

Yield to Maturity (YTM) 10%

EVALUATE the change in the expected market price of the Bond, if there is a decrease in the YTM by 200 basis points based on

- (i) By Macaulay's Duration after making Convexity Adjustment.
- (ii) By Intrinsic Value Method.

Given

Years	1	2	3	4	5
PVIF (10%, n)	0.909	0.826	0.751	0.683	0.621
PVIF (8%, n)	0.926	0.857	0.794	0.735	0.681

(MTP April – 2022)

Solution:

Macaulay's Duration

Year	CF	YTM (10%)	P.V.	Weights	W × year
1	850	0.909	772.65	0.082	0.082
2	850	0.826	702.10	0.074	0.148
3	850	0.751	638.35	0.068	0.204
4	850	0.683	580.55	0.062	0.248
5	10,850	0.621	6737.85	0.714	3.570
			9431.50		4.252

$$\begin{aligned} \text{Macaulay's Duration} &= \frac{D}{1 + \text{YTM}} \\ &= \frac{4.252}{1.10} = 3.865 \end{aligned}$$

Intrinsic Value

Yield = 12%

$$\begin{aligned} IV_0 &= (850 \times 3.605) + (10,000 \times 0.567) \\ &= ₹ 8,734.25 \end{aligned}$$

Yield = 8%

$$IV_0 = (850 \times 3.993) + (10,000 \times 0.681)$$

$$= ₹ 10,204.05$$

Calculation of Convexity

$$C^* = \frac{P_2 + P_1 - 2 P_0}{2 P_0 \times \Delta Y^2}$$

$$= \frac{10,204.05 + 8,734.25 - 2 \times 9,431.50}{2 \times 9,431.0 \times (0.02)^2}$$

$$= 9.979$$

$$C.A = C^* \times 100 \times \Delta Y^2$$

$$= 9.979 \times 100 \times (0.02)^2$$

$$= 0.399$$

Bond price after CA**Yield ↓ 200 BP**

$$\text{Effective Duration} = \left(-3.865 \times \frac{-200}{100} \right) + 0.399$$

$$= 8.129$$

$$\text{Price} = 9,431.50 + 8.129\% = 10,198$$

Yield ↓ 200 BP

- * On the basis of Macaulay Duration after C.A.

$$\text{Price} = ₹ 10,198$$

- * On the basis of Intrinsic Value

$$\text{Price} = 10,204.05$$

Question – 18

An investor, in the beginning of 2022, has purchased substantial number of 8 year 7.50% ₹ 1,000 bond with 5% premium on maturity at a required Yield to Maturity (YTM) of 8.50%. However, due to the continuing war in Europe, the inflation is running very high in the economies of the countries. The yield on

the bonds is decreasing. The risk averse investor wants to protect himself from further loss and decides to sell the bonds in 2023. He has got a proposal from another investor who is willing to purchase these bonds by shelling out a maximum amount of ₹ 797.50 per bond.

Investor follows intrinsic value method for valuation of the Bonds.

You are required to determine

- (i) The market price, duration and volatility of the bond.
- (ii) Will it be a right decision of the new investor if he is looking for Required Yield to Maturity (YTM) as 12% p.a.?

Period	1	2	3	4	5	6	7
PVIF (8.50%, n)	0.9217	0.8495	0.7829	0.7216	0.6650	0.6129	0.5649

(Exam May – 2023)

Solution:

(i) (A) Market Price of Bond

$$\begin{aligned}
 &= 1,000 \times 7.50\% \times (\text{PVIAF } 8.50\%, 7) + 1,050 \times (\text{PVIF } 8.5\%, 7) \\
 &= 75 \times 5.1185 + 1050 \times 0.5649 \\
 &= 383.89 + 593.15 = ₹ 977.04
 \end{aligned}$$

(B) Duration of Bond

Year	Cash Flow	P.V. @ 8.5%		Proportion of Bond Value	Proportion of Bond Value × Time (years)
1	75	0.9217	69.128	0.071	0.071
2	75	0.8495	63.713	0.065	0.130
3	75	0.7829	58.718	0.060	0.180
4	75	0.7216	54.120	0.055	0.220
5	75	0.6650	49.875	0.051	0.255
6	75	0.6129	45.968	0.047	0.282
7	1125	0.5649	635.513	0.651	4.557
			977.035		5.695

Duration of the Bond is 5.695 years.

