A Forward-Looking Assessment of Interest Rate Risk
By Thomas J. Emmerling and Jared Kizer

Much has been written about the risks that rising interest rates pose to fixed income portfolios. However, much of this analysis has been simplistic or focused on historical periods, which are of little relevance to today’s environment of ultra-low nominal rates. On the simplistic side, market commentary has regularly focused on the certainty of upward rate movements when rates are by no means guaranteed to increase, particularly over shorter horizons. Market commentary has also focused on the notion that the impact of rate movements on fixed income portfolios is as straightforward as determining whether rates will go up or down. At first glance, it appears this is true since bond prices move in the opposite direction of interest rates. However, this viewpoint misses the vitally important notion that the right question to ask is whether rates will move by more or less than the market has already accounted for. This is a completely different question and one that market timers find more difficult to answer correctly.

This piece provides insight into the risks that fixed income investors face over the next year using today’s rate levels and a model of interest rate volatility. While no one knows exactly what the future holds, we believe this is a much better way to examine interest rate risk compared with historical analyses of rate movements and fixed income returns and compared with analyses that do not account for the market’s expectations for rate increases and maturity premia.

The Flaws in Historical Analyses

Historical analyses of rate movements and fixed income returns suffer from at least two flaws:

1) The analyses typically focus on nominal returns, which can drastically overstate net-of-inflation (or real) returns.

2) Generally, historical nominal rate levels have been much higher than rate levels today. This too can understatement the risks that today’s fixed income investors face since high “starting” rates provide a buffer against upward rate movements.

We can illustrate both of these flaws by looking at five-year Treasury rates, returns and inflation in the early 1980s. In 1980, the five-year Treasury returned 3.9 percent even in the face of interest rate increases of more than 2 percent. One might think this result shows that investors should not worry about interest rate risk today, because in some past periods rates have moved up sharply but returns have still been positive. We would argue though that this historical result has virtually no relevance for today’s fixed income environment. First, while the nominal return on a five-year Treasury was 3.9 percent in 1980 the real return, or net-of-inflation return, was –7.6 percent due to
high inflation in 1980. This is a significant loss in purchasing power. More important for today's environment, the five-year Treasury yield was 10.4 percent at the start of 1980, which provided a significant nominal return buffer against the increase in rates that occurred during 1980. This “starting condition” of high rates is obviously not relevant today.

Over a one-year period, the return on a bond or portfolio of bonds can be approximated by the following equation:

\[ R = Y - \text{Dur} \times \Delta Y, \]

In this equation, \( R \) is the one-year return, \( Y \) is the starting yield, \( \text{Dur} \) is the duration of the bond or portfolio of bonds and \( \Delta Y \) is the actual change in the yield over the one-year holding period.

Duration is a measure of interest rate risk and is always positive (unless you are shorting fixed income securities or dealing with relatively exotic fixed income securities). Therefore, during periods when rates move up, the second part of the equation will be negative and detract from overall portfolio return. Let's assume the starting yield of a portfolio is 5 percent, duration is 5 percent and that rates move up by 1 percent.

\[ R = 5\% - 5\% \times 1\% = 0\%. \]

Here we see that the 5 percent yield helped completely offset the 1 percent increase in rates. However, if we assume the starting yield is 2 percent but leave the other aspects of the equation unchanged, the result is:

\[ R = 2\% - 5\% \times 1\% = -3\%. \]

Instead of earning no return when the starting yield was 5 percent, we have lost 3 percent when the starting yield was just 2 percent (again keeping in mind this equation is an approximation). This illustrates the fundamental flaw of extrapolating past historical results into today's low-rate environment.

This example also demonstrates an important fact concerning duration when evaluating an investment's return. Namely, the value of the duration does not necessarily dictate the return of the investment under a 1 percent change in yield. In fact, only when the starting yield is 0 percent will the return match its duration if the yield changes by 1 percent.

