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ORIGINAL ARTICLE

BOND DURATION AND IMMUNIZATION –ANALYSIS OF FACTORS INFLUENCING PRICE VOLATILITY OF BONDS

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Abstract:

Bonds have been issued by a variety of debtors to raise funds from the market. Understanding various terms associated with the pricing of a bond as also the factors associated with valuation of bonds is extremely necessary for making an intelligent investment decision. Bond Duration Analysis helps investors to decide strategies to immunize their portfolio from factors which may adversely affect the return on their investment portfolio.

KEYWORDS:

Analysis , Factors Influencing , investment portfolio , Immunization.

INTRODUCTION

Bond is an instrument of indebtedness of the bond issuer to the holders. It is a debt security, under which the issuer owes the holders a debt and, depending on the terms of the bond, is obliged to pay them interest (the coupon) and/or to repay the principal at a later date, termed the maturity date. Interest is usually payable at fixed intervals -semi-annual, annual and sometimes monthly. Very often the bond is negotiable, i.e. the ownership of the instrument can be transferred in the secondary market. Thus a bond is a form of loan or IOU: the holder of the bond is the lender (creditor), the issuer of the bond is the borrower (debtor), and the coupon is the interest.

Principal

Nominal, principal, par or face amount is the amount on which the issuer pays interest, and which, most commonly, has to be repaid at the end of the term. Some structured bonds can have a redemption amount which is different from the face amount and can be linked to performance of particular assets such as a stock or commodity index, foreign exchange rate or a fund. This can result in an investor receiving less or more than his original investment at maturity.

Maturity

The issuer has to repay the nominal amount on the maturity date. As long as all due payments have been made, the issuer has no further obligations to the bond holders after the maturity date. The length of time until the maturity date is often referred to as the term or tenor or maturity of a bond. The maturity can be any length of time, although debt securities with a term of less than one year are generally designated money market instruments rather than bonds.

Coupon

The coupon is the interest rate that the issuer pays to the holder. Usually this rate is fixed

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throughout the life of the bond. It can also vary with a money market index, such as LIBOR, or it can be even more exotic. The name "coupon" arose because in the past, paper bond certificates were issued which had coupons attached to them, one for each interest payment. On the due dates the bondholder would hand in the coupon to a bank in exchange for the interest payment. Interest can be paid at different frequencies: generally semi-annual, i.e. every 6 months, or annual.

Yield

The yield is the rate of return received from investing in the bond. It usually refers either to the current yield, or running yield, which is simply the annual interest payment divided by the current market price of the bond, or the yield to maturity or redemption yield, which is a more useful measure of the return of the bond, taking into account the current market price, and the amount and timing of all remaining coupon payments and of the repayment due on maturity. It is equivalent to the internal rate of return of a bond.

Bond Pricing

Bonds can be priced at a premium, discount, or at par. If the bond's price is higher than its par value, it will sell at a premium because its interest rate is higher than current prevailing rates. If the bond's price is lower than its par value, the bond will sell at a discount because its interest rate is lower than current prevailing interest rates. Fundamentally, however, the price of a bond is the sum of the present values of all expected coupon payments plus the present value of the par value at maturity.

$$\text{Bond Price} = \sum_{t}^{T} \frac{\text{coupon}}{(1+y)^{t}} + \frac{\text{Face Value}}{(1+y)^{t}}$$

Here t represents the time left for each coupon payment and T is the time to maturity, y is the required rate of return as prevalent in the market for the period of the bond. The succession of coupon payments to be received in the future is referred to as an ordinary annuity, which is a series of fixed payments at set intervals over a fixed period of time. If the Coupon is paid at Half-Yearly intervals the Bond Price is calculated as under:

$$\text{Bond Price} = \sum_{t}^{T} \frac{\text{Coupon}}{(1+\frac{y}{2})^{t}} + \frac{\text{Face Value}}{(1+\frac{y}{2})^{t}}$$

Pricing Zero-Coupon Bonds

In zero-coupon bond, there is no coupon payment until maturity. We simply calculate the present value of the par value (Face Value) at maturity.

$$\text{Zero Coupon Bond Price} = \frac{\text{Face Value}}{(1+y)^{t}}$$

Here y is the required rate of return and t is the period after which redemption is due for the Zero Coupon Bond.

Yield and Bond Price

The general definition of yield is the return an investor will receive by holding a bond to maturity. Required yield, on the other hand, is the yield or return a bond must offer in order for it to be worthwhile for the investor. The required yield of a bond is usually the yield offered by other plain vanilla bonds that are currently offered in the market and have similar credit quality and maturity.

