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Duration

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What Is Duration?

Duration is a measure of the sensitivity of the price of a [bond](#) or other [debt instrument](#) to a change in [interest rates](#). A bond's duration is easily confused with its term or [time to maturity](#), because they are both measured in years. However, a bond's term is a linear measure of the years until repayment of [principal](#) is due; it does not change with the interest rate environment. Duration, on the other hand is non-linear and accelerates as time to maturity lessens.

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Duration measures how long it takes, in years, for an investor to be repaid the bond's price by the bond's total cash flows. At the same time, duration is a measure of sensitivity of a bond's or fixed income portfolio's price to changes in interest rates. In general, the higher the duration, the more a bond's price will drop as interest rates rise (and the greater the interest rate risk). As a general rule, for every 1% change in interest rates (increase or decrease), a bond's price will change approximately 1% in the opposite direction, for every year of duration. If a bond has a duration of 5 years, for example, its price would drop by about 5% if interest rates rose by 1%.

How Duration Works

Duration measures how long it takes, in years, for an investor to be repaid the bond's price by the bond's total cash flows. At the same time, duration is a [measure of sensitivity of a bond's or fixed income](#) portfolio's price to changes in interest rates. In general, the higher the duration, the more a bond's price will drop as interest rates rise (and the greater the interest rate risk). As a general rule, for every 1% change in interest rates (increase or decrease), a bond's price will change approximately 1% in the opposite direction, for every year of duration. If a bond has a duration of 5 years, for example, its price would drop by about 5% if interest rates rose by 1%.

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Certain factors can affect a bond's duration, including:

- **Time to maturity.** The longer the [maturity](#), the higher the duration, and the greater the interest rate risk. Consider two bonds that each yield 5% and cost \$1,000, but have different maturities. A bond that matures faster – say, in one year – would repay its true cost faster than a bond that matures in 10 years. Consequently, the shorter-maturity bond would have a lower duration and less risk.
- **Coupon rate.** A bond's [coupon rate](#) is a key factor in calculation duration. If we have two bonds that are identical with the exception on their coupon rates, the bond with the higher coupon rate will pay back its original costs faster than the bond with a lower yield. The

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value of future bond payments, the Macaulay duration helps an investor evaluate and compare bonds independent of their term or time to maturity.

The second type of duration is called "modified duration" and, unlike Macaulay duration, is not measured in years. Modified duration measures the expected change in a bond's price to a 1% change in interest rates. In order to understand modified duration, keep in mind that bond prices are said to have an inverse relationship with interest rates. Therefore, rising interest rates indicate that bond prices are likely to fall, while declining interest rates indicate that bond prices are likely to rise.

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KEY TAKEAWAYS

- Duration, in general, measures a bond's or fixed income portfolio's price sensitivity to interest rate changes.
- Macaulay duration estimates how many years it will take for an investor to be repaid the bond's price by its total cash flows, and should not be confused with its maturity.
- Modified duration measures the price change in a bond given a 1% change in interest rates.
- A fixed income portfolio's duration is computed as the weighted average of individual bond durations held in the portfolio.

Macaulay Duration

Macaulay duration finds the present value of a bond's future [coupon](#) payments and maturity value. Fortunately for investors, this measure is a standard data point in most bond searching and analysis software tools. Because Macaulay duration is a partial function of the time to maturity, the greater the duration, the greater the interest-rate risk or reward for bond prices.

Macaulay duration can be calculated manually as follows:

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$$f=1 \left(1 + \frac{y}{k}\right)$$

where:

f = cash flow number

CF = cash flow amount

y = yield to maturity

k = compounding periods per year

t_f = time in years until cash flow is received

PV = present value of all cash flows

The previous formula is divided into two sections. The first part is used to find the present value of all future bond cash flows. The second part finds the weighted average time until those cash flows are paid. When these sections are put together, they tell an investor the weighted average amount of time to receive the bond's cash flows.

Macaulay Duration Calculation Example

Imagine a three-year bond with a face value of \$100 that pays a 10% coupon semi-annually (\$5 every six months) and has a [yield to maturity \(YTM\)](#) of 6%. In order to find the Macaulay duration, the first step will be to use this information to find the present value of all the future cash flows as shown in the following table:

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Cash Flow #	Cash Flow	PV of CF $CF/(1+YTM/2)^f$
1	\$5.00	\$4.85
2	\$5.00	\$4.71
3	\$5.00	\$4.58
4	\$5.00	\$4.44
5	\$5.00	\$4.31
6	\$105.00	\$87.94
	Total	\$110.83

This part of the calculation is important to understand. However, it is not necessary if you already know the YTM for the bond and its current price. This is true because, by definition, the current price of a bond is the present value of all its cash flows.

