

## Bond's duration

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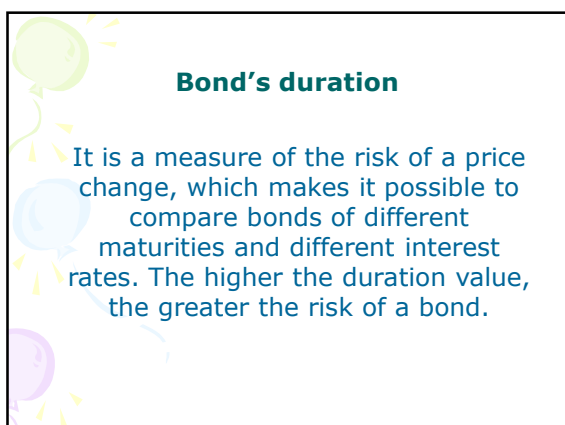
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### Bond's duration

It is a measure of the risk of a price change, which makes it possible to compare bonds of different maturities and different interest rates. The higher the duration value, the greater the risk of a bond.

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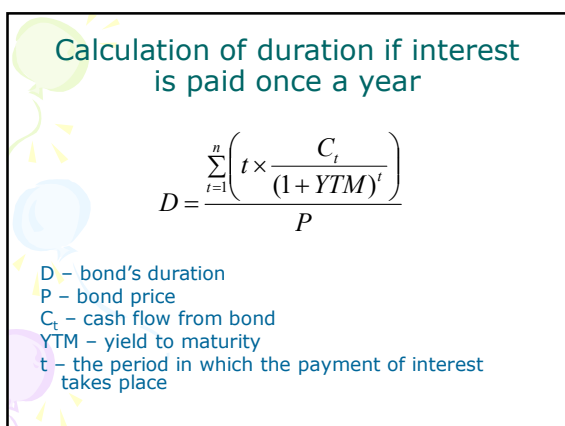
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### Calculation of duration if interest is paid once a year

$$D = \frac{\sum_{t=1}^n \left( t \times \frac{C_t}{(1+YTM)^t} \right)}{P}$$

D – bond's duration  
 P – bond price  
 C<sub>t</sub> – cash flow from bond  
 YTM – yield to maturity  
 t – the period in which the payment of interest takes place

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Calculation of duration if interest is paid more than once a year

$$D = \frac{\sum_{t=1}^{nm} \left( t \times \frac{C_t}{\left(1 + \frac{YTM}{m}\right)^t} \right)}{P} \div m$$

- D – bond's duration
- P – bond price
- C<sub>t</sub> – cash flow from bond
- YTM – yield to maturity
- t – the period in which the payment of interest takes place
- m – number of interest payments during the year

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The formula for calculating the approximate percentage change of the price of bonds when the rate of return changes on time to maturity

$$\frac{P_1 - P_0}{P_0} = -D \times \frac{(1 + YTM_1) - (1 + YTM_0)}{1 + YTM_0}$$

- P<sub>0</sub> – the price of bond before the change of rate of return
- P<sub>1</sub> – the price of bond after the change of rate of return
- D – bond's duration
- YTM<sub>0</sub> – yield to maturity before the change
- YTM<sub>1</sub> – yield to maturity after the change

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Duration of the bond portfolio

$$D_p = \sum_{i=1}^n (w_i \times D_i)$$

- D<sub>p</sub> – duration of the bond portfolio
- w<sub>i</sub> – the weight of individual bonds in the portfolio
- D<sub>i</sub> – duration of individual bonds in the portfolio

