CHAPTER 11

# Managing Bond Portfolios

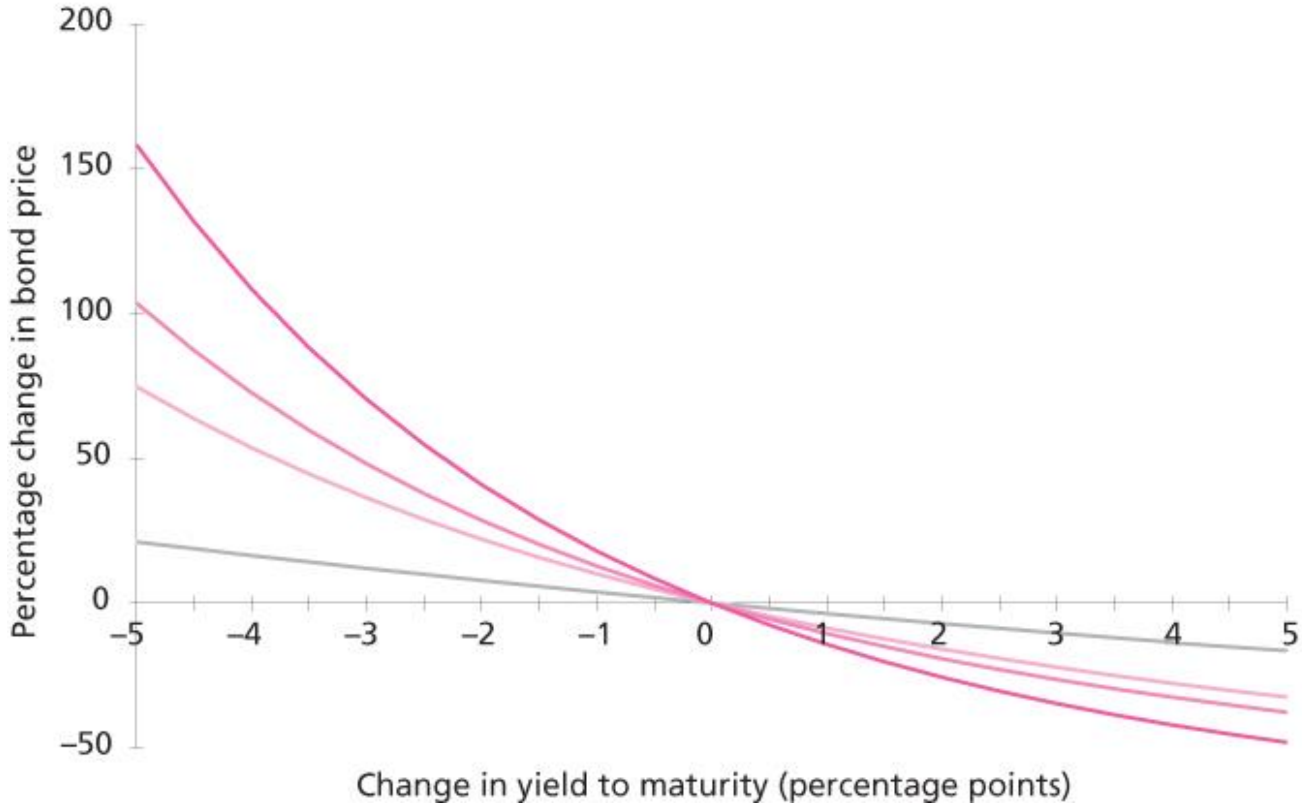
# Managing Fixed Income Securities: Basic Strategies

- Active strategy
  - has as its goal to secure superior returns from the fixed-income portfolio
  - Trade on interest rate predictions
  - Trade on market inefficiencies
- Passive strategy
  - takes market prices of securities as set fairly.
  - Act to maintain appropriate risk-return balance
  - Immunization strategy that attempts to insulate ***Pf*** from interest rate risk.

# Bond Pricing Relationships

1. Inverse relationship between price and yield
2. An increase in a bond's yield to maturity results in a smaller price decline than the gain associated with a decrease in yield
3. Long-term bonds tend to be more price sensitive than short-term bonds
4. As maturity increases, price sensitivity increases at a decreasing rate
5. Price sensitivity is inversely related to a bond's coupon rate
6. Price sensitivity is inversely related to the yield to maturity at which the bond is selling

# Figure 11.1 Change in Bond Price as a Function of YTM




| Bond | Coupon | Maturity | Initial YTM |
|---|---|---|---|
| *A* | 12% | 5 years | 10% |
| *B* | 12% | 30 years | 10% |
| *C* | 3% | 30 years | 10% |
| *D* | 3% | 30 years | 6% |

# Duration

- A measure of the effective maturity of a bond

→***Duration measures the period of time required to recover the initial investment on the loan***.

- The weighted average of the times until each payment is received, with the weights proportional to the present value of the payment
- Duration is shorter than maturity for all bonds except zero coupon bonds
- Duration is equal to maturity for zero coupon bonds

# Example of Duration

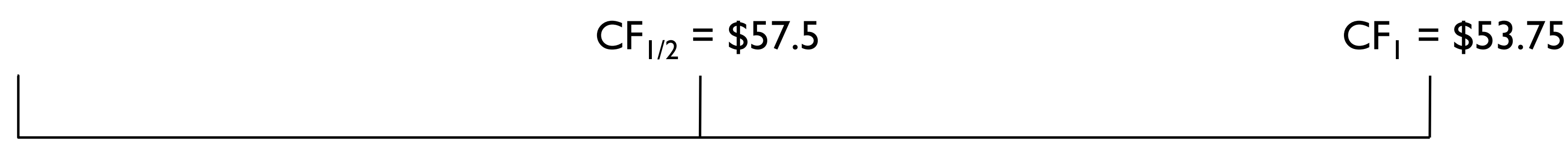
- Bond w/ one-year 15% annual interest rate.
- Pay half of $100 at the end of six months.

