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Waiting to extend: A forward-looking approach to fixed income investing

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Investors sometimes want to invest with a money manager who will shorten portfolio duration in advance of an expected increase in interest rates. The problem with any strategy that depends on predicting changes in interest rates is that you can be right about the direction, but wrong about the timing. As a result, your return could be less than you would have received by simply investing in a long-term bond. Here we offer a tool for quantifying the consequences of delaying one's purchase of long-term bonds, and for setting a target that interest rates must reach in order to justify such a delay.

Suppose a couple had some money that they knew they would not need for at least another five years. In the meantime, they wanted to invest that money in a fixed income security that could increase in value over time. Suppose further that on 21 Sep 2022, they could have invested in tax-exempt, coupon-bearing bonds or zero coupon bonds with the following yields to maturity.

Figure 1 – Sample yields

Years to maturity	Bond yields (%)	Zero coupon yields (%)
1	2.63	2.63
2	2.69	2.69
3	2.71	2.71
4	2.74	2.74
5	2.75	2.75
6	2.81	2.81
7	2.86	2.87
8	2.93	2.95
9	3.02	3.05
10	3.08	3.12

Data source: Bond yields from Standard & Poor's scale of triple-A rated municipal bonds. Zero coupon yields extrapolated from bond yields by Nuveen and rounded to two decimal places. Data as of 21 Sep 2022. See the Appendix for a more thorough explanation of the formulas used to produce zero coupon yields.

Zero coupon bonds, which do not pay interest until maturity, generally have higher interest rates than those that pay periodic coupons (although the differential is small when rates are low). The higher yield compensates for the fact that they have longer durations, which means that their price fluctuates more when interest rates change. If rates rise, the holder of a current coupon bond can reinvest coupon interest earnings at the new, higher yields, which softens the impact of the higher rates and thereby makes current coupon bonds more valuable than zero coupon bonds when rates are increasing.

Because the couple in this hypothetical scenario has no need of the income, and they want as predictable a return as possible, they decide they want zero coupon bonds (a decision that will also simplify comparisons later in this report). But they are apprehensive about buying a 5-year zero coupon bond since they think interest rates might rise sometime in the next five years, and they would like to be able to reinvest their principal in a new, higher yielding bond if that happens.

The dilemma for the couple is that if they buy a short-term bond now, which would give them the potential of reinvesting later at higher yields, they will have to accept an interest rate that is lower than they would receive on a longer bond. One way to resolve this question is by determining how much interest rates need to rise in the future so that the combination of two short-term bonds, purchased sequentially, will provide the same return over the period as a single 5-year bond.

BUYING TWO SHORT-TERM BONDS

If they invested $100 in a 5-year zero coupon bond yielding 2.755% (the precise spot rate), five years from now that bond would be worth $114.56. (Assuming annual compounding to simplify the presentation, the math is $1.0275^5 = 1.1456$.) If the couple bought a 1-year bond yielding 2.63% today, with plans to buy a 4-year bond a year from now, how much would the 4-year bond have to yield in order for the combination of the 1-year and 4-year bond to provide the same return as the 5-year bond?

On 21 Sep 2022, 4-year zero coupon bonds were yielding 2.74%. A year from now a 4-year bond would have to yield 2.79% to compensate for the lower yield in the first year. The math for this calculation is:

$$1.1456 / 1.0263 = 1.1162$$
$$1.1162^{(1/4)} = 1.0279$$

In other words, the 4-year bond would have to produce a return over the next four years of 11.62%, which is equivalent to 2.79% per year.

We can perform similar calculations for different maturities of bonds.

- If 1-year bond yields 2.63%, a 4-year bond must yield 2.79% instead of 2.74%.
- If 2-year bond yields 2.69%, a 3-year bond must yield 2.80%, instead of 2.71%.
- If 3-year bond yields 2.71%, a 2-year bond must yield 2.82%, instead of 2.69%.
- If 4-year bond yields 2.74%, a 1-year bond must yield 2.83%, instead of 2.63%.

A clear pattern emerges. The longer it takes for interest rates to rise, the greater the increase in rates must be for the remaining period. Thus, for whatever time period is chosen for the first bond, the question becomes whether one thinks rates will rise enough by the time one buys the second bond. Suppose someone is deciding whether it would be more beneficial to buy a 2-year bond or a 5-year bond. To justify buying a 2-year bond now, one must be convinced that over the next two years 3-year bond yields will rise from 2.71% to 2.80%.