Calculating Current Yield

The current yield calculates the percentage return that the annual coupon payment provides to the investor.

$$\textbf{Current Yield} = \frac{\text{Coupon Payment}}{\text{Current Market Price of the Bond}} \times 100$$

This calculation does not include any capital gains or losses the investor would make if the bond were bought at a discount or premium. Because the comparison of the bond price to its par value is a factor that affects the actual current yield, the above formula would give a slightly inaccurate answer - unless of course the investor pays par value for the bond. To correct this, investors can modify the current yield formula by adding the result of the current yield to the gain or loss the price gives the investor: [(Par Value – Bond Price)/Years to Maturity]. The modified current yield formula then takes into account the discount or premium at which the investor bought the bond.

$$\textbf{Adjusted Current Yield} = \left[\frac{\text{Annual Coupon}}{\text{Market Price}}\right] \times 100 + \left[\frac{(\text{Face Vlue} - \text{Market Price})}{\text{Years to Maturity}}\right]$$

Yield to Maturity (YTM)

The current yield calculation does not take into account the time value of money or, more specifically, the present value of the coupon payments the investor will receive in the future. Yield to maturity (also called YTM) is the most popular concept used to compare bonds. It refers to the Internal Rate of Return earned from holding the bond till maturity.

Duration

It is a measurement of how long, in years, it takes for the price of a bond to be repaid by its internal cash flows. It is an important measure for investors to consider, as bonds with higher durations carry more risk and have higher price volatility than bonds with lower durations. For two basic types of bonds the duration is the following:

A. Zero-Coupon Bond –Duration is equal to its time to maturity.
B. Vanilla Bond - Duration will always be less than its time to maturity.

TYPES OF DURATIONS –

There are four main types of duration calculations, each of which differ in the way they account for factors such as interest rate changes and the bond's embedded options or redemption features. The four types of durations are Macaulay Duration, Modified Duration, Effective Duration and Key Rate Duration. However, we will concentrate only on Macaulay and Modified duration for the sake of simplicity in this paper.

Macaulay Duration

Macaulay duration is calculated by adding the results of multiplying the present value of each cash flow by the time it is received and dividing by the total price of the security. The formula for Macaulay duration is as follows:

$$\textbf{Macaulay duration} = \frac{\sum_{t}^{n} 1 \frac{t*c}{(1+y)^{t}} + \frac{n*M}{(1-y)^{n}}}{P}$$

n = number of cash flows
t = time to maturity
C = cash flow
y = required yield
M = maturity (par) value
P = Bond Price

TABLE-1
DURATION WITH INCREASING MATURITY PERIOD

S.No.	Maturity Period-Years	Coupon (%)	Yield (%)	Duration
1	2	8	7	1.89
2	3	8	7	2.73
3	4	8	7	3.51
4	5	8	7	4.24
5	6	8	7	4.91
6	7	8	7	5.54
7	8	8	7	6.12
8	9	8	7	6.67
9	10	8	7	7.18
10	15	8	7	9.26
11	20	8	7	10.76

Thus duration of a Bond is always less than its maturity period.

Modified Duration

Modified duration is a modified version of the Macaulay model that accounts for changing interest rates. Because they affect yield, fluctuating interest rates will affect duration, so this modified formula shows how much the duration changes for each percentage change in yield. For bonds without any embedded features, bond price and interest rate move in opposite directions, so there is an inverse relationship between modified duration and an approximate 1% change in yield. Because the modified duration formula shows how a bond's duration changes in relation to interest rate movements, the formula is appropriate for investors wishing to measure the volatility of a particular bond. Modified duration is calculated as under:

$$\textbf{Modified Duration} = \left[\frac{Macaulay\ Duration}{\left\{1+\frac{Yield\ to\ Maturity}{Number\ of\ coupons\ period\ per\ year}\right\}}\right]$$

TABLE-2
DURATION AND MODIFIED DURATION-COMPARISION

S.No.	Maturity Period	Coupon (%)	Yield (%)	Duration	Modified Duration
1	2	8	7	1.89	1.82
2	3	8	7	2.73	2.64
3	4	8	7	3.51	3.39
4	5	8	7	4.24	4.09
5	6	8	7	4.91	4.74
6	7	8	7	5.54	5.39
7	8	8	7	6.12	5.92
8	9	8	7	6.67	6.44
9	10	8	7	7.18	6.93
10	15	8	7	9.26	8.95
11	20	8	7	10.76	10.40

It is evident from the above that Modified Duration of Bond is always less than its Duration.

Duration and Bond Price Volatility

When interest rates rise, bond prices fall, and vice versa. But how does one determine the degree of a price change when interest rates change? Generally, bonds with a high duration will have a higher price fluctuation than bonds with a low duration. But it is important to know that there are also three other factors that determine how sensitive a bond's price is to changes in interest rates. These factors are term to maturity, coupon rate and yield to maturity. Knowing what affects a bond's volatility is important to investors who use duration-based immunization strategies in their portfolios. Three factors which influence the volatility of a bond are:

i.Coupon Rate
ii.Term to Maturity ,and
iii.Yield to Maturity

Factors i. and ii. : Coupon rate and Term to Maturity

If term to maturity and a bond's initial price remain constant, the higher the coupon, the lower the volatility, and the lower the coupon, the higher the volatility. Here we have taken fixed maturity of 10 years and coupon rate has been varied from 10% to 19% and the percentage change in price (volatility) has been compared with percentage change in coupon.