$CF_{1/2}$= \$57.5 (\$100×0.075) $PV_{1/2}$ = \$57.5/(1.075) = \$53.49

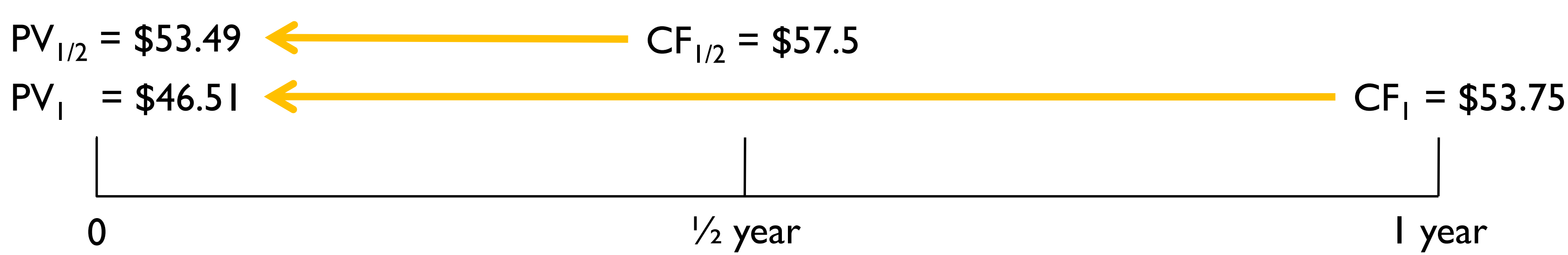
$CF_{1}$ = \$53.75 (\$50×0.075) $PV_{1}$ = \$53.75/(1.075) = \$46.51

$CF_{1/2}$ + $CF_{1}$ = \$111.25 $PV_{1/2}$ + $PV_{1}$ = \$100.00

**< Promised cash flows on the one year <u>loan</u> >**




**< PV of the cash flows from the <u>loan</u> >**



# Example of Duration (continued)

- $X_{1/2}$(= HPR of $PV_{1/2}$) + $X_1$(=HPR of $PV_1$) = 1

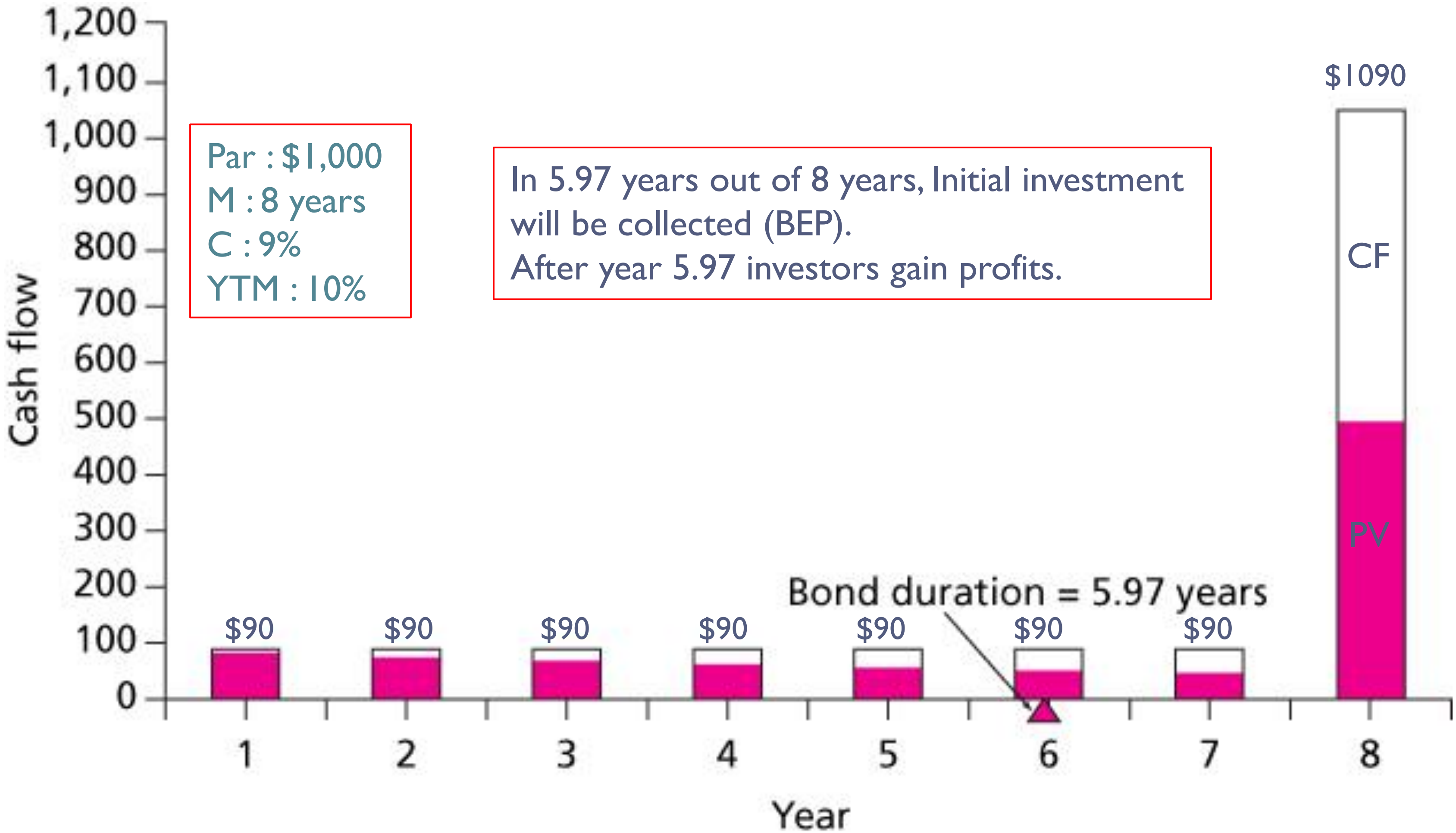
  where, X is weight

- Dur = $PV_{1/2}$ (1/2) + $PV_1$(1) = 0.5349(1/2) + 0.4651(1)

