BOND MARKET AND INTEREST RATES BASICS

Institute of Trading & Portfolio Management

What are Bonds?

Bonds are fixed-income assets that represent the debt of issuers. There are a number of ways these issuers can be characterized, for example, by their characteristics:

- Supranational Organizations (E.g. World Bank, IMF)
- Sovereign (national) Governments (E.g. United Kingdom)
- Non-sovereign (local) Governments (E.g. State of Pennsylvania)
- Companies and Corporations (E.g. Amazon, Apple, Ford)

Or, their creditworthiness as judged by credit-rating agencies:

Credit Rating Scales by Agency, Long-Term

Moody's	S&P	Fitch	
Aaa	AAA	AAA	Prime
Aa1	AA+	AA+	High grade
Aa2	AA	AA	
Aa3	AA-	AA-	
A1	A+	A+	Upper medium grade
A2	A	A	
A3	A-	A-	
Baa1	BBB+	BBB+	Lower medium grade
Baa2	BBB	BBB	
Baa3	BBB-	BBB-	
Ba1	BB+	BB+	Non-investment grade speculative
Ba2	BB	BB	
Ba3	BB-	BB-	
B1	B+	B+	Highly speculative
B2	B	B	
B3	B-	B-	
Caa1	CCC+	CCC	Substantial risk
Caa2	CCC		Extremely speculative
Caa3	CCC-		Default imminent with little prospect for recovery
Ca	CC	CC	
	C	C	
C	D	D	In default
/			
/			

"Junk"

The two major types of issuers that Retail Traders should focus on are Sovereign/National Governments and Companies. When debts are issued by these entities they are typically divided up and sold to investors in smaller units (bonds). For example, a $10mn debt issuance may be allocated through ten-thousand $1,000 bonds.

The reason debt is raised, and bonds are issued by both governments and corporations are as a means to finance projects and operations. Governments may need to finance fiscal activities that require more capital than that which is raised through taxes, and corporations often require debt to finance their operations (or perhaps leverage their operations). Both government and corporate bonds have a large secondary market, where investors can buy and sell the instruments between themselves.

In terms of risk, bonds are considered to be more conservative than equities, and therefore expected returns are also lower. In the case of corporate debt, bonds are also more senior to stocks in the event of issuer bankruptcy – this means bond holders will be paid out before equity holders during liquidation.

Bonds are essentially just loans, and although there are many different ways in which their cash flows can be organized, the typical structure involves the issuer paying interest over the term of the bond followed by a principal payment at the end of the term.

One of the most important things to understand about bonds are that their prices are inversely related to interest rates. This is due to a basic financial concept – the Time Value of Money. Money now is worth more than the same amount of money in the future because interest could be earned over the period. That means that the prices of financial products that provide future cashflows have to be discount by interest rates to obtain a present value → therefore **bond prices are inversely related to interest rates**.

The discount factor (or interest rate/yield to maturity) for a given bond depends on two core risks; changes in the "risk-free" interest rate of the same term (usually dictated by the Sovereign Bond Yield Curve) plus changes in the perceived credit premium required. For traders and investors, these credit and interest rate risks are the biggest risks. Since bonds are debts, if the issuer fails to pay back their debt, the bond can default. As a result, the riskier the issuer, the higher the interest rate will be demanded on the bond (over and above the risk-free rate dictate by sovereign yields).

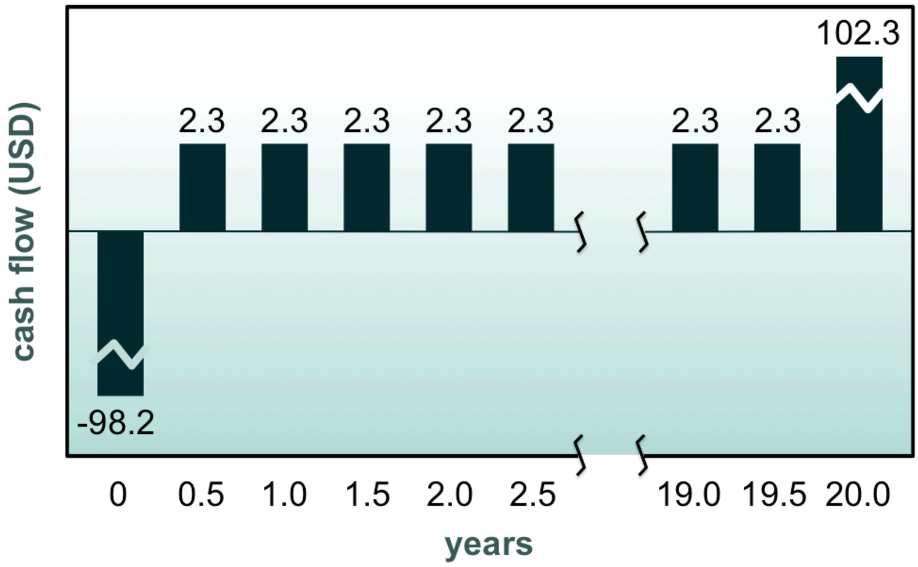
Before jumping into an example, let's get to grips with some bond terminology:

- The **Maturity** of a bond refers to the date on which the issuer has promised to repay the entire outstanding principal on the bond. Similarly, the **term to maturity** or **tenor** of a bond is the period of time remaining until the bond's maturity date.
- The **Par Value** (or Principal, or Face Value) refers to the amount that the issuer promises to repay bondholders on the maturity date.
    - Typically bond prices are quoted as a percentage of their par value, so for example, a quote of 90 on a $1,000 bond implies a current price of $900.
        1. When a bond's price is above 100% of par, it is said to be trading at a **premium.**
        2. When a bond's price is below 100% of par, it is said to be trading at a **discount.**
        3. When a bond's price is at 100% of par, it is said to be trading at **par.**
- The **Coupon Rate** of a bond refers to the annual interest that the issuer promises to pay bondholders until the bond matures. The amount of interest paid each year by the issuer is known as the **coupon**, and is calculated by multiplying the coupon rate by the bond's par value. For example, a 3% coupon rate on a bond with a par value of $1,000 requires annual interest of $30 to be paid by the issuer. Coupons can be paid annually, semi-annually, quarterly or monthly and will be specified by the bonds indenture. For the above example, if coupons were paid semi-annually, a coupon of $15 would be paid twice a year. For reference, US government bonds pay coupons on a semi-annual basis.
    - Note that there are some bonds that do not make any interest payments until maturity. These **zero-coupon** bonds are issued at a discount of a premium and redeemed at par – the difference between those values being the effective interest on the loan.
- The **Yield-To-Maturity (YTM)** of a bond is calculated as the discount rate that equates the present value of the bond's expected future cashflows until maturity to its current price.

- Essentially, the YTM represents the internal rate of return on the bond's expected cashflows. Said differently, the YTM represents the annual return that an investor will earn on a bond if they…
    1. Purchase it today (for its current price)
    2. Hold it until maturity
    3. Reinvest all interim cashflows at the stated YTM
- All else being equal, a bond's yield-to-maturity is inversely related to its price. Given a set of expected future cash flows, the lower (higher) the YTM or discount rate, the higher (lower) the bond's current price.

Cash Flow Example

Imagine a bond with a face value of $100 being issued at a discount, for 98.2. The coupon rate is 4.6% and the bond has a maturity of 20 years. This is what the bond's expected cash flows would look like:



The issuer receives $98.20 from an investor, and has to pay $2.30 semi annually for 20 years followed by a final principal payment of $100 (face value) in return. Note the final payment is inclusive of both the final coupon and the principal amount = $2.30 + $100.00 = $102.30. This bond is said to be trading a discount since the price paid is less than the face value of the bond.

- We can also infer the bond's YTM is lower than the coupon rate, given the bond trades at a discount. This will become clearer in the next section.

Pricing Bonds

As alluded to previously, a bond's price equals the *present value* of its *expected future cash flows.* The rate of interest used to discount the bond's cash flows is known as the *yield to maturity.*

Pricing Coupon Bonds

A coupon-bearing bond may be priced with the following formula:

$$P = \sum_{t=1}^{T} \frac{C}{(1+r)^t} + \frac{F}{(1+r)^T}$$

where:
C = the periodic coupon payment
r = the yield to maturity (YTM)
F = the bond's par or face value
t = time
T = the number of periods until the bond's maturity date

The formula above shows that the price of a bond is equal to the present value of its future cash flows. As an example, suppose that a bond has a face value of $1,000, a coupon rate of 3% and a maturity of four years. The bond makes annual coupon payments. If the yield to maturity is 3%, the bond's price is determined as follows:

$$P = \frac{30}{(1.03)^1} + \frac{30}{(1.03)^2} + \frac{30}{(1.03)^3} + \frac{1030}{(1.03)^4}$$

$$P = 29.13 + 28.28 + 27.45 + 915.14 = \$1{,}000.00$$

If the yield to maturity is 4%, the price is:

$$P = \frac{30}{(1.04)^1} + \frac{30}{(1.04)^2} + \frac{30}{(1.04)^3} + \frac{1030}{(1.04)^4}$$

$$P = 28.84 + 27.74 + 26.67 + 880.45 = \$963.71$$

If the yield to maturity is 2%, the price is:

$$P = \frac{30}{(1.02)^1} + \frac{30}{(1.02)^2} + \frac{30}{(1.02)^3} + \frac{1030}{(1.02)^4}$$

$$P = 29.41 + 28.83 + 28.27 + 951.56 = \$1038.08$$

These results show the following important relationships:

- if r > coupon rate, P < face value (*trading at a discount)*
- if r = coupon rate, P = face value (*trading at par)*
- if r < coupon rate, P > face value (*trading at a premium)*
- when yields rise, bond prices fall
- when yields fall, bond prices rise

Adjusting for Semi-Annual Coupons
For a bond that makes semi-annual coupon payments, the following adjustments must be made to the pricing formula:

- the coupon payment is cut in half
- the yield is cut in half
- the number of periods is doubled

As an example, let's say we have a bond that has a face value of $1,000, a coupon rate of 7% and a time to maturity of two years. The bond makes semi-annual coupon payments, and the yield to maturity is 5%. The semi-annual coupon is $35, the semi-annual yield is 2.5%, and the number of semi-annual periods is four. The present value of the related cashflows, and therefore the price of the bond is:

$$P = \frac{35}{(1.025)^1} + \frac{35}{(1.025)^2} + \frac{35}{(1.025)^3} + \frac{1035}{(1.025)^4}$$

$$P = 34.15 + 33.31 + 32.50 + 937.66 = \$1037.62$$

Pricing Zero-Coupon Bonds

A *zero-coupon* bond is one that does not make any coupon payments, but instead it is sold to investors at a *discount* from face value and the difference between the price paid for the bond and the face value is the return to the investor and essentially dictates the interest earned over the period. The pricing formula for a zero-coupon bond is:

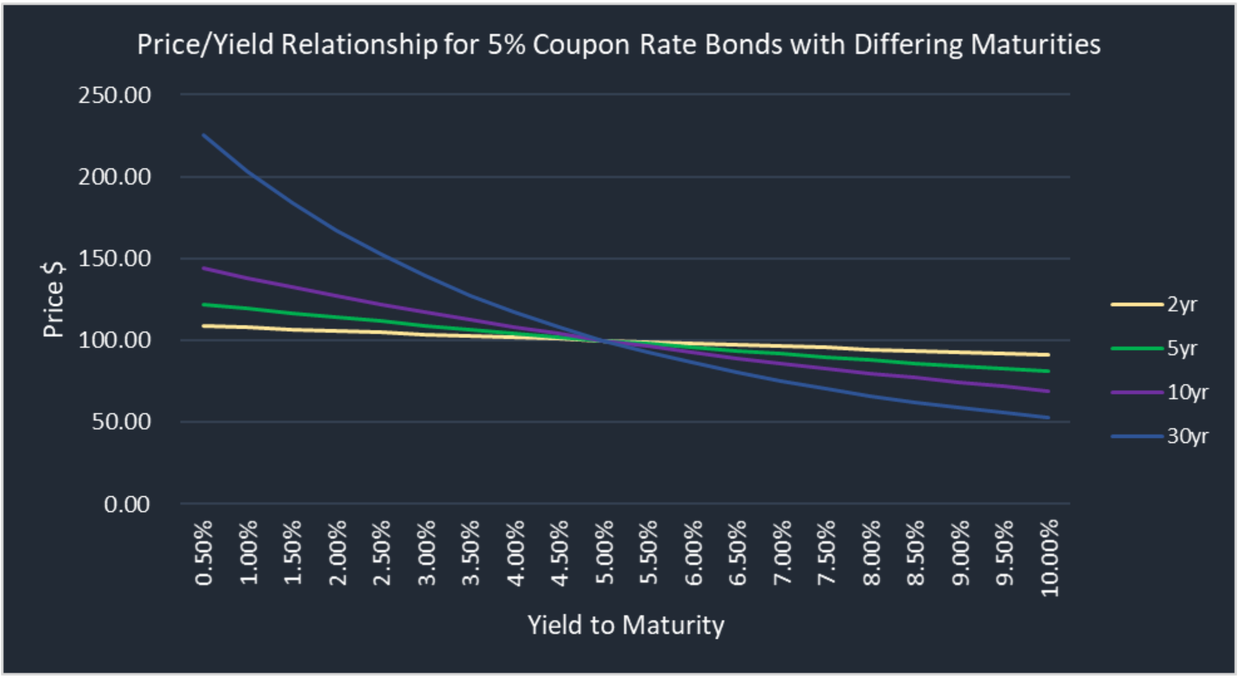
$$P = \frac{F}{(1+r)^T}$$

Example: A one-year zero-coupon bond is issued with a face value of $1,000. The discount rate for this bond is 5%. What is the market price of this bond?

$$P = \frac{1000}{(1.05)^1} = \$952.38$$

Relationship between the Bond Price and Bond Characteristics

1. A bond's price is inversely related to the market discount rate (the **inverse effect**). When the discount rate increase (decreases) the price of the bond decreases (increases).



2. Given the same coupon rate and term to maturity, the percentage price change is greater in terms of absolute magnitude when the discount rate decreases than when it increases (the **convexity effect**).
3. For the same term to maturity, a lower coupon bond is more sensitive to change in the market discount rate than a higher coupon bond (the **coupon effect**).
4. Generally speaking, for the same coupon rate, a longer-term bond is more sensitive to changes in the market discount rate than a shorter-term bond (the **maturity effect**).
    a. Note that while the maturity effect always holds true for zero-coupon paying bonds and for bonds priced at par or premium to par, it does not always hold true for long-term low coupon (not zero coupon) bonds that are trading at a discount.
5. Bond values are "pulled to par" as time to maturity decreases, all else being equal.
    a. A premium bond's value decreases towards par as it nears maturity.
    b. A discount bond's value increases towards par as it nears maturity.
    c. A par bond's value remains unchanged as it nears maturity.

Bond Duration & Convexity

Traders of fixed income securities should be aware of the relationship between interest rates and a bond's price. As already highlighted a few times, the price of a bond is inversely related to its yield-to-maturity.

Macaulay duration is the weighted-average maturity of a bond's cashflows, which is measured in years. It can be thought of as the average economic life time (balance point) of a collection of cash flows. The longer the Macaulay duration, the more sensitive the bond price will be to interest rate changes.

Modified duration is another measure of price sensitivity to interest rate changes but instead is stated in terms of a percentage change in price given a unit change in the yield to maturity. Typically, when duration is quoted, it is referring to a bond's *Modified duration* rather than *Macaulay duration*.

Taking this concept one step further, a bond's *convexity* (the derivative of duration) is a measurement of how duration changes as yields to maturity change. Taken together, these two measurements provide insight into how a bond's price is expected to perform should interest rates change and it can help investors and traders understand the price risk of fixed income securities in different interest rate environments through things like scenario analysis.

Duration

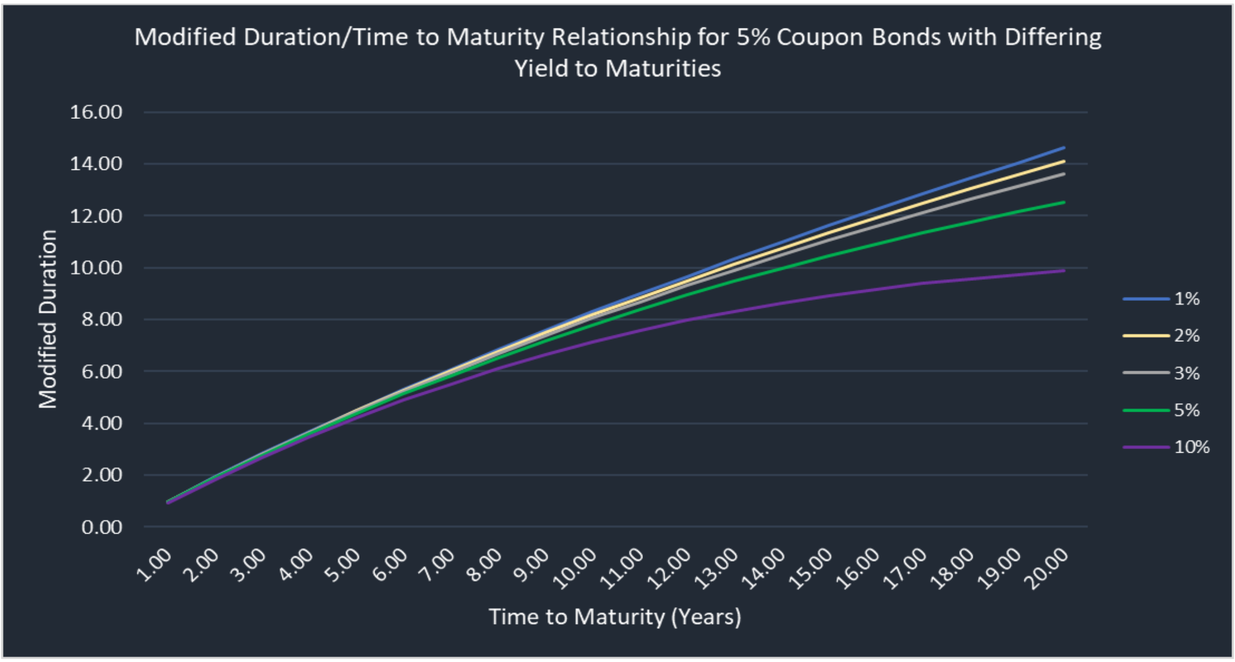
Put simply, modified duration estimates how the price of a bond will be affected should interest rates change. Higher durations imply greater price risk for a given unit change in the yield to maturity. As stated previously, Modified Duration is quoted as the percentage change in price for each given percent change in interest rates.

Example: The price of a bond with a duration of 1.5 would be expected to increase (decrease) by about 1.50% for each 1.00% move down (up) in rates.

The duration of a bond is primarily affected by its coupon rate, yield to maturity, and remaining time to maturity. A bond's duration has the following relationships:

- The duration of a bond will be higher the lower its coupon.
- Duration will be higher the lower its yield.
- Duration will also be higher the longer its maturity.

- **Example:** When Coupon Rate and Yield to Maturity are the same, duration increases with time left to maturity…



Time to Maturity	1%	2%	3%	5%	10%
1.00	0.98	0.98	0.97	0.96	0.94
2.00	1.92	1.91	1.90	1.88	1.83
3.00	2.82	2.80	2.78	2.75	2.67
4.00	3.68	3.66	3.63	3.58	3.46
5.00	4.51	4.48	4.44	4.37	4.20
6.00	5.32	5.27	5.22	5.13	4.89
7.00	6.09	6.03	5.97	5.84	5.52
8.00	6.84	6.76	6.68	6.52	6.10
9.00	7.58	7.48	7.38	7.17	6.64
10.00	8.29	8.17	8.04	7.79	7.13
11.00	8.98	8.83	8.68	8.37	7.57
12.00	9.66	9.49	9.30	8.93	7.96
13.00	10.33	10.12	9.90	9.47	8.32
14.00	10.98	10.73	10.49	9.97	8.64
15.00	11.61	11.33	11.04	10.45	8.92
16.00	12.23	11.92	11.59	10.91	9.16
17.00	12.85	12.49	12.12	11.35	9.38
18.00	13.45	13.04	12.63	11.77	9.57
19.00	14.04	13.59	13.12	12.16	9.73
20.00	14.62	14.12	13.60	12.54	9.87

