Understanding duration

DURATION: A MEASURE OF BOND PRICE VOLATILITY

How do maturity and coupon rate affect volatility? Both determine how quickly you, the bondholder, get your money back. The longer you must wait to get your principal back, the more the price of your bond will fluctuate with a given change in interest rates. This effect is lessened by the receipt of coupon payments over the life of the bond. A higher coupon rate means you get a higher portion of your total return prior to maturity in the form of interest payments.

In the calculation of duration, each payment to the bondholder is multiplied by the amount of time that will elapse until that payment is received. But there is a twist — duration is based not on the time-weighted cash amount of each payment, but the time-weighted present value of each payment.*

Once you have added up all the time-weighted present values of the payments, you divide that number by the price of the bond (which is the sum of the unweighted present values) and the result is duration, a measure of time. This measurement aims to calculate the average amount of time it takes to receive the present value of your investment.

$$\text{Duration} = \frac{\text{sum of (present value of each payment x time until that payment is received)}}{\text{price of bond}}$$

For example, a par bond due in 10 years with a 3.00% coupon would have a duration of 8.71 years, calculated as follows:

$$\frac{\text{871 dollar-years}}{\text{100 dollars}} = \text{8.71 years}$$

The 871 dollar-years in the numerator is the time-weighted present value of the various coupon payments and the final principal payment. Alternatively, if that bond had a 4.00% coupon and a dollar price of 108.58, the duration would be lower:

$$\frac{\text{914 dollar-years}}{\text{108.58 dollars}} = \text{8.42 years}$$

Bond volatility refers to the degree of price fluctuation over time, determined by changes in interest rates, credit risk, liquidity and market sentiment. However, changes in interest rates have the most significant impact on volatility. One of the first things one learns about bonds is that their prices increase when interest rates decline and decrease when interest rates rise.

A bond's volatility depends on two factors: its coupon rate and when it will be retired (at maturity or call date). Other things being equal, the general rule is that:

1. The longer the time until retirement, the greater the price volatility.
2. The lower the coupon rate, the greater the price volatility.

So, if two bonds have the same maturity (assuming no call options), the one with the lower coupon will be more volatile. On the other hand, if two bonds have the same coupon rate, the one with the longer maturity will be more volatile.

But how do we compare the volatility of two bonds with different coupon rates and maturities? We use duration.

* The present value of a sum yet to be received is the amount of money required today to have the desired amount at a specified future date after compounding interest earnings at an assumed rate.

DURATION AS A PREDICTOR OF PRICE CHANGES

Duration has a very useful quality. With a slight modification (dividing by one plus the semiannual yield of the bond) the duration number can estimate how much a bond's price will change in response to changing interest rates. If you multiply the new "modified duration" by the assumed change in interest rates, you can approximate the percentage change that will occur in the bond's price.

For example, consider again the 3.00% par bond due in 10 years (with no call options). That bond would have a modified duration of 8.58 years (8.71 divided by 1.015). On the basis of duration, we would expect a decline of 10 basis points (0.10%) in yields to increase the value of the bond by 0.858% to 100.858. In fact, the bond's value would rise to 100.863. In this case, the difference between the pure duration-based estimate and the actual price change was quite small. A greater change in interest rates would produce a less accurate prediction based on duration. The difference between the actual change in price and the expected change in price due to duration is the result of a characteristic of bonds known as convexity.

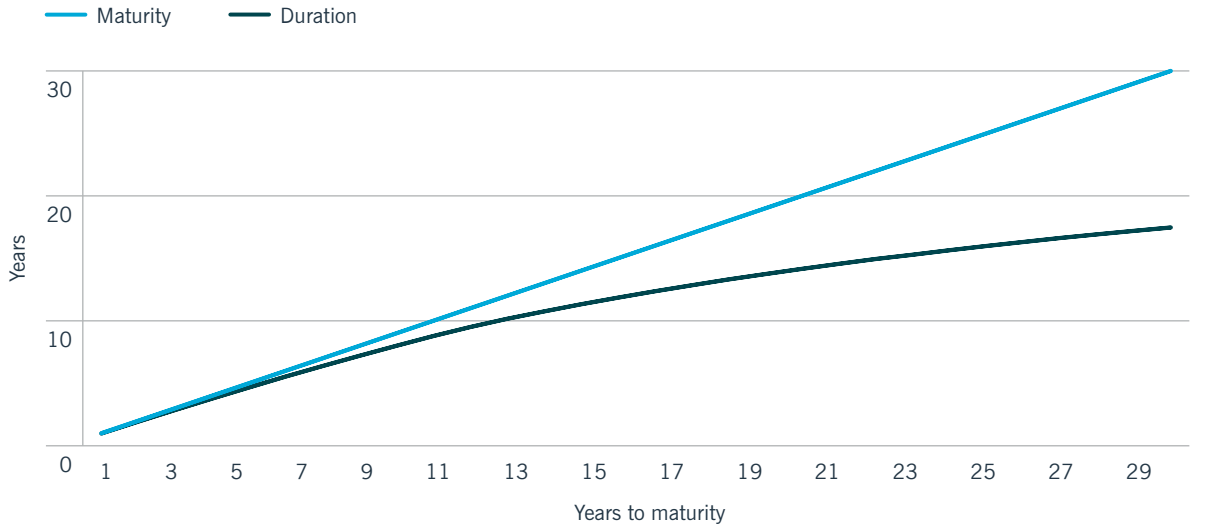
THE EFFECTS OF COUPON AND MATURITY

In our previous example, the 3% par bond with a 10-year maturity had a modified duration of 8.58 years. If a bond with the same coupon rate and price had a maturity of 11 years, its modified duration would be 9.31 years. The longer the time until retirement, the greater the price volatility. If the coupon were 4.00% instead, but with the same 3.00% yield and 11-year maturity, the modified duration would be reduced back to 8.98 years. The larger the coupon rate, the shorter the duration.

As a general rule, bonds that pay interest prior to maturity will have a duration that is shorter than their years to maturity. Consequently, reducing the coupon rate to zero makes the duration equal to maturity. This is logical since the full amount of one's investment return will be received in one lump sum when the bond matures. There are no payments to reduce the average time it takes to recover the present value of the investment.

The following graph shows the relationship between a bond's effective maturity (when the bond is expected to be retired) and its modified duration. As you can see, duration does not increase as quickly as maturity.

Maturity vs. modified duration



Data source: Securities Evaluations, Inc. (a subsidiary of Intercontinental Exchange, Inc.). The bonds in the above graph are noncallable bonds priced at par with yields that vary by maturity. Duration was calculated using yields for AAA-rated bonds as of 31 Mar 2024 as appropriate for each maturity.

These examples are hypothetical and in no way intended to represent the performance of any Nuveen investment.

REDEMPTION PROVISIONS

Call provisions can also cause a bond's duration to be less than its maturity. Typically duration is calculated based on the date to which the bond is priced. A premium bond, which is redeemable at par sometime before maturity, will be priced to a call date. So the modified duration will correspond to the call date, not the maturity date. Thus, in a market where prices are rising, the volatility of a portfolio will tend to decline as more and more bonds are priced to their call dates rather than to maturity. On the other hand, when prices fall, volatility and average duration tend to increase because of the increase in the number of bonds that are priced to maturity.

This also means that modified durations of callable bonds priced near par may shift rapidly as prices move above and below par – and duration shifts from the call date to the more distant maturity date.

An alternative measure of duration – known as "option-adjusted duration" or "effective duration" – takes into account the effect of the call option on the expected life of a bond. It weighs the probability that the bond will be called based on the spread between its coupon rate and its yield, as well as the volatility of interest rates. Generally speaking, option-adjusted duration (OAD) will be longer than modified duration when a bond is priced to a call date, and shorter than modified duration when a bond is priced to maturity. OAD is typically used to report the duration of portfolios containing mortgage-backed securities.

Call options limit the potential price appreciation of a bond, but do not limit the downside, when the bond is priced to maturity. As a result, callable bonds typically have negative convexity since the change in price in a rising market is not as great as the change in price in a falling market.

DURATION AND PORTFOLIO MANAGEMENT

In any case, since duration reflects bond price volatility, a portfolio's average duration is more meaningful than its average maturity. By comparing a bond's duration with an existing portfolio's average duration, a portfolio manager tries to anticipate the effect that buying or selling that bond would have on the portfolio's volatility. Further, by exploring how the duration of a bond might change in different market environments, a portfolio manager can better evaluate the relative value of call protection.

Using duration analysis, the portfolio manager may elect, for example, to buy high-coupon, premium bonds to reduce downside risk, or buy deep discount bonds to try to maximize potential price appreciation. Or the manager may decide that intermediate-term, current coupon bonds offer the best value. Whatever the approach, duration analysis helps the portfolio manager evaluate the effects of various trading strategies in an effort to better achieve the goal of minimizing price volatility while maximizing total return.

For more information, please visit us at nuveen.com.

Endnotes

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