  = ***<u>0.7326 years</u>***

→ ***<u>Initial investment is recovered after 0.7326 years. After that time this investor earns profits.</u>***

# Figure 10.2 Cash Flows of 8-yr Bond with 9% annual coupon and 10% YTM



# Duration: Calculation

$$w_t = \frac{CF_t \big/ (1+r)^t}{\text{Bond price}}$$

$$D = \sum_{t=1}^{T} t \times w_t$$

$CF_t$ = Cash flow for period $t$

# Duration Calculation

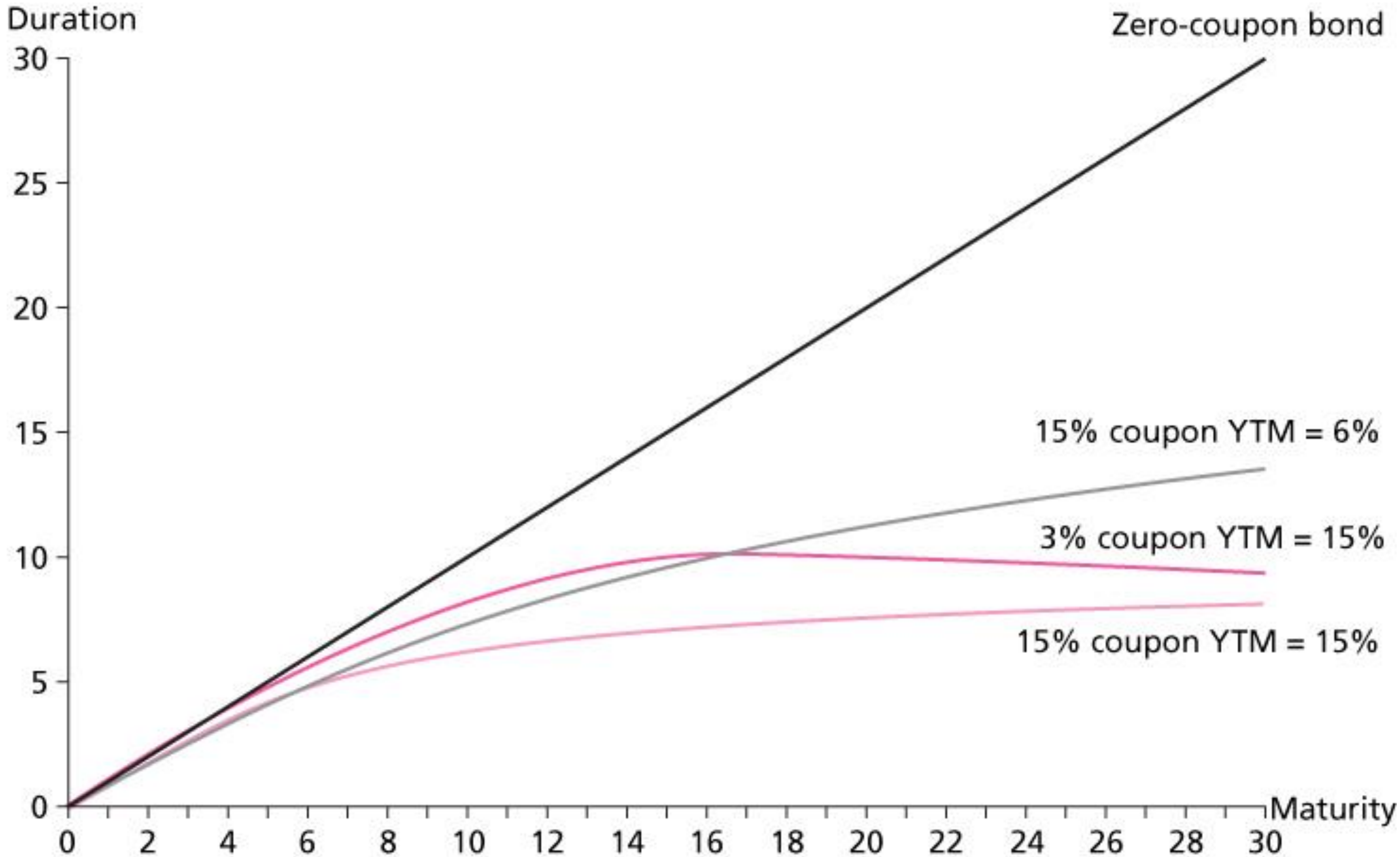
| 8% (annual) Bond | Time Year | Payment | PV of CF (10%) | Weight | Years× Weight |
|---|---|---|---|---|---|
| 1 | 1 | 80 | 72.727 | 0.0765 | 0.0765 |
| 2 | 2 | 80 | 66.116 | 0.0690 | 0.1392 |
| 3 | 3 | 1,080 | 811.420 | 0.8539 | 2.5617 |
| Sum | | | 950.263 | 1.00 | 2.7774 |

| 8% (semi-) Bond | Time Year | Payment | PV of CF (10%) | Weight(W) | W × years |
|---|---|---|---|---|---|
| 1 | 0.5 | 40 | 36.36364 | 0.049228 | 0.024614 |
| 2 | 1 | 40 | 33.05785 | 0.044752 | 0.044752 |
| 3 | 1.5 | 40 | 30.05259 | 0.040684 | 0.061026 |
| 4 | 2 | 40 | 27.32054 | 0.036985 | 0.073971 |
| 5 | 2.5 | 40 | 24.83685 | 0.033623 | 0.084058 |
| 6 | 3 | 1040 | 587.0529 | 0.794728 | 2.384183 |
| | | | 738.6844 | 1.00 | 2.672604 |