To complete the calculation, an investor needs to take the present value of each cash flow, divide it by the total present value of all the bond's cash flows and then multiply the result by the time to maturity in years. This calculation is easier to understand in the following table:

Cash Flow #	Cash Flow	PV of CF $CF/(1+YTM/2)^f$	(PV/Total)(t _f)
1	\$5.00	\$4.85	0.0219
2	\$5.00	\$4.71	0.0425
3	\$5.00	\$4.58	0.0619
4	\$5.00	\$4.44	0.0802
5	\$5.00	\$4.31	0.0973
6	\$105.00	\$87.94	2.3802
	Total	\$110.83	2.6840

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to changes in interest rates. If the YTM rises, the value of a bond with 20 years to maturity will fall further than the value of a bond with five years to maturity. How much the bond's price will change for each 1% the YTM rises or falls is called modified duration.

Modified Duration

The modified duration of a bond helps investors understand how much a bond's price will rise or fall if the YTM rises or falls by 1%. This is an important number if an investor is worried that interest rates will be changing in the short term. The modified duration of a bond with semi-annual coupon payments can be found with the following formula:

$$ModD = \frac{\text{Macaulay Duration}}{1 + \left(\frac{YTM}{2}\right)}$$

Using the numbers from the previous example, you can use the modified duration formula to find how much the bond's value will change for a 1% shift in interest rates, as shown below:

$$\underbrace{\$2.61}_{ModD} = \frac{2.684}{1 + \left(\frac{YTM}{2}\right)}$$

In this case, if the YTM increases from 6% to 7% because interest rates are rising, the bond's value should fall by \$2.61. Similarly, the bond's price should rise by \$2.61 if the YTM falls from 6% to 5%. Unfortunately, as the YTM changes, the rate of change in the price will also increase or decrease. The acceleration of a bond's price change as interest rates rise and fall is called "[convexity](#)."

Usefulness of Duration

Investors need to be aware of two main risks that can affect a bond's investment value: [credit risk](#) (default) and [interest rate risk](#) (interest rate fluctuations). Duration is used to quantify the potential impact these factors will have on a bond's price because both factors will affect a bond's expected YTM.

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Duration Strategies

In the financial press, you may have heard investors and analysts discuss long-duration or short-duration strategies, which can be confusing. In a trading and investing context, the word "[long](#)" would be used to describe a position where the investor owns the underlying asset or an interest in the asset that will appreciate in value if the price rises. The term "[short](#)" is used to describe a position where an investor has borrowed an asset or has an interest in the asset (e.g. [derivatives](#)) that will rise in value when the price falls in value.

However, a long-duration strategy describes an investing approach where a bond investor focuses on bonds with a high duration value. In this situation, an investor is likely buying bonds with a long time before maturity and greater exposure to interest rate risks. A long-duration strategy works well when interest rates are falling, which usually happens during [recessions](#).

A short-duration strategy is one where a fixed-income or bond investor is focused on buying bonds with a small duration. This usually means the investor is focused on bonds with a small amount of time to maturity. A strategy like this would be employed when investors think interest rates will rise or when they are very uncertain about interest rates and want to reduce their risk.

Duration Summary

A bond's duration can be split into two different features. The Macauley duration is the weighted average time to receive all the bond's cash flows and is expressed in years. A bond's modified duration converts the Macauley duration into an estimate of how much the bond's price will rise or fall with a 1% change in the yield to maturity. A bond with a long time to maturity will have larger duration than a short-term bond. As a bond's duration rises, its interest rate risk also rises because the impact of a change in the interest rate environment is larger than it would be for a bond with a smaller duration.

Related Terms

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Convexity Measures Bond Price and Bond Yield Relationships

Convexity is a measure of the relationship between bond prices and bond yields that shows how a bond's duration changes with interest rates. [more](#)

Bond

A bond is a fixed income investment in which an investor loans money to an entity (corporate or governmental) that borrows the funds for a defined period of time at a fixed interest rate. [more](#)

Dollar Duration Definition

The dollar duration, or DV01, of a bond is a way to analyze the change in monetary value of a bond for every 100 basis point move. [more](#)

Understanding Interest Rate Sensitivity

Interest rate sensitivity is a measure of how much the price of a fixed-income asset will fluctuate as a result of changes in the interest rate environment. [more](#)

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