Video 12.1 - Bond Risks part 1: Interest Rate Risk

The following is a supplementary transcript for tutorial videos from https://blogs.ubc.ca/financefundamentals/

Hello everyone. Ready to learn some finance? Then let's continue our discussion of bonds. Over the next two videos, we will talk about the different properties of bonds and how they affect the risk of a bond. In this video, we will talk about interest rate risk. We will learn that bonds with longer terms or lower coupon rates are more sensitive to interest rate risk. This risk affects all bonds, even treasury bills that we think of as being "risk-free." In the next video, we will talk about another type of risk that affects our return, known as default risk.

Video at 00:40

Recall that investors require a return on their investments that cover their risk, inflation, and opportunity cost. Why do they require a return on risk? Because risk lowers the expected value of an investment. If an investment claims to offer a $10 return in today's dollars, but there is a 10% chance that I will earn nothing (in other words, 90% chance that I will earn the $10 return), then my expected return is really only 90% * $10 = $9.

Video at 01:08

Aside from the lower expected value, most investors are risk-averse. What does it mean to be risk-averse? Let's say you can choose between two options. Option 1: I give you $100 right now. Option 2: I flip a coin. If it is heads, I give you $200. If it is tails, you get nothing. The expected value in both these cases is $100, but there are three options regarding your preferences. You may decide to play it safe and go with Option 1. This would be the risk-averse option. Risk-averse investors aim to maximize returns for a given level of risk and minimize risk for a given level of return. Most investors fall into this category. You may also choose to gamble and go for Option 2. This risk-seeking behavior is usually only seen in isolated contexts, like at the casino, rather than in the financial markets, where the standard assumption is that people are risk-averse. Or, you may be indifferent between the two options. This behavior is risk-neutral, as it seeks to maximize returns, regardless of risk.

Video at 02:14

Risk-averse investors require an additional return, in the form of a higher interest rate, in exchange for taking on an investment that has a higher uncertainty of receiving future cash

flows (such as Option 2). We call this extra return the risk premium. So what risks do investors need to consider? There are two key risks that impact the expected return on a bond: interest rate risk and default risk. In this video, we will discuss interest rate risk. In Part B of this video ("Bond Risks part 2: Default Risk"), we will introduce the concept of default risk.

Video at 02:46

First, let's talk about interest rate risk. This is the risk that the market interest rate will change while you are holding a bond. Recall that, when the interest rate rises, the value of a bond falls in the market. For example, let's say you invest in a 10-year, $1,000 face value bond issued by a not-for-profit man-bun rehabilitation center that pays a 5% coupon rate, while the market rate is 5%. We know that this bond would currently sell at its par, or face value of $1,000, since the 5% coupon payments exactly compensate the investor for her risk, inflation, and opportunity cost, or the 5% discount rate. We can prove this using our PV annuity formula.

$$price\ of\ bond\ =\ PV\ =\ \$C \times \left[\frac{1-(1+r)^{-n}}{r}\right] + \frac{FV}{(1+r)^n}$$

$$price\ of\ bond\ =\ PV\ =\ \$50 \times \left[\frac{1-(1+0.05)^{-10}}{0.05}\right] + \frac{\$1{,}000}{(1+0.05)^{10}}\ =\ \$1,000$$

Video at 03:31

However, what happens if next year, the market interest rate increases to 8%? Your 5% coupon bond isn't looking so great now, is it? While you earn a measly return of 5%, other investors in the market can earn 8%. So, nobody is going to want to buy your $1,000 bond at full price. We know from our bond valuation formula, which is a combination of the PV of an annuity formula for our coupons ($\$C \times \left[\frac{1-(1+r)^{-n}}{r}\right]$) and the PV of a single sum for our principal ($\frac{FV}{(1+r)^n}$), that this bond is now only worth $798.70 in the market.

$$price\ of\ bond\ =\ PV\ =\ \$50 \times \left[\frac{1-(1+0.08)^{-10}}{0.08}\right] + \frac{\$1{,}000}{(1+0.08)^{10}}\ =\ \$798.70$$

The value of your investment fell by 20% ($\frac{\$798.70-\$1{,}000}{\$1{,}000}$). All bonds are susceptible to interest rate risk, but it turns out that certain bonds are more sensitive than others to interest rate changes. This sensitivity depends on a bond's time to maturity.

Video at 04:24

Which do you think would be more sensitive to interest rate changes: a long-term bond or a short-term bond? Pause the video and think about this for a moment.