# What determines Duration?

- ***Rule 1*** : The duration of zero-coupon bond equals its time to maturity.
- ***Rule 2*** : Holding time to maturity and yield to maturity constant, a bond's duration and interest rate sensitivity are higher when the coupon rate is lower.
- ***Rule 3*** : Holding the coupon rate constant, a bond's duration and interest rate sensitivity generally increase w/ time to maturity. Duration always increases w/ maturity for bonds selling at par or at a premium to par.
- ***Rule 4*** : Holding other factors constant, the duration and interest rate sensitivity of a coupon bond are higher when the bond's yield to maturity is lower.
- ***Rule 5*** : The duration of a level perpetuity is (1+r)/r

# Figure 11.2 Duration as a Function of Maturity



# Example of Duration

- Face value = \$100, Maturity = 2 years
- YTM = 5%, Coupon rate = 50%
- Bond price = $(50/1.05)+(150/1.05^2)=183.67$

$$Dur=\sum_{t=1}^{n}(t)\times\left(\frac{CF(t)\big/(1+r)^t}{P}\right)=(1)\times\left(\frac{CF(1)\big/(1+r)^1}{P}\right)+(2)\times\left(\frac{CF(2)\big/(1+r)^2}{P}\right)$$

$$=(1)\times\frac{50\big/(1+0.05)}{183.67}+(2)\times\frac{150\big/(1+0.05)^2}{183.67}=0.257+2\times0.741=1.741\,years$$

# Duration/Price Relationship

- Price change is proportional to duration and not to maturity

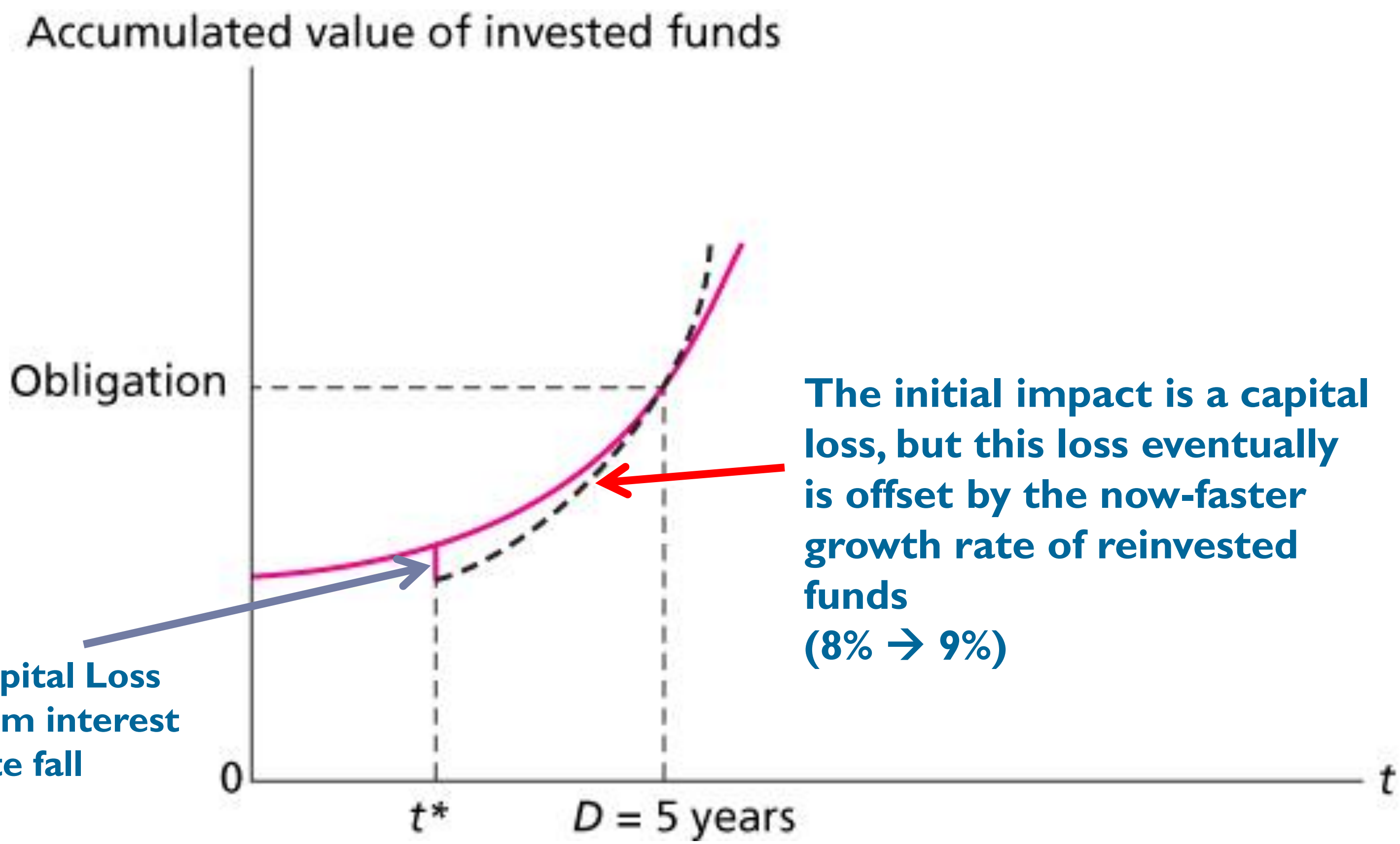
$$\frac{\Delta P}{P} = -D \times \left( \frac{\Delta r}{(1+r)} \right) = \frac{-D}{(1+r)} \times \Delta r = -MD \times \Delta r$$

where, MD= *modified duration*

# Uses of Duration

- Summary measure of length or effective maturity for a portfolio
- Immunization of interest rate risk (passive management)
  - Net worth immunization
  - Target date immunization
- Measure of price sensitivity for changes in interest rate