- **Example:** When the maturity and yield are the same, duration increases with a lower coupon…

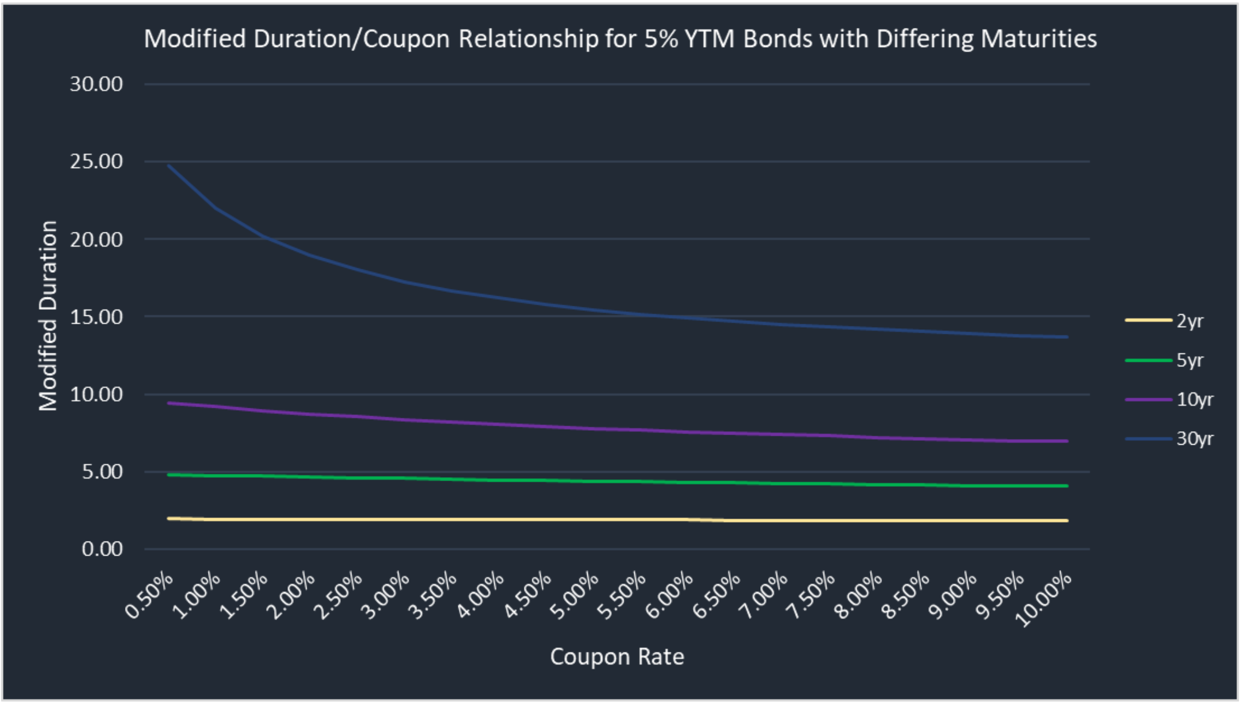


Table: Bonds with Various Maturities and 5% YTM, Duration vs Coupon Relationship

Coupon Rate	**1yr**	**2yr**	**3yr**	**5yr**	**10yr**	**20yr**	**30yr**
0.50%	0.97	1.94	2.91	4.82	9.45	17.91	24.73
1.00%	0.97	1.94	2.89	4.76	9.19	16.72	22.03
1.50%	0.97	1.93	2.87	4.70	8.95	15.79	20.24
2.00%	0.97	1.92	2.85	4.65	8.73	15.05	18.97
2.50%	0.97	1.91	2.83	4.60	8.54	14.44	18.01
3.00%	0.97	1.91	2.82	4.55	8.36	13.94	17.27
3.50%	0.97	1.90	2.80	4.50	8.20	13.51	16.68
4.00%	0.97	1.89	2.78	4.46	8.05	13.14	16.20
4.50%	0.96	1.89	2.77	4.42	7.92	12.83	15.79
5.00%	0.96	1.88	2.75	4.38	7.79	12.55	15.45
5.50%	0.96	1.87	2.74	4.34	7.68	12.31	15.16
6.00%	0.96	1.87	2.73	4.30	7.57	12.09	14.91
6.50%	0.96	1.86	2.71	4.27	7.47	11.90	14.69
7.00%	0.96	1.86	2.70	4.23	7.38	11.72	14.49
7.50%	0.96	1.85	2.68	4.20	7.29	11.56	14.32
8.00%	0.96	1.84	2.67	4.17	7.21	11.42	14.17
8.50%	0.96	1.84	2.66	4.14	7.14	11.29	14.03
9.00%	0.95	1.83	2.65	4.11	7.06	11.17	13.90
9.50%	0.95	1.83	2.63	4.08	7.00	11.06	13.79
10.00%	0.95	1.82	2.62	4.05	6.93	10.96	13.68

- **Example:** When the coupon and maturity are the same, duration increases with a lower yield…

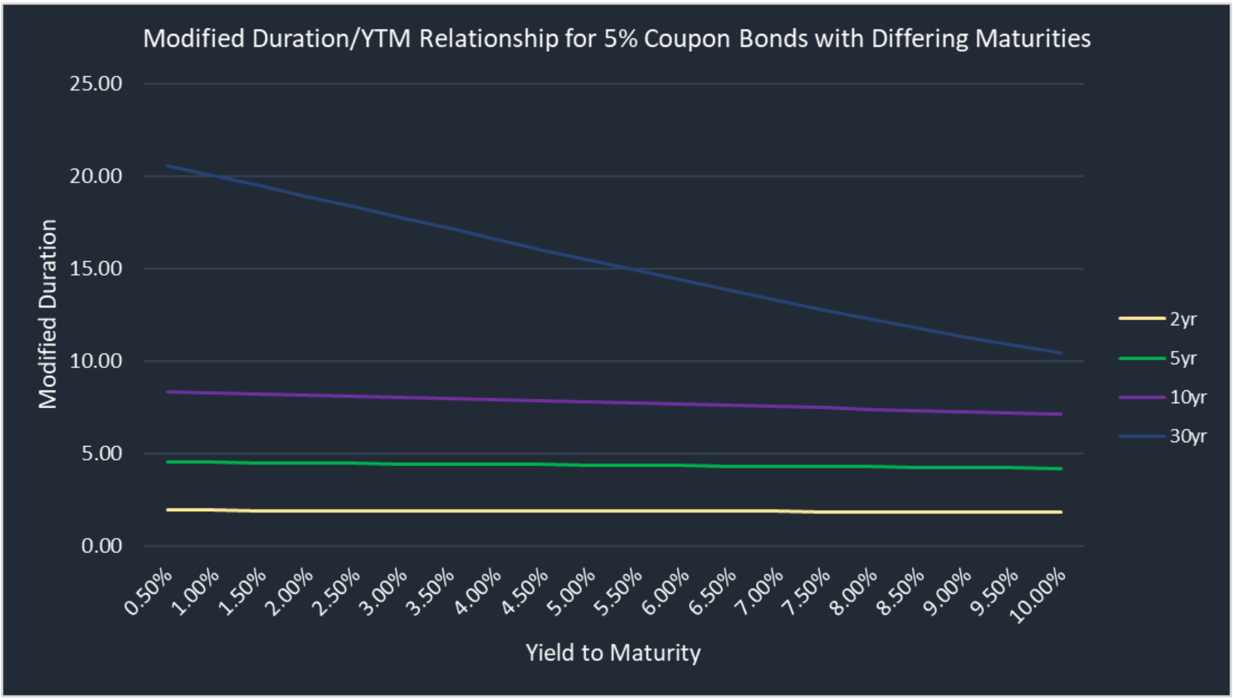
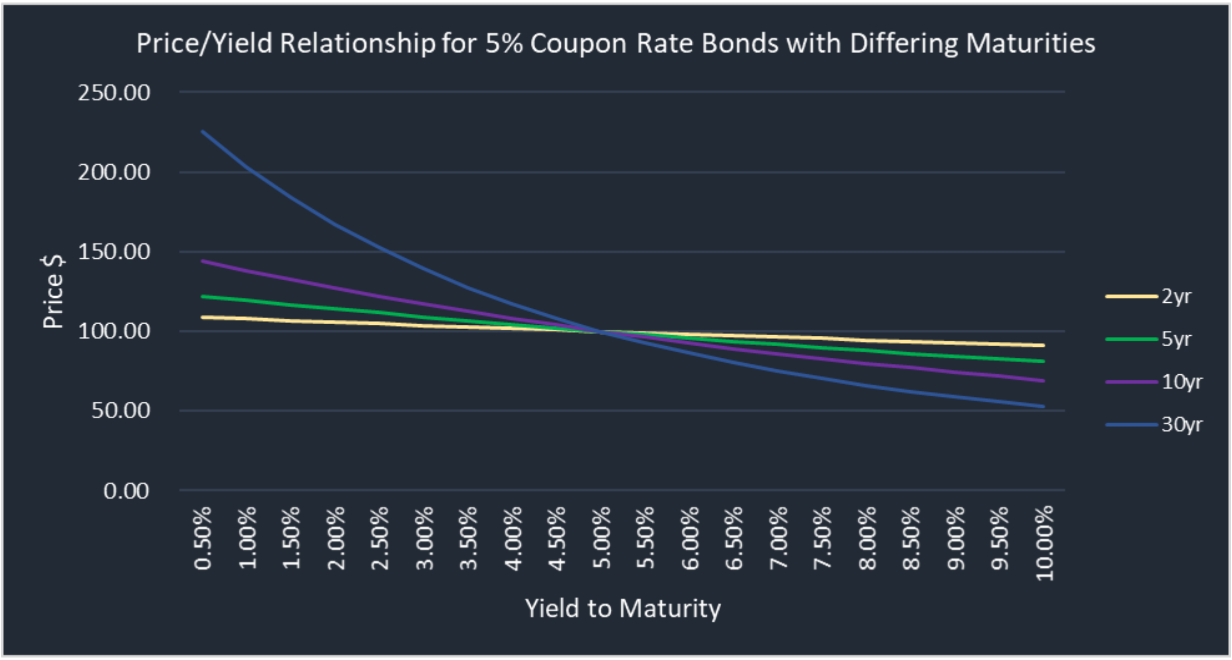


Table: Bonds with Various Maturities and 5% Coupon Rate, Duration vs YTM Relationship

YTM	1yr	2yr	3yr	5yr	10yr	20yr	30yr
0.50%	0.99	1.93	2.83	4.53	8.36	14.88	20.61
1.00%	0.98	1.92	2.82	4.52	8.30	14.64	20.05
1.50%	0.98	1.92	2.81	4.50	8.23	14.39	19.49
2.00%	0.98	1.91	2.80	4.48	8.17	14.13	18.91
2.50%	0.98	1.91	2.80	4.46	8.11	13.88	18.34
3.00%	0.97	1.90	2.79	4.45	8.05	13.62	17.76
3.50%	0.97	1.90	2.78	4.43	7.99	13.35	17.18
4.00%	0.97	1.89	2.77	4.41	7.92	13.09	16.60
4.50%	0.97	1.89	2.76	4.39	7.86	12.82	16.02
5.00%	0.96	1.88	2.75	4.38	7.79	12.55	15.45
5.50%	0.96	1.88	2.75	4.36	7.73	12.28	14.89
6.00%	0.96	1.87	2.74	4.34	7.67	12.01	14.34
6.50%	0.96	1.87	2.73	4.32	7.60	11.74	13.80
7.00%	0.95	1.86	2.72	4.31	7.53	11.47	13.27
7.50%	0.95	1.86	2.71	4.29	7.47	11.20	12.76
8.00%	0.95	1.85	2.71	4.27	7.40	10.93	12.26
8.50%	0.95	1.85	2.70	4.26	7.33	10.67	11.78
9.00%	0.95	1.84	2.69	4.24	7.27	10.40	11.31
9.50%	0.94	1.84	2.68	4.22	7.20	10.14	10.86
10.00%	0.94	1.83	2.67	4.20	7.13	9.88	10.44

Convexity

Unfortunately, the duration of a bond is not fixed, and it itself moves as the yield on a bond change. Convexity measures the sensitivity of a bond's duration to changes in the yield. Duration is an imperfect way of measuring a bond's price change, as it indicates that this change is linear when in fact it exhibits a sloped or "convex" shape. For example, refer back to the chart we looked at earlier comparing bond prices with varying yields. The convex shape is most easily seen on the 30yr bond but exists on the others as well:



A bond is said to have positive convexity if duration rises as the yield declines (as above). A bond with positive convexity will have larger price increases due to a decline in yields than price declines due to an increase in yields. Positive convexity can be thought of as working in the holder's favour, since the price becomes less sensitive when yields rise (prices down) than when yields decline (prices up). Bonds can also have negative convexity, which would indicate that duration rises as yields increase and can work against the holder's interest.

Yield Spreads

To understand why bond prices and yields change, it is useful to separate the yield-to-maturity into two components: the benchmark yield and the spread.

The benchmark yield is the base rate, and is also referred to as the risk-free rate of return. It captures macroeconomic factors, such as the expected rate of inflation, currency denomination, and the impact of monetary and fiscal policy. Changes in these factors impact all bonds in the market. The benchmark can also be broken down into (1) the expected inflation rate and (2) the expected real rate.

The spread refers to the difference between the yield-to-maturity on a bond and on the benchmark. It captures all microeconomic factors specific to the issuer, such as credit risk of the issuer, changes in the issue's credit rating, liquidity, and tax status of the bond. The spread is also known as the risk premium over the risk-free rate of return.

Changes in macroeconomic factors can also cause spreads to narrow or widen across all issuers.

For example, consider a 5-year corporate bond that offers a yield-to-maturity of 5.50%. The benchmark bond is a 5-year U.S. Treasury, which offers a yield of 4.50%. This means that the corporate bond offers a spread of 100 bps. Now suppose that the yield on the corporate bond increases from 5.50% to 6.00%.

If the yield on the benchmark has also increased by 50 bps, we can infer that the change in the bond's yield is caused by macroeconomic factors that affect all bond yields.

However, if the yield on the benchmark has remained the same, we can infer that the change in the bond's yield was caused by firm-specific factors, such as changes in the issuer's creditworthiness.