Long-term bonds are more susceptible to interest rate changes. Think about it: longer-term bonds have coupon payments that won't arrive for a long time, meaning that these cash flows must be discounted more to reach their present values. Compare the $50 coupon you'll receive in 5 years to the one you'll receive in 10 years. At 5% interest,

$$PV(\$C_5) = \frac{\$50}{(1.05)^{-5}} = \$39.18$$

$$PV(\$C_{10}) = \frac{\$50}{(1.05)^{-10}} = \$30.70$$

the 5th year coupon is worth $39.18 and the 10-year coupon is worth $30.70, in today's terms. If the interest rate jumps to 8%,

$$PV(\$C_5) = \frac{\$50}{(1.08)^{-5}} = \$34.03 < \$39.18$$

$$PV(\$C_{10}) = \frac{\$50}{(1.08)^{-10}} = \$23.16 << \$30.70$$

the present value of the 5th year coupon falls to $34.03, and the 10th year coupon falls to $23.16. The value of the 5th year coupon fell 13% ($\frac{\$34.03 - \$39.18}{\$39.18}$), while the value of the coupon in year 10 fell 25% ($\frac{\$23.16 - \$30.70}{\$30.70}$). That's because for each additional period, you are dividing by another (1 + r).

Video at 05:26

So when "r" increases, the value of each coupon decreases "n" times over (the exponent when discounting), with “n” being the number of periods from today. And just think; most of the value of a bond investment comes from the big principal payment at the very end. So, the longer the term of the bond, the more the value of the principal payment, and thus, the entire bond will fall as the interest rate increases. Of course, investors also stand to benefit from rate changes in the other direction. If market interest rates fell, the value of longer-term bonds will increase more than shorter-term bonds. Thus, longer-term bonds are more sensitive to rate changes.

Video at 06:06

Another property of a bond that affects interest rate sensitivity is its coupon rate. The effect of coupon size on interest rate risk may not be immediately obvious. Pause the video and take a moment to think about which bonds you think are more susceptible to interest rate risk; bonds with low coupon rates or bonds with high coupon rates? Here's a tip: Try to think about how the timing of cash flows affects how our returns are discounted.

Video at 06:32

Let's test this out: we know that a significant portion of a bond's value comes from the large principal payment at the end of the bond. And we know that these payments are most sensitive to interest rate changes, since they occur the farthest into the future. So bonds with high coupon rates are less sensitive to interest rate changes, since more of the value of the bond is recovered in earlier periods, when it is less affected by interest rate changes. That is, the value of the coupons have a greater influence on the total value of the bond relative to the principal. Meanwhile, bonds with lower coupon rates are more sensitive to interest rate changes, since the coupon payments are smaller, relative to the principal payment at the end.

Video at 07:14

Let's revisit our man-bun bond example from earlier. When we received a $50 annuity payment each year for 5 years, this bond was valued at $1,000. Let's compare this to a zero-coupon bond. A zero-coupon bond, as you may guess, does not pay any coupons. Instead, the value of the bond comes solely from the principal payment the investor receives at the end. Thus, according to our present value formula, a zero-coupon bond, or receiving $1,000 in 5 years, will be worth $783.52

$$price\ of\ bond\ =\ PV\ =\ \$0 \times \left[\frac{1-(1+0.05)^{-5}}{0.05}\right] + \frac{\$1{,}000}{(1+0.05)^5}\ =\ \frac{\$1{,}000}{(1+0.05)^5}\ =\ \$783.52$$

Video at 7:54

Now suppose the market rate increases from 5% to 8%. The value of the original coupon bond falls by 12% ($\frac{\$880.21-\$1{,}000}{\$1{,}000}$) to $880.21,

$$price\ of\ bond\ =\ PV\ =\ \$50 \times \left[\frac{1-(1+0.08)^{-5}}{0.08}\right] + \frac{\$1{,}000}{(1+0.08)^5}\ =\ \$880.21$$

while the value of the zero-coupon bond falls by 13% ($\frac{\$680.58-\$783.52}{\$783.52}$) to $680.58.

$$price\ of\ bond\ =\ PV\ =\ \frac{\$1{,}000}{(1+0.08)^5}\ =\ \$680.58$$

Notice that the zero-coupon bond is more sensitive to interest rate changes, since more of its value comes in later periods that are more heavily discounted. Thus, bonds with lower coupons and longer terms are more sensitive to interest rate changes. In other words, these bonds must offer a higher return to investors to compensate them for taking on this increased interest rate risk.

Video at 08:35

Today, we learned about how all bonds are susceptible to interest rate risk, although bonds with longer terms and bonds with lower coupon rates are more sensitive to interest rate changes. Investors expect to be compensated for this added risk, in the form of higher interest rates. Make sure to watch the next video in this two-part series, where we will go over the other type of risk that can affect bond returns, known as default risk. See you there!