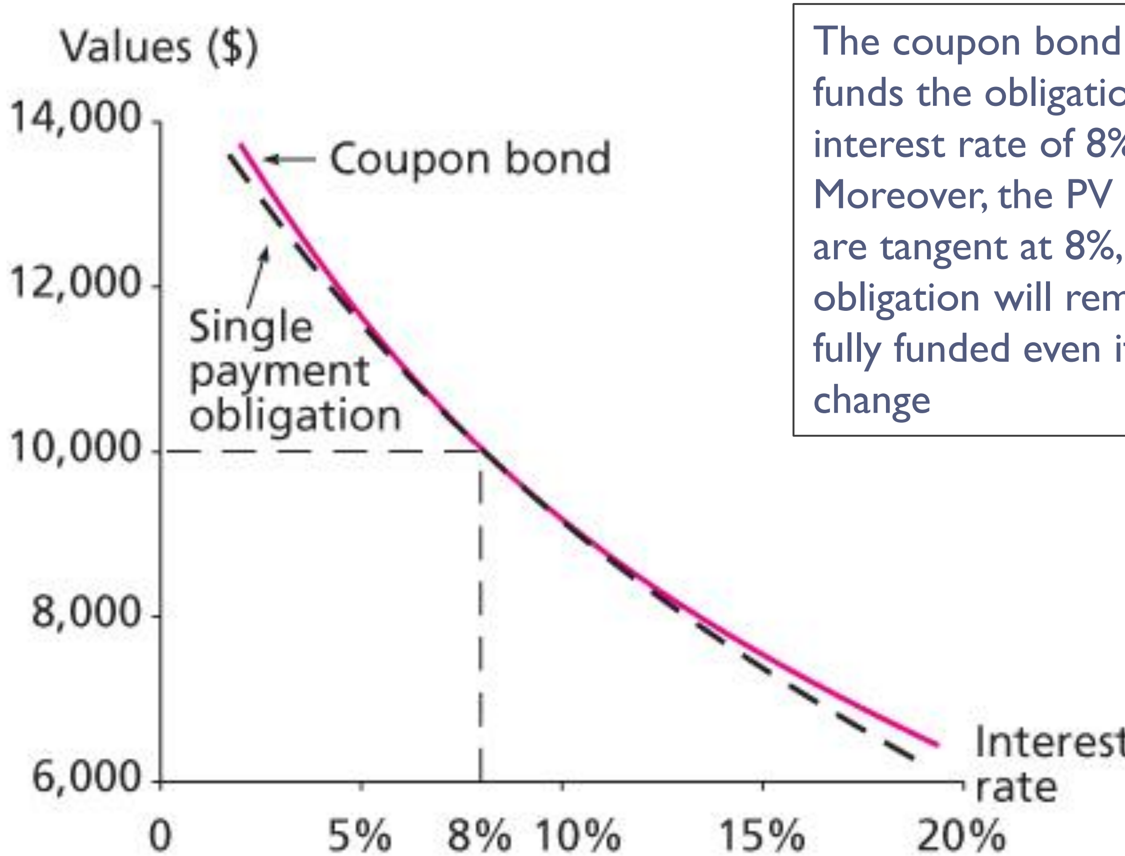
# Figure 11.3 Growth of Invested Funds




The initial impact is a capital loss, but this loss eventually is offset by the now-faster growth rate of reinvested funds
(8% → 9%)

