstrapping. Thus, the Duration of these two bonds can be calculated below.

Here is some basic information about the two bonds chosen from the market. The first bond is called Shangrao Investment Holding Group (SRTK). It has a face value of 100, a time to maturity of seven years, and a yield to maturity of 1.45%. The second bond chosen from the market was 14Tianrui02, and the bond code was Sh124815. The Trianrui Co. LTD constructs it. The bonds have a coupon rate of 8.5% and a yield to maturity of 10.59% with a face value of 100 and a time value of 10 years.

3.2.1. 22Shangkong02

The bond 22Shangkong 02 is traded on the Shanghai Stock Exchange according to SRTK’s Annual Report on the debts of the Company [6], and the issuer will pay the interest once a year, paying the principal back to the buyer at the end of the interest rate, October 13th, 2028. According to the annual report of Shangri Investment Holding Group, we can recognize the contract of the bond investors and the protection clause. The bond issuer commits that if they cannot pay the cash to the investors at the promised date, they are responsible for getting bank loans, trust loans, loans from finance companies, and other forms. If the money mansion above and the monetary payment obligation reaches 3000 yuan or accounts for the most recent consolidated financial statement of the issuer more than 10% of

the audited net assets at the end of the first period, and so far, the placement has no irregularity during raising. Until 2028, 22 Shanghai 02 still has 1.7 billion yuan to invest.

Table 1 The duration and information of bond one: 22Shangkong02

Year	Cash flow	Discount factor	Present value	Weight
1(2022)	4.28	0.963	4.123	4.123
2(2023)	4.28	0.927	3.971	7.942
3(2024)	4.28	0.893	3.825	11.475
4(2025)	4.28	0.861	3.684	14.737
5(2026)	4.28	0.829	3.549	17.745
6(2027)	4.28	0.798	3.418	20.511
7(2028)	104.28	0.769	80.229	561.604
Total			102.8	638.138
Macaulay Duration				6.21

The total present value is the sum of the present value, which is a significant rate of return on the current value of total money in the future. According to the information in Table 1 and equation (1), the Macaulay Duration of the bond is around 6.21.

3.2.2. Tianrui Co. LTD

According to the company Tianrui 2023 bond interim report [7], it claims that as a company that involves many sectors and has a large market among every sector, especially for the sector of Tianrui Cement, which is one of the sectors that takes a large proportion and listed in Hong Kong Exchanges and Clearing Limited and started earlier in the industry of cement even globally with unique method. For last year, 2023, the sector Tianrui cement is still getting stable needs and revenue in the industry. Therefore, the issuer defines it as a significant benefit of the company. The Bond 14Tianrui02 is the first tranche of the Tianrui Group and promises the investors that they will pay the interest once a year, and the principle of the period ends. The situation of funds raised by corporate bonds is stated, and none of the company's corporate bonds involve using or rectifying the reporting period. The remaining bond amount for the company is 8430.57million yuan, and the bond will end on 2024 June 25th

Table 2 The duration and the information of bond 2 14Tianrui02

Year	Cash flow	Discount factor	Present value	Weight
1(2022)	8.5	0.914	7.771	7.771
2(2023)	8.5	0.835	7.105	14.211
3(2024)	108.5	0.914	82.923	248.770
Total			97.8	270.751
Macaulay Duration				2.768

The total present value is the sum of the present value, which is a significant rate of return in the current value of total money in the future. According to Table 2 and Equation (1), the Macaulay Duration of the bond is around 2.77.

3.2.3. Using Duration to reduce the risk

The investor will start the investment in 2022 for their first investment. The investor aims to achieve 100,000 in revenue in a 5-year time value. Now, to reduce the risk, it is necessary to use Duration to reduce the risk. Tables 1 and 2 show the basic information and the Duration of the two bonds' perspectives. The goal is to achieve 100,00 RMB in 5 years. Therefore, the risk can be diversified if the two bonds are joined as a portfolio. The significant Duration of the liability is 5. Let x be the portfolio share of 22Shangkong02 and (1-x) be the share of bond 14Tianrui02. The equation will be

$$6.21 \times x + 2.77 \times (1 - x) = 5$$
$$x = 64.93\%.$$

64.93% is the proportion of 22Shangkong02 in the portfolio, and the proportion of 14Tianrui02 is 35.07%. These two percentages show the investor if the portfolio balances each other as the abovementioned proportion. Then, the risk could be the least. So the investor is planning to achieve 100,000 in the future, and it needs to be measured in its present value, the liability to be paid of the present value, which is using 100,000/(1+0.1)5 =62092.13231RMB this is the money that is discounted by the 100,000 to now, and 10% is the annual rate of return of the bond. After knowing the 100,000 present value, the managers of this company can use the proportion to know the actual amount the investors should invest in each bond. Thus, the investor will get 21777.41 RMB of 14Tianrui02 and 40414.892 RMB of 22Shangkong02. That is 392 units of 22 Shangkong02 in the portfolio while 223 units of 14Tianrui02.

4. Conclusion

To sum up, the bond market is a fixed-income security and debt financing type. It usually has broad ownership, and bank loans are with a single bank, a single bank, or a consortium bank. Prims prefer fixed-income securities as the interest rates are lower than bank debt and are more generous. In general, only larger firms can issue fixed-income securities. Duration is a term that can help with dealing with the weighted average of the maturity of individual cash flows, with the weights being proportional to their present values when the interest rate of duration increases, and the Duration will change based on the volume distribution. The higher the coupon rate, the lower the Duration, and the longer the maturity, the higher the Duration, the higher the yield, and the lower the Duration. When organizing a portfolio, if the investors calculate the Duration, it would be more precise for them to recognize and match different types of financial products; here, the financial products are not only bonds, they could also be stocks. Investing in a portfolio diversifies the risk to lower the risk as much as possible and increase the rate of return. After calculating a bond in the portfolio, comparing the bonds due to the yield to maturity is also efficient. Different bonds will have different yields, affecting the risks and the return. Therefore, this paper has stated a symbiotic relationship between Duration and risk reduction. Viewing the risks, the time valuation, and mitigating the risks to individuals and businesses can enhance the basics of potential adversities.

This research provided a method to reduce the interest rate risk of an investment. However, there are some limitations to this strategy. It only protects the firm against parallel shifts of the yield curve that are also assumed to be flat, and this method does not take other kinds of yield changes into account. The Duration is only valuable temporarily since the market value will change, and the portfolio weight needs to be constantly rebalanced. The Duration needs to be updated if the market value changes, not only because the interest rate level may change over time but also because the durations of assets and liabilities will change.

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