TABLE-3
CONSTANT MATURITY AND CONSTANT YIELD
INCREASING COUPON VS PRICE CHANGE (VOLATILITY)

S.No.	Maturity in years	Yield	Coupon	Market Price*	% Change in Coupon	% Change in Price (Volatility)
1	10	7	10	122.75	-	-
2	10	7	11	130.33	10.00	6.18
3	10	7	12	137.91	9.09	5.82
4	10	7	13	145.50	8.33	5.50
5	10	7	14	153.08	7.69	5.21
6	10	7	15	160.66	7.14	4.99
7	10	7	16	168.25	6.67	4.72
8	10	7	17	175.83	6.25	4.51
9	10	7	18	183.41	5.88	4.31
10	10	7	19	191.00	5.56	4.13

* Face Value of the Bond has been taken as Rs 100 for better understanding and Market Price of Bond has been calculated accordingly.

If the coupon rate and the bond's initial price are constant, the bond with a longer term to maturity will display higher price volatility and a bond with a shorter term to maturity will display lower price volatility. Therefore, if one would like to invest in a bond with minimal interest rate risk, a bond with high coupon payments and a short term to maturity would be optimal.

TABLE-4
INCREASING MATURITY AND CONSTANT YIELD
CHANGE IN MATURITY VS CHANGE IN PRICE (VOLATILTY)

S.No.	Yield %	Maturity Period in years	Coupon (Interest Rate (%)	Price*	change in Maturity in years	% Change in Price (Volatility)
1	9	10	10	106.50	-	
2	9	11	10	106.89	1	0.36
3	9	12	10	107.25	2	0.70
4	9	13	10	107.57	3	1.00
5	9	14	10	107.87	4	1.28
6	9	15	10	108.14	5	1.54
7	9	16	10	108.39	6	1.78
8	9	17	10	108.62	7	1.99
9	9	18	10	108.83	8	2.19
10	9	19	10	109.02	9	2.37

* Face Value of the Bond has been taken as Rs 100 for better understanding and Market Price of Bond has been calculated accordingly.

Factor iii.: Yield to Maturity (YTM)

The sensitivity of a bond's price to changes in interest rates also depends on its yield to maturity. A bond with a high yield to maturity will display lower price volatility than a bond with a lower yield to maturity, but a similar coupon rate and term to maturity. Yield to maturity is affected by the bond's credit rating, so bonds with poor credit ratings will have higher yields than bonds with excellent credit ratings. Therefore, bonds with poor credit ratings typically display lower price volatility than bonds with excellent credit ratings.

TABLE-5
CONSTANT MATURITY, CONSTANT COUPON
INCREASING YIELD VS CHANGE IN PRICE (VOLATILITY)

S. No.	Maturity in years	Yield %	Coupon %	Market Price*	% Change in Coupon	% Change in Price
1	10	5	12	154.56	-	-
2	10	6	12	144.63	20	6.42
3	10	7	12	135.53	40	12.31
4	10	8	12	127.18	60	17.72
5	10	9	12	119.51	80	22.68
6	10	10	12	112.46	100	27.24
7	10	11	12	105.98	120	31.44
8	10	12	12	100.00	140	35.30
9	10	13	12	94.49	160	38.87
10	10	14	12	89.41	180	42.16

* Face Value of the Bond has been taken as Rs 100 for better understanding and Market Price of Bond has been calculated accordingly.

The volatility in price is quite high when the yield is low but tapers off as the yield increases. So, if a bond has both a short term to maturity and a low coupon rate, its characteristics have opposite effects on its volatility: the low coupon raises volatility and the short term to maturity lowers volatility. The bond's volatility would then be an average of these two opposite effects.

IMMUNIZATION STRATEGIES

The interrelated factors of duration, coupon rate, term to maturity and price volatility are important for those investors employing duration-based immunization strategies. These strategies aim to match the durations of assets and liabilities within a portfolio for the purpose of minimizing the impact of interest rates on the net worth. Understanding what duration is, how it is used and what factors affect it will help one to determine a bond's price volatility. Volatility is an important factor in determining the strategy for capitalizing on interest rate movements. Thus Bond immunization is an investment strategy used to minimize the interest rate risk of bond investments by adjusting the portfolio duration to match the investor's investment time horizon. It does this by locking in a fixed rate of return during the amount of time an investor plans to keep the investment without cashing it in. Normally, interest rates affect bond prices inversely. When interest rates go up, bond prices go down. But 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. In other words, the bond is "immune" to fluctuating interest rates. To immunize a bond portfolio, one need to know the duration of the bonds in the portfolio and adjust the portfolio so that the portfolio's duration equals the investment time horizon. A portfolio is immunized when its duration equals the investor's time horizon. At this point, any changes to interest rates will affect both price and reinvestment at the same rate, keeping the portfolio's rate of return the same. Maintaining an immunized portfolio means rebalancing the portfolio's average duration every time interest rates change, so that the average duration continues to equal the investor's time horizon.

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