The hypothetical scenario described above compares rates over two relatively short time periods, but this sort of analysis can also be used for longer time horizons. Figure 2 shows the computations for someone investing for 10 years. The column on the far right shows the amount by which the yield on the second bond must increase from today's levels. Note that in all cases the second bond must yield more than today's yield on 10-year bonds, even though the remaining maturity would be shorter than 10 years.

Figure 2 – Investment over 10 years

Years to maturity of first bond	Zero coupon rate (%)	Cumulative value (%)	Years to maturity of second bond	Yield required on second bond (%)	Required increase in yield (%)
1	2.63	102.63	9	3.17	0.13
2	2.69	105.45	8	3.23	0.28
3	2.71	108.36	7	3.29	0.42
4	2.74	111.41	6	3.37	0.56
5	2.75	114.56	5	3.48	0.73
6	2.81	118.11	4	3.58	0.84
7	2.87	121.93	3	3.69	0.98
8	2.95	126.18	2	3.80	1.11
9	3.05	130.99	1	3.78	1.15
10	3.12	135.95	0		

Target ending value: 135.95%

This hypothetical example is shown for illustrative purposes only. Data is based on past performance of market yields and in no way should be considered representative of an actual investment product or predictive of future investment expectations for market performance. Different benchmarks and economic periods will produce different results.

STAYING IN SHORT-TERM INSTRUMENTS UNTIL RATES RISE

Suppose the couple does not want to select a short-term bond whose maturity corresponds to when they guess rates will rise, but they just want to keep money invested in 1-year paper, which they will roll over into new 1-year notes until they think rates are high enough to justify committing to buy a long-term bond. After 10 years, a 10-year zero coupon bond that yields 3.12% would be worth 135.95% of its original value. Figure 3 shows how high interest rates need to be for the remainder of a 10-year time horizon to compensate for receiving today's 1-year yields in the early years. This strategy is a proxy for keeping money invested in a money market fund or in a series of short-term certificates of deposit until long-term bond rates rise.

Figure 3 – Interest rates needed to compensate for receiving 1-year yields

Years in 1-year bonds	Zero coupon rate (%)	Compounded annually to maturity (%)	Years to maturity of long bond	Yield required on long bond	Required increase in yield (%)
1	2.63	102.63	9	3.17	0.13
2	2.63	105.34	8	3.24	0.29
3	2.63	108.11	7	3.33	0.45
4	2.63	110.96	6	3.44	0.63
5	2.63	113.88	5	3.61	0.85
6	2.63	116.88	4	3.85	1.11
7	2.63	119.96	3	4.26	1.54
8	2.63	123.12	2	5.08	2.39
9	2.63	126.36	1	7.58	4.95
10	2.63	129.69	0		
10-year bond:	**3.12**	**135.95**			

This hypothetical example is shown for illustrative purposes only. Data is based on past performance of market yields and in no way should be considered representative of an actual investment product or predictive of future investment expectations for market performance. Different benchmarks and economic periods will produce different results.

Once again, we see that the longer one must wait for rates to rise, the greater the increase in rates must be.

FORWARD RATES

The preceding analysis assumed that 1-year yields remain constant for as long as the couple is investing in 1-year paper. In a rising rate environment, one would expect both short-term and long-term rates to increase. We can calculate how high future short-term rates must be in order for a series of investments in short-term securities to provide the same return as an investment in a long-term bond of a given maturity. The resulting short-term interest rates are known as "forward rates." To find the forward rate for any period, we divide the compounded value of an investment in a zero coupon bond maturing at the end of that period by the compounded value of a zero coupon bond maturing in the next earlier period. The formula for this computation is:

$$ForwardRate_t = \frac{(1+SpotRate_t)^t}{(1+SpotRate_{t-1})^{t-1}}$$

Where: SpotRate = rate on zero coupon bond maturing in period t.

