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The Science of Finance

RYAN RESEARCH

The Seven Flaws of Duration

Duration has become accepted as the key risk barometer of the bond market and, perhaps, the stock market. Money managers throughout America have duration targets for their bond portfolios. Most bond trades are done with a duration strategy in mind. Performance measurement studies are now done versus a short, intermediate and long duration profile. As such an important measurement, the weaknesses or inaccuracies of duration should be made clear.

Duration, in any form, is a measurement of price volatility only. **It is not a measurement of total return volatility since income is not being measured**. If risk is the uncertainty or volatility of total return then duration is a measurement of partial risk not total risk.

Moreover, **duration is only an "approximate" measure of pricevolatility**. Given certain interest rate environments or yield movements, duration and convexity can become a very inaccurate price volatility measurement.

Duration Defined

Duration was originally formulated by Frederick R. Macaulay in 1938 as an alternative to measure a bond's life. Duration is defined as the average life of a bond's cash flow in present value dollars. A bond's duration is a function of its coupon, yield and maturity. A mortgage's duration is a function of its contract rate, yield, maturity and repayment term. To use as a price sensitivity tool, duration must be **modified** for fixed income securities paying periodic interest n times a year:

$$\text{Modified Duration} = \frac{\text{Duration of bond}}{(1 + \text{yield}/n)}$$

The yield movement of a bond or mortgage multiplied by the negative of its modified duration is supposed to approximate price volatility.

Convexity Defined

Convexity was formulated to help explain the inaccuracies of duration. Convexity measures the change in modified duration given a change in yield. However, convexity is still a price volatility measurement and does not measure total return volatility. As a result, convexity also suffers from the same difficulties as duration since it is a derivative.

Time Horizon: 1 Year				Total Return @yield move of:	
Coupon	Maturity	Yield	MDur	100 bp	-100 bp
0.00	5.2 yrs	7.00	5.00	2.86	11.56
0.00	10.4 yrs	7.00	10.00	-2.13	17.29
Differerence		same	2x	4.99	5.73

1. Proportionality

Duration levels are not proportional such that twice the duration produces twice the total return. This is proof that duration only measures price sensitivity and does not measure income returns.

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Time Horizon: 1 Year				Total Return @yield move of:	
Coupon	Maturity	Yield	MDur	100 bp	-100 bp
8.50	23.0 yrs	8.50	10.00	-0.45	19.34
7.00	17.5 yrs	7.00	10.00	-1.95	17.50
Differerence		1.50	same	1.50	1.84

2. Same Durations

Even the same duration bonds won't produce the same returns. Once again, this is due to income not being accounted for in the duration price volatility estimate.

Time Horizon: 1 Year				Total Return @yield move of:	
Coupon	Maturity	Yield	MDur	100 bp	-100 bp
7.00	17.5 yrs	7.00	10.00	-1.95	17.50
0.00	10.4 yrs	7.00	10.00	-2.13	17.29
Differerence		same	same	0.18	0.21

3. Same Yield, Same Durations

Two bonds with the same yield and beginning durations may have completely different durations at the end of the time horizon. This is due to a difference in coupon, maturity or yield. As a result, they won't have the same price or total return.

Coupon	Maturity	Yield	Dur
6.00	18.0 yrs	14.00	7.59
6.00	20.5 yrs	14.00	7.65 (max MDur)
6.00	22.5 yrs	14.00	7.60

4. Maximum Duration

Duration actually peaks out at high yields such that each extension of maturity will shorten duration not lengthen it. Accordingly, **there is a maximum duration**. The lower the coupon, the shorter the maturity needed before duration peaks out. This was a common situation in the last two years of the bear market of 1977-1981.

Time Horizon: 1 Year				Total Return @yield move of:		
Coupon	Maturity	Yield	MDur	-100	-200	-300
8.50	23.0 yrs	8.50	10.00	19.34	31.84	46.56
Negative Duration	x Yield Move	+ Income	=	18.50	28.50	38.50
		Margin of error =		0.84	3.34	8.06

5. Large Yield Moves

Modified Duration (negative) times large yield moves results in large price return errors. The larger the yield move the larger the error.

6. Time

Duration is a spot calculation only good for a one day horizon. Every day duration can and should change, especially on zero coupon bonds. However, each bond's duration can have radically different duration changes depending on coupon, maturity and yield differences.

Time Horizon: 1 Year

Coupon	Maturity	Yield	Beginning MDuration	Ending MDuration
0.00	10.4 yrs.	7.00	10.00	9.00
8.50	23.0 yrs.	8.50	10.00	9.85

7. Averages

Using portfolio averages for duration normally gives totally inaccurate and useless information. Duration is a function of coupon, yield and maturity. If any one of these features is different, future duration changes will be different. The reason is that bond math is not linear such that a six year duration bond will not exhibit the same price sensitivity as a portfolio of equally weighted two and ten year duration bonds. Remember too, duration is a spot calculation and ending durations may be far different than beginning durations, especially coupon bonds vs zero coupon bonds. Only the durations of homogeneous bonds (same maturity or duration) would produce meaningful results. A diversified portfolio of various maturities, coupons and yields (i.e. Bond Index) would produce erroneous averages. The Lehman Govt/Corporate index for July 1990 is a great example:

	Coupon	Maturity	Yield	Price	Duration
July 1990	9.13	9.99	8.57	100.00	5.24

Obviously, these averages look incongruous. How could a coupon of 9.13% priced at par yield 8.57%? Keep in mind if either coupon, maturity or yield are incorrect then duration as a function of these three variables is incorrect.

Solution

Nothing replaces proper total return sensitivity analysis. Until accurate total return calculations are made for each scenario, it is difficult if not impossible to assess the risk and reward of any bond or any portfolio. Duration is an incomplete answer. **Duration is useful for price sensitivity over very short horizons.** To misuse duration as a representation of total return volatility or total risk measurement could lead to very erroneous risk/reward assumptions. **Caveat Emptor!!**