Alternatively, it can also be calculated as follows:

Year (1)	Cash flow (2)	PVF (3)	PV (4)	(1) × (4)
1	75	0.9217	69.13	69.13
2	75	0.8495	63.71	127.42
3	75	0.7829	58.72	176.16
4	75	0.7216	54.12	216.48
5	75	0.6650	49.88	249.40
6	75	0.6129	45.97	275.82
7	1125	0.5649	635.51	4448.57
			977.04	5562.98

$$\text{Duration of the Bond} = \frac{5,562.98}{977.04} = 5.69 \text{ years}$$

(C) Volatility of Bond

$$\begin{aligned} \text{Volatility} &= \text{Duration} / (1 + \text{YTM}) \\ &= 5.695 / (1 + 0.085) = 5.249 \\ \text{Or} &= 5.69 / (1 + 0.085) = 5.24 \end{aligned}$$

(ii) PV of Bond @ 12% YTM

$$\begin{aligned} &= ₹ 75 \text{ PVIAF } (12\%, 7) + ₹ 1050 \times \text{PVIF } (12\%, 7) \\ &= ₹ 75 \times 4.5637 + ₹ 1050 \times 0.4523 \\ &= ₹ 342.28 + ₹ 474.92 = ₹ 817.20 \end{aligned}$$

Since, Intrinsic Value of Bond is ₹ 817.20 the decision of new investor is right at purchase price of ₹ 797.50.

BOND IMMUNIZATION

Question – 19

Mr. A will need ₹ 1,00,000 after two years for which he wants to make one time necessary investment now. He has a choice of two types of bonds. Their details are as below:

	Bond X	Bond Y
Face value	₹ 1,000	₹ 1,000
Coupon	7% payable annually	8% payable annually
Years to maturity	1	4

Current price	₹ 972.73	₹ 936.52
Current yield	10%	10%

Advice Mr. A whether he should invest all his money in one type of bond or he should buy both the bonds and, if so, in which quantity? Assume that there will not be any call risk or default risk.

(SM TYK – 27, MTP March – 2021 & RTP November – 2021)

Solution:

Bond Duration [Bond X]

YEAR	CF	PVF (10%)	PV	WEIGHT	YEAR × W
1	1,070	0.909	972.63	1	1
			972.63	Bond Duration = 1	

Bond Duration [Bond Y]

YEAR	CF	PVF (10%)	PV	WEIGHT	YEAR × W
1	80	0.909	72.72	0.078	0.078
2	80	0.826	66.08	0.071	0.142
3	80	0.757	60.08	0.064	0.192
4	1080	0.683	737.64	0.788	3.152
			936.52	Bond Duration = 3.564	

Duration of Liability = 2 years, hence we have to invest in bond having duration is 2 years but such bond is not available

In this situation, we have to invest in both bonds in a proportion so that duration of bonds should be 2 years

Immunization is a period at which

$$D_L = D_A$$

$$2 = (1 \times W_A) + (3.564 \times W_B)$$

$$2 = W_A + 3.564 (1 - W_A)$$

$$2 = W_A + 3.564 - 3.564 W_A$$

$$W_A = 0.61$$

$$W_B = 0.39$$

$$\begin{aligned}
 \text{Investment in x} &= ₹ 1,00,000 \times 0.61 \\
 &= ₹ 61,000 \\
 &= ₹ 61,000 \times 0.826 \\
 &= ₹ 50,386
 \end{aligned}$$

$$\begin{aligned}
 \text{No.} &= \frac{₹ 50,386}{972.73} = 51.80 \\
 &= 52 \text{ Bonds}
 \end{aligned}$$

$$\begin{aligned}
 \text{Investment in y} &= ₹ 1,00,000 \times 0.39 \\
 &= ₹ 39,000 \\
 &= ₹ 39,000 \times 0.826 \\
 &= ₹ 32,214
 \end{aligned}$$

$$\begin{aligned}
 \text{No.} &= \frac{₹ 32,214}{936.52} = 34.40 \\
 &= 34 \text{ Bonds}
 \end{aligned}$$

Question – 20

The following data are available for three bonds A, B and C. These bonds are used by a bond portfolio manager to fund an outflow scheduled in 6 years. Current yield is 9%. All bonds have face value of ₹ 100 each and will be redeemed at par. Interest is payable annually.

Bond	Maturity (Years)	Coupon rate
A	10	10%
B	8	11%
C	5	9%

- (i) Calculate the duration of each bond.
- (ii) The bond portfolio manager has been asked to keep 45% of the portfolio money in Bond A. Calculate the percentage amount to be invested in bonds B and C that need to be purchased to immunize the portfolio.

- (iii) After the portfolio has been formulated, an interest rate change occurs, increasing the yield to 11%. The new duration of these bonds are: Bond A = 7.15 years, Bond B = 6.03 years and Bond C = 4.27 years.

Is the portfolio still immunized? Why or why not?

- (iv) Determine the new percentage of B and C bonds that are needed to immunize the portfolio. Bond A remaining at 45% of the portfolio.