For example, in Figure 2, 9-year zero coupon bonds yielded 3.05% (3.045% to be precise) and 10-year zero coupon bonds yielded 3.12%. Inserting those values into the formula produces:

$$ForwardRate_t = \frac{1.0312^{10}}{1.0305^{9}}$$

$$ForwardRate_t = \frac{1.3595}{1.3099} - 1 = 3.78\%$$

Thus, the forward rate for 1-year bonds that are bought nine years from now is 3.78%. Forward rates are not a prediction of what the market expects money market or short-term yields to be in the future, but simply an indication of how high short-term rates would have to be in order for money market instruments to provide a return equal to that of a long-term bond of a given maturity.

If future rates on 1-year bonds equal the forward rates shown in Figure 4, then the return from owning a series of 10 1-year bonds would be the same as that from owning a 10-year zero coupon bond. The third column shows the cumulative value of the investment if one invests in a 1-year bond, then at that bond's maturity reinvests the proceeds into another 1-year bond that has the forward rate shown for year 2, and so forth. The cumulative values in this figure are the same as the cumulative values in Figure 2, which means that the preceding analysis of how high long-term bond yields must be during the remainder of the investment period applies whether one buys two short-term bonds or a series of money market instruments that yield the forward rate, and then buys a longer-term bond.

Financial advisors typically caution investors not to try to time the market. The tools presented in this paper quantify the changes in interest rates that must occur in order to get a better return by delaying an investment in long-term assets. While the analysis becomes more complicated, one could also use these methodologies to determine the relative attractiveness of making incremental long-term investments (sometimes called dollar-cost averaging), or assembling a laddered portfolio of various maturities.

Currently, the municipal yield curve is unusually flat, with not much difference between yields of different maturities. For example, at the end of August, the spread between 10- and 1-year yields was just 0.38%, compared to an average spread of 0.81% over the last two years and 1.19% over

Figure 4 – Forward rates compound to produce the long bond's return

Year	Forward rates (%)	Cumulative value (%)	Years to maturity of bond	Yield required on bond (%)	Required increase in yield (%)
1	2.63	102.63	9	3.17	0.13
2	2.75	105.45	8	3.23	0.28
3	2.76	108.36	7	3.29	0.42
4	2.81	111.41	6	3.37	0.56
5	2.83	114.56	5	3.48	0.73
6	3.10	118.11	4	3.58	0.84
7	3.24	121.93	3	3.69	0.98
8	3.49	126.18	2	3.80	1.11
9	3.81	130.99	1	3.78	1.15
10	3.78	135.95	0		

the last 10 years. The increase in yields needed to justify delaying a long-term investment would be greater if the yield curve more closely resembled historical patterns. Under such circumstances, the cost of waiting increases, making this sort of analysis especially important.

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Appendix: computing spot rates

In Figure 1, the zero coupon rates, or spot rates, were computed based on the current coupon rates. The formula used for this computation was:

$$SpotRate_t = \left(\frac{FinalCashFlow}{Price - \sum PVofPriorCoupons} \right)^{\frac{1}{t}} - 1$$

Where:

$SpotRate_t$ = the semiannual zero coupon rate

t = the number of semiannual periods

FinalCashFlow = principal payment and final interest payment on current coupon bond

Price = Price of current coupon bond

∑PVofPriorCoupons = the sum of the present value of the bond's coupon payments except the last coupon payment. When computing the present value of the prior coupon payments, one uses the spot rate appropriate for each payment, dividing each payment by the result from raising (1 + spot rate) to the power equal to the number of compounding periods. One constructs a series of spot rates by starting with the yield on securities due in six months, and using that yield as the spot rate for discounting the present value of the one coupon payment that will be made before maturity on a 1-year bond, to compute the 1-year spot rate. Then one has spot rates for discounting the present value of coupon payments due in six and 12 months on bonds due in 18 months. This process is continued to compute spot rates for all positions on the yield curve.

For example, we derived a 5-year spot rate from a 5-year current coupon bond with the following characteristics:

coupon rate: 3.00%

yield to maturity: 2.75%

price: 101.151

For every $100 of par value, this bond would pay a $1.50 coupon every six months. The final payment at maturity would be $101.50. Using shorter spot rates, we found that the present value of the earlier coupon payments was 12.6293. We now have the values needed.

$$SpotRate_{10} = \left(\frac{101.50}{101.151 - 12.6293} \right)^{\frac{1}{10}} - 1$$

$SpotRate_{10} = 1.14661^{0.1} - 1$

$SpotRate_{10} = 1.3775\%$

The annual spot rate would be 2.755%.

Endnotes

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