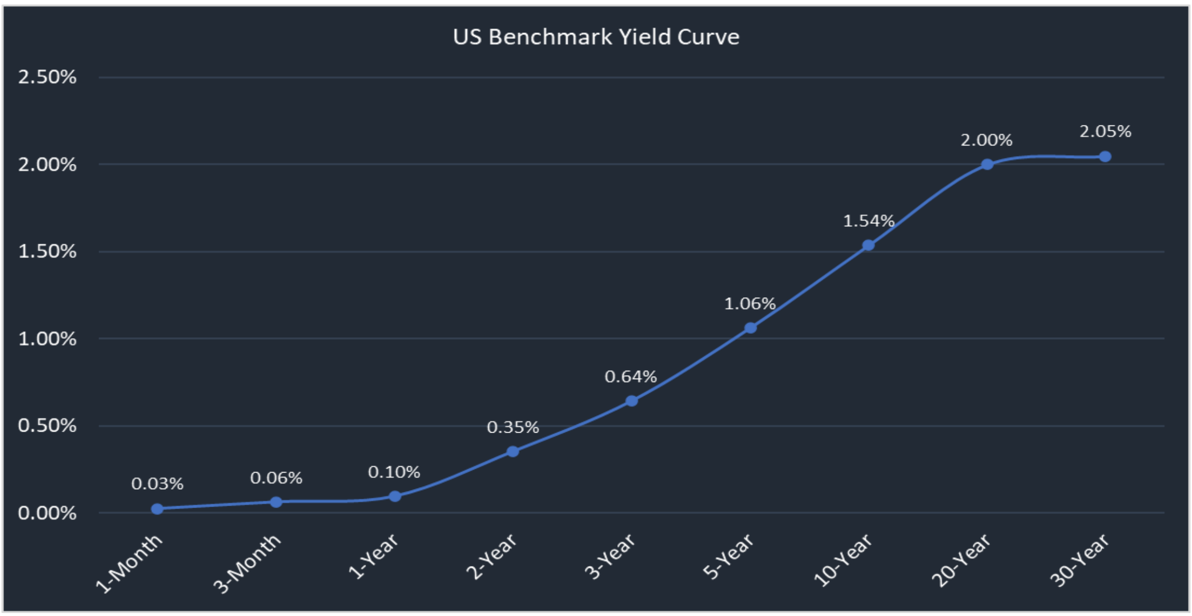
The benchmark varies across financial markets. Fixed-rate bonds often use the yield on a government bond with the same term to maturity as the bond being studied as the benchmark. Typically, the benchmark is the most recently issued or on-the-run security. On-the-run securities are the most actively traded and have coupon rates closest to the current market yield for a given maturity. Off-the-run securities are more seasoned issues. Generally speaking, on-the-run issues tend to trade at slightly lower yields-to-maturity (higher price) than off-the-run issues because of (1) differences in demand and (2) differences in the cost of financing the securities in the repo market.

US Treasury Yield Curve

The Treasury yield curve, which is also known as the term structure of interest rates, draws out a line chart to demonstrate a relationship between yields and maturities of on-the-run Treasury fixed-income securities. It illustrates the yields of Treasury securities at fixed maturities; therefore, they are commonly referred to as “constant maturity Treasury” rates or CMTs.

Market participants pay very close attention to yield curves, as they are used in deriving interest rates (using bootstrapping), which are in turn used as discount rates for each payment to value Treasury securities. In addition to this, market participants are also interested in identifying the spread between short-term rates and long-term rates to determine the slope of the yield curve, which is a predictor of the economic situation of the country.

Yields on Treasury securities are in theory free of credit risk and are often used as a benchmark to evaluate the relative worth of U.S. non-Treasury securities. Below is the Treasury yield curve chart as on 13th October 2021:



The above chart shows a "normal" yield curve, exhibiting an upward slope. This means that 30-year Treasury securities are offering the highest returns, while 1-month maturity Treasury securities are offering the lowest returns. The scenario is considered normal because investors are compensated for holding longer-term securities, which possess greater investment risks. The spread between 2-year U.S. Treasury securities and 10-year U.S. Treasury securities is typically used to define the slope of the yield curve, which in this case is roughly 118 basis points. There is no industry-wide accepted definition of the maturity used for the long end and the maturity used for the short end of the yield curve, so other maturities can be used to define the slope as well.

One of the most common theories about what drives the shape of the yield curve (the term structure) is the *expectations hypothesis*:

Expectations Hypothesis

The Expectations Hypothesis says that current yields on treasuries with different maturities reflect investors' expectations of future interest rates. The intuition here is that the yield on holding a long-term bond is equal to the expected yield from purchasing a sequence of short-term bonds.

Consider a simple scenario with no uncertainty. Arbitrage requires that:

$$(1 + i2_t)^2 = (1 + i1_t)(1 + i1_{t+1})$$

Meaning, the 2-year annual interest rate (i2) at time t, compounded over two years should equal the 1-year annual interest rate (i1) at time t multiplied by the 1-year interest rate (i1) in one-years' time. *Note that 1 is added to each interest rate so that compounding can take place.*

The expectations hypothesis replaces the future rate with its expected value:

$$(1 + i2_t)^2 = (1 + i1_t)E_t(1 + i1_{t+1})$$

Where E_t is the expectation at time t.

Expected future short rates are largely determined by what investors think inflation will be in future years. So, today's yield curve will be upward sloping if investors think that inflation between years 1 & 2, and 2 & 3 will be higher than the rate of inflation for the current year, for example. Hence, the shape of the yield curve gives an indication of the market's view on future inflation.

A "normal" upward-sloping yield curve implies that both fiscal and monetary policies are currently expansionary and future rates are expected to increase, likely due to higher inflation expectations in the future. An "inverted" yield curve reveals the opposite and is a well-documented predictor of recessions, albeit with uncertain forecasting times.

One of the drawbacks in the expectations hypothesis is that there is no account for term risk. This means that there is no account for the additional risk that holding an instrument for a longer period of time represents. Strictly speaking, there should be larger term risk built into longer term maturities as inflation (and therefore interest rate) expectations are less certain further into the future. The *liquidity preference hypothesis* adds a term premium at each maturity to try and account for this, but any more detail about yield curve theory is beyond the scope of this document!