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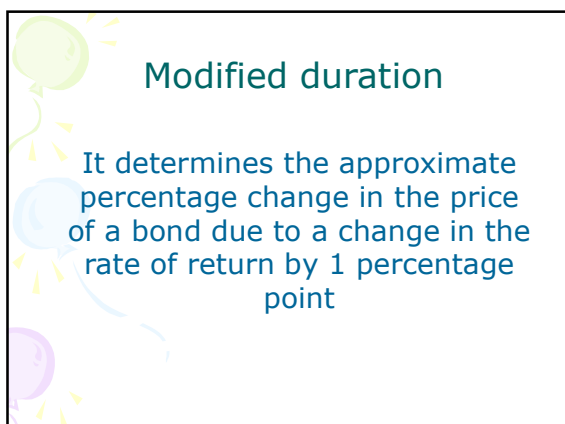
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### Modified duration

It determines the approximate percentage change in the price of a bond due to a change in the rate of return by 1 percentage point

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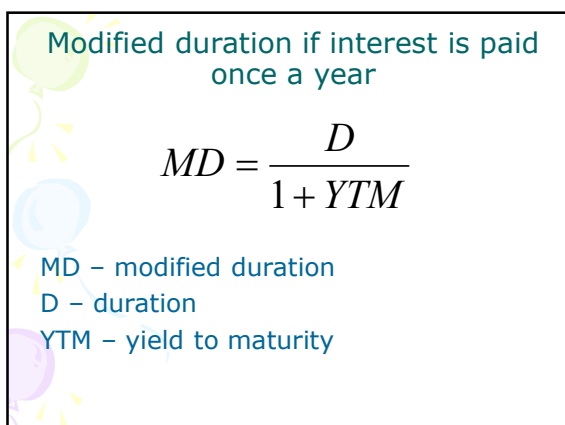
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### Modified duration if interest is paid once a year

$$MD = \frac{D}{1 + YTM}$$

MD – modified duration  
D – duration  
YTM – yield to maturity

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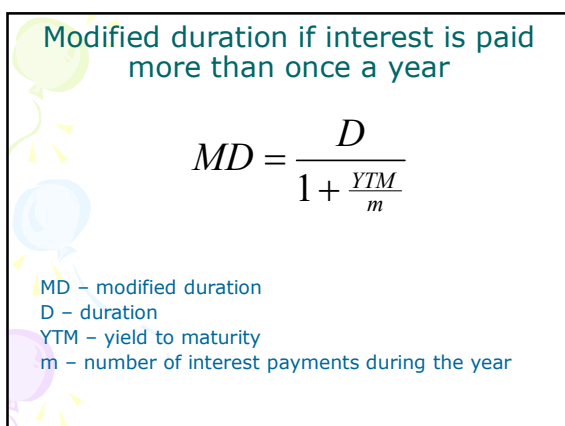
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### Modified duration if interest is paid more than once a year

$$MD = \frac{D}{1 + \frac{YTM}{m}}$$

MD – modified duration  
D – duration  
YTM – yield to maturity  
m – number of interest payments during the year

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The formula for calculating the approximate percentage change of the price of bonds when the rate of return changes on time to maturity

$$\frac{P_1 - P_0}{P_0} = -MD \times (YTM_1 - YTM_0)$$

$P_0$  – the price of bond before the change of rate of return  
 $P_1$  – the price of bond after the change of rate of return  
 MD – modified duration  
 $YTM_0$  – yield to maturity before the change  
 $YTM_1$  – yield to maturity after the change

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### Task 1

1. Prepare a table of cash flows from bonds.
2. Estimate the discount factor which we need to calculate the discounted cash flow. Use the following formula:

$$\text{Discount factor} = \frac{1}{\left(1 + \frac{YTM}{m}\right)^t}$$

3. Multiply the cash flow by the discount factor and calculate the discounted cash flow

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### Task 1

4. Sum up all discounted cash flows and calculate bond price (P)
5. Multiply the discounted cash flow by the (t) period
6. Sum up all  $t \times PV\_Ct$
7. Use the following formula to estimate the duration:

$$D = \frac{\sum_{t=1}^n \left( t \times \frac{C_t}{(1 + YTM)^t} \right)}{P}$$


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