Capital Loss from interest rate fall

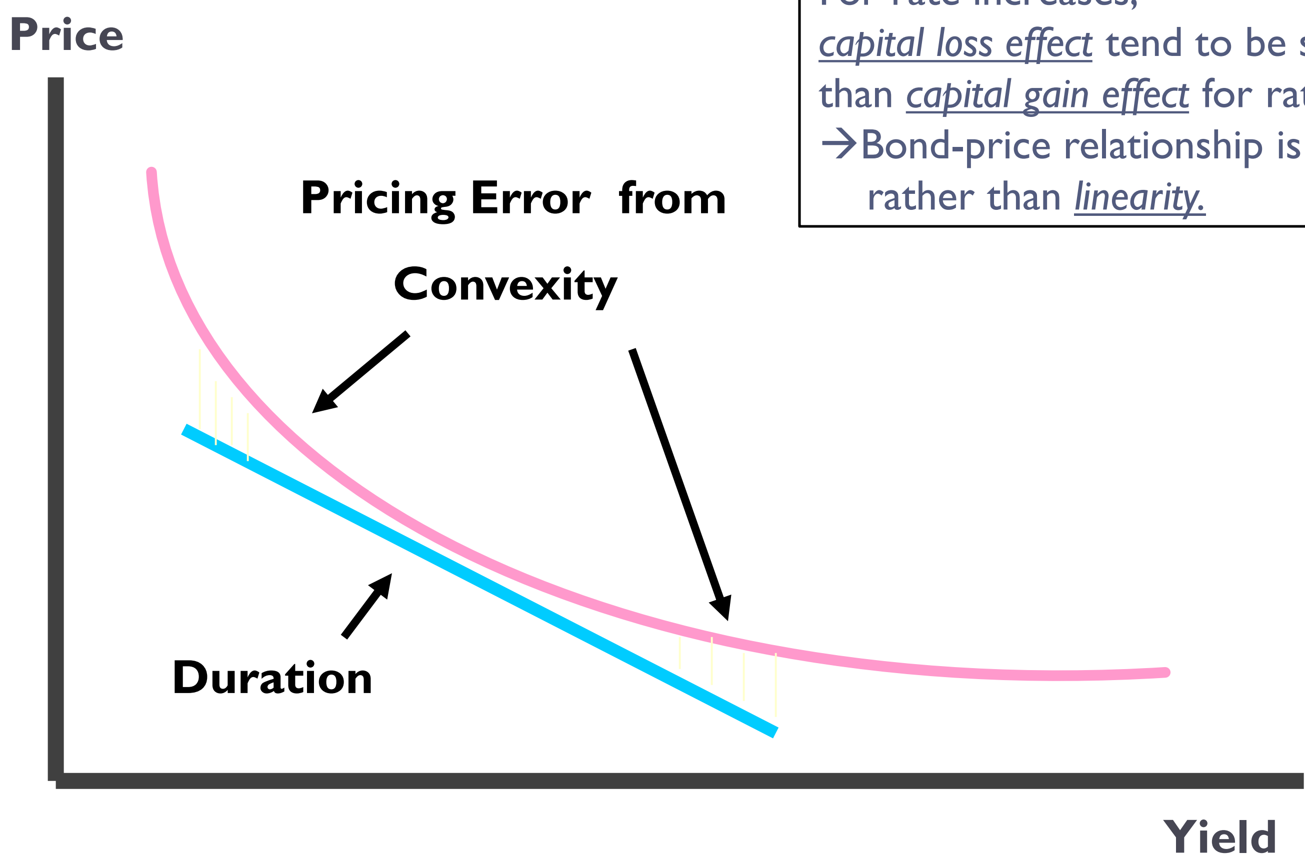
# Figure 11.4 Immunization




The coupon bond fully funds the obligation at an interest rate of 8%. Moreover, the PV curves are tangent at 8%, so the obligation will remain fully funded even if rates change

# Pricing Error from Convexity

For rate increases,
*capital loss effect* tend to be smaller
than *capital gain effect* for rate decreases
→Bond-price relationship is *convexity*
rather than *linearity.*



# Correction for Convexity

- ***Modify the pricing equation:***

$$\frac{\Delta P}{P} = -D \times \Delta r + \frac{1}{2} convexity \times (\Delta r)^2$$

- ***Convexity is Equal to:***

Scaling factor × [capital loss from 1bp rise in yield + capital gain from 1bp fall in yield]

$$Convexity = \frac{1}{P \times (1+r)^2} \sum_{t=1}^{n} \left[ \frac{CF_t}{(1+r)^t} (t^2 + t) \right]$$

Where, $CF_t$ is the cash flow (interest and/or principal) at time $t$.

# Example 11.4

- 30 year maturity, 8% coupon, 8% of initial YTM. This bond sells at par value, $1,000.
- Modified Duration = 11.26 years, Convexity = 212.4
- If YTM 8% → 10%, bond price will fall to $811.46 (18.85% decline)
- Prediction of price change is

$$\frac{\Delta P}{P} = -MD \times \Delta r = -11.26 \times 0.02 = -0.2252(-22.52\%)$$

- Use duration-with-convexity is

$$\frac{\Delta P}{P} = -D \times \Delta r + \frac{1}{2} convexity \times (\Delta r)^2$$

$$= -11.26 \times 0.02 + \frac{1}{2} \times 212.4 \times (0.02)^2 = -0.1827(-18.27\%)$$

# Calculation of CX

- Example: convexity of 8% coupon, 8% yield, six-year maturity Eurobond priced at $1,000.

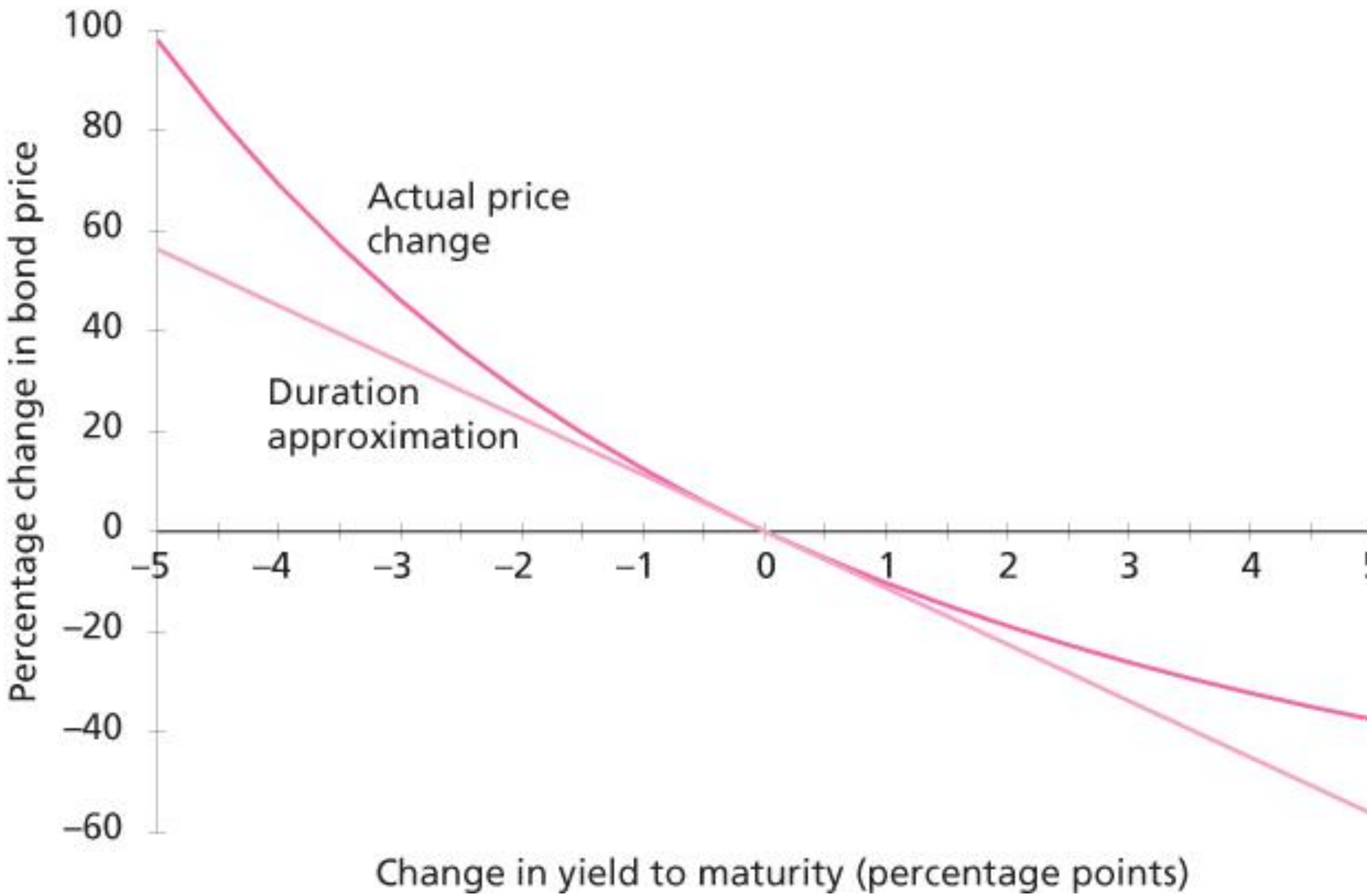
$$CX = 10^8\left[\frac{999.53785-1{,}000}{1{,}000}+\frac{1{,}000.46243-1{,}000}{1{,}000}\right]$$
$$= 10^8[0.00000028] = 28$$

- Price change from 2% increase in interest rate (8→10%)

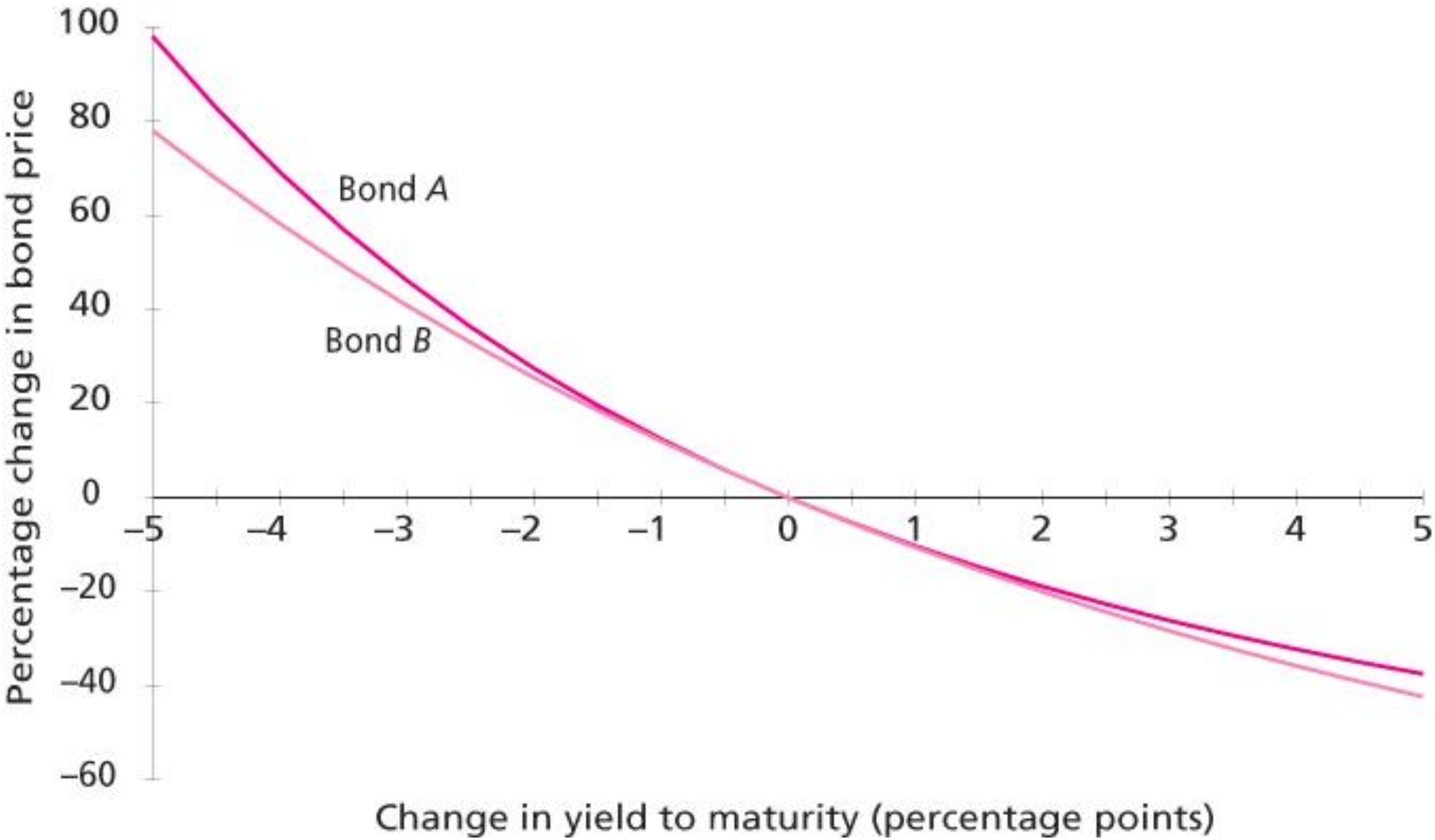
$$\frac{\Delta P}{P} = -MD\times\Delta r + \frac{1}{2}\times Convexity\times(\Delta r)^2$$
$$= -\left[\frac{4.993}{1.08}\right]\times(0.02) + \frac{1}{2}(28)(0.02)^2$$
$$= -0.0925 + 0.0056 = -0.0869(-8.69\%)$$

→ ***Simple duration model predicts 9.25% drop on bond price***

# Figure 11.5 Bond Price Convexity

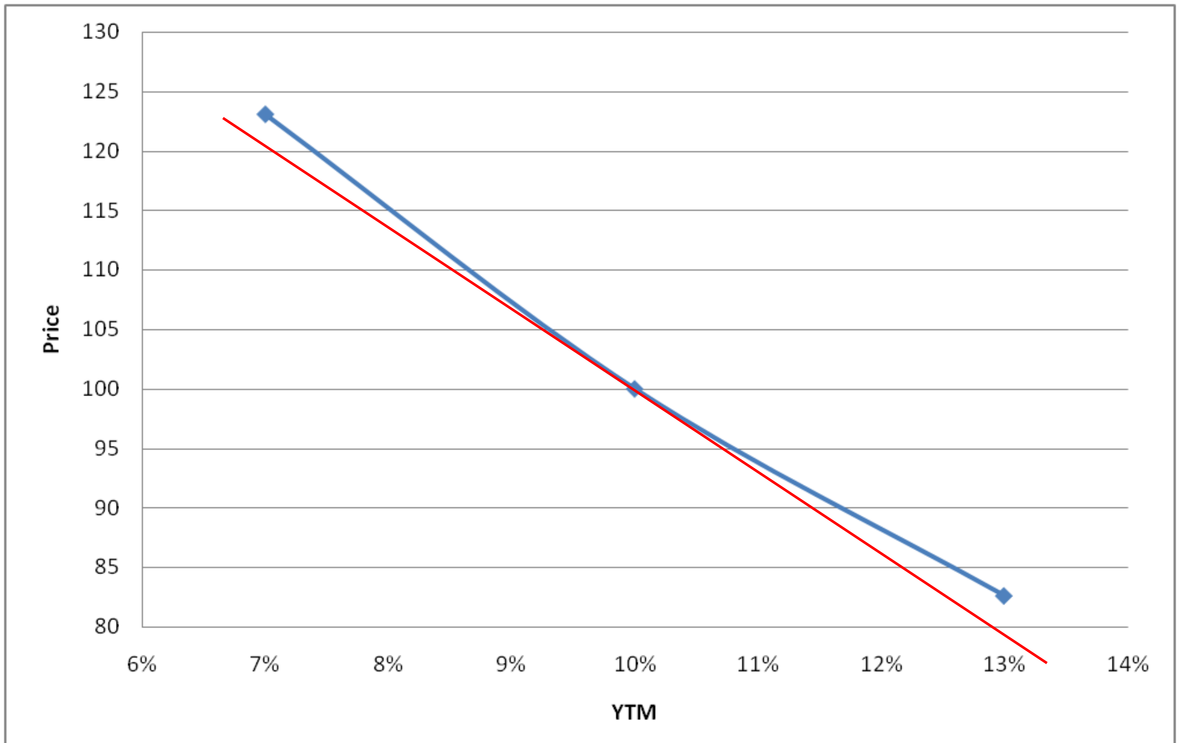


# Figure 11.6 Convexity of Two Bonds



# Example of Convexity

| | 2% | 10% | 18% |
|---|---|---|---|
| 1 | 9.803922 | 9.090909 | 8.474576 |
| 2 | 9.611688 | 8.264463 | 7.181844 |
| 3 | 103.6555 | 82.64463 | 66.9494 |
| total | 123.0711 | 100 | 82.60582 |



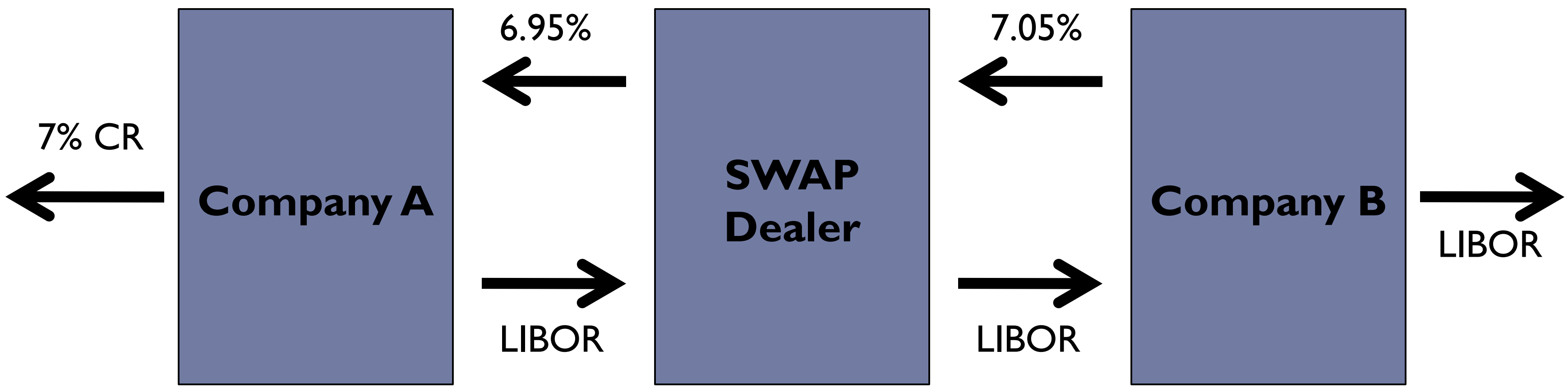
# Active Bond Management: Swapping Strategies

- ***Substitution swap***
  - Exchange of one bond for a bond with similar attributes but more attractively price.
- ***Intermarket swap***
  - Switching from one segment of the bond market to another.
- ***Rate anticipation swap***
  - A switch made in response to forecasts of interest rate changes.
- ***Pure yield pickup***
  - Moving to higher yield bonds, usually with longer maturities
- ***Tax swap***
  - Swapping two similar bonds to receive a tax benefit.

# Interest Rate Swaps

- ***Interest rate swap basic characteristics***
  - One party pays fixed and receives variable
  - Other party pays variable and receives fixed
  - Principal is notional
- ***Growth in market***
  - Started in 1980
  - Estimated over $60 trillion today
- ***Hedging applications***

# Interest rate swap: structure




- Company B pay 7.05% of fixed rate, receive LIBOR
- Company A pay LIBOR, receive 6.95% of fixed rate
- Dealer make 0.1% return in every period.