Present values be used as follows:

Present Values	t_1	t_2	t_3	t_4	t_5
$PVIF_{0.09,t}$	0.917	0.842	0.772	0.708	0.650

Present Values	t_6	t_7	t_8	t_9	t_{10}
$PVIF_{0.09,t}$	0.596	0.547	0.502	0.460	0.4224

(MTP March – 2021)

Solution:

(i) Calculation of Bond Duration

Bond A

Year	Cash flow	P.V. @ 9%		Proportion of bond value	Proportion of bond value $\times$ time (years)
1	10	0.917	9.17	0.086	0.086
2	10	0.842	8.42	0.079	0.158
3	10	0.772	7.72	0.073	0.219
4	10	0.708	7.08	0.067	0.268
5	10	0.650	6.50	0.061	0.305
6	10	0.596	5.96	0.056	0.336
7	10	0.547	5.47	0.051	0.357
8	10	0.502	5.02	0.047	0.376
9	10	0.460	4.60	0.043	0.387
10	110	0.4224	46.46	0.437	4.370
			106.40	1.000	6.862

Duration of the bond is 6.862 years or 6.86 year

Bond B

Year	Cash flow	P.V. @ 9%		Proportion of bond value	Proportion of bond value × time (years)
1	11	0.917	10.087	0.091	0.091
2	11	0.842	9.262	0.083	0.166
3	11	0.772	8.492	0.076	0.228
4	11	0.708	7.788	0.070	0.280
5	11	0.650	7.150	0.064	0.320
6	11	0.596	6.556	0.059	0.354
7	11	0.547	6.017	0.054	0.378
8	111	0.502	55.772	0.502	4.016
			111.224	1.000	5.833

Duration of the bond B is 5.833 years or 5.84 years.

Bond C

Year	Cash flow	P.V. @ 9%		Proportion of bond value	Proportion of bond value × time (years)
1	9	0.917	8.253	0.082	0.082
2	9	0.842	7.578	0.076	0.152
3	9	0.772	6.948	0.069	0.207
4	9	0.708	6.372	0.064	0.056
5	109	0.650	70.850	0.709	3.545
			100.00	1.000	4.242

Duration of the bond C is 4.242 years or 4.24 years

(ii) Amount of Investment required in Bond B and C

$$DL = DA$$

$$6 = (6.86 \times 0.45) + 5.84 W_B + 4.24 (0.55 - W_B)$$

$$6 = 3.087 + 5.84 W_B + 2.332 - 4.24 W_B$$

$$0.581 = 1.6 W_B$$

$$W_B = 0.3631 \text{ (36.31\%)}$$

$$W_C = 1 - 0.45 - 0.3631$$

$$= 0.1869 \text{ (18.69\%)}$$

(iii) With revised yield the Revised Duration of Bond stands

$$0.45 \times 7.15 + 0.36 \times 6.03 + 0.19 \times 4.27 = 6.20 \text{ year}$$

No portfolio is not immunized as the duration of the portfolio has been increased from 6 years to 6.20 years.

(iv) New percentage of B and C bonds that are needed to immunize the portfolio.

$$DL = DA$$

$$6.20 = (7.15 \times 0.45) + 6.03 W_B + 4.27 (0.55 - W_B)$$

$$6.20 = 3.218 + 6.03 W_B + 2.348 - 4.27 W_B$$

$$0.634 = 1.76 W_B$$

$$W_B = 0.3602 \text{ (36.02\%)}$$

$$W_C = 1 - 0.45 - 0.3602$$

$$= 0.1898 \text{ (18.90\%)}$$

(IV) OPTION EMBEDDED BONDS**(1) CONVERTIBLE BONDS****Question – 21**

The following data is related to 8.5% Fully Convertible (into Equity shares) Debentures issued by JAC Ltd. at ₹ 1,000.

Market Price of Debenture	₹ 900
Conversion Ratio	30
Straight Value of Debenture	₹ 700
Market Price of Equity share on the date of Conversion	₹ 25
Expected Dividend Per Share	₹ 1

You are required to calculate:

- (a) Conversion Value of Debenture
- (b) Market Conversion Price
- (c) Conversion Premium per share
- (d) Ratio of Conversion Premium
- (e) Premium over Straight Value of Debenture
- (f) Favorable income differential per share
- (g) Premium pay back period

(RTP November – 2021)

Solution:

- (a) Conversion Value of Debenture

= Market Price of one Equity Share $\times$ Conversion Ratio

$$= ₹ 25 \times 30 = ₹ 750$$

- (b) Market Conversion Price

$$= \frac{\text{Market Price of Convertible Debenture}}{\text{Conversion Ratio}}$$

$$= \frac{₹ 900}{30} = ₹ 30$$

- (c) Conversion Premium per share

Market Conversion Price – Market Price of Equity Share

$$= ₹ 30 - ₹ 25 = ₹ 5$$

- (d) Ratio of Conversion Premium

$$\frac{\text{Conversion premium per share}}{\text{Market Price of Equity Share}} = \frac{₹ 5}{₹ 25} = 20\%$$

- (e) Premium over Straight Value of Debenture