**Understanding How Interest Rate Increases Actually Affect Returns**

Before reviewing our forward-looking analysis, it is important to understand that market pricing can help protect investors against sizable rate increases. Most investors wrongly believe that interest rate increases mean returns will be “bad” while interest rate decreases mean returns will be “good.” The more nuanced reality is that a steep yield curve — that is, a yield curve in which longer-term rates are higher than shorter-term rates — provides some protection against rate increases. This is important to understand since yield curves have generally been steep over the past few years.
Consider an investor with a one-year investment horizon and suppose a one-year, zero-coupon bond is yielding 1 percent, and a two-year, zero-coupon bond is yielding 2 percent. Given these two rates, the investor who purchases the two-year bond will earn a higher return over the next year compared with the investor who purchases the one-year bond, as long as the one-year interest rate does not increase by 2 percent or more. Said differently, as long as the one-year rate — which is 1 percent today — is less than 3 percent in one year, the two-year bond will earn a higher return than the one-year bond. For example, assume the one-year rate increases from 1 percent to 2.5 percent over the next year. In that case, the return on the two-year bond will be:

\[
\text{Return} = \left( \frac{97.56}{96.12} - 1 \right) \times 100\% = 1.5\%.
\]

We see that the 1.5 percent return on the two-year bond exceeded the 1 percent return on the one-year bond even though interest rates increased.

**A Forward-Looking Analysis of Interest Rate Risk**

Our first equation above shows that an investment’s return depends upon the change in the investment’s yield. When this investment consists of more than one bond, such as with a laddered bond portfolio, the change in yield depends upon several rates for different bond maturities. In other words, a 1 percent change in the portfolio’s yield can result from many different changes to the shape of the yield curve. Arguably, an effective analysis of the future return of such portfolios should include a consideration into different evolutions of the whole yield curve.

Given today’s interest rates and reasonable expectations of interest rate volatility, what is the range of returns that a fixed income investor could expect over the next year? We answer that in this section by examining the forward-looking risk profile of a laddered bond portfolio with starting maturities ranging from one year to eight years. Generally, interest rates could change in countless ways over the next year, so the only way to get an assessment of the risk of a portfolio is by simulating different changes in interest rates and calculating portfolio returns for each simulation. We simulated 100,000 different interest rate paths. Figure 1 shows returns for a selected number of simulations.

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Bond Ladder Returns (%)</th>
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</thead>
<tbody>
<tr>
<td>5th Percentile</td>
<td>-5.3</td>
</tr>
<tr>
<td>10th Percentile</td>
<td>-4.1</td>
</tr>
<tr>
<td>25th Percentile</td>
<td>-2.2</td>
</tr>
<tr>
<td>Median</td>
<td>0.0</td>
</tr>
<tr>
<td>Average</td>
<td>0.1</td>
</tr>
<tr>
<td>75th Percentile</td>
<td>2.3</td>
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<tr>
<td>90th Percentile</td>
<td>4.5</td>
</tr>
<tr>
<td>95th Percentile</td>
<td>5.8</td>
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This analysis shows that if interest rates were to rise sharply, the laddered portfolio would decline by 5.3 percent, which is the 5th percentile result. If interest rates were to decline sharply, the laddered portfolio would increase by 5.8 percent. Further, in many of the positive return scenarios, rates actually increased over the next year. Nevertheless, they did not increase enough to lead to negative portfolio returns.

This analysis also shows that relative to bad equity market returns, which could easily be -20 percent or worse over a 12-month period, bad returns on a short-duration fixed income portfolio are not nearly as negative. Further, it could be that some of the scenarios in which rates increase sharply are also periods when equity market performance is strong, offsetting the negative returns of the fixed income portion of the portfolio. Finally, long-horizon investors should keep in mind that while interest rate increases may lead to portfolio losses in the short term, higher real interest rates are a positive over longer periods of time for short-to-intermediate maturity bond portfolios. That is, as a lender of money, ask yourself whether you would prefer lending at higher or lower interest rates over the next 20 years.

**Summary**

We show that historical analysis of bond returns during periods of rising rates potentially suffers from two flaws. First, since many of these historical periods were also periods when inflation was high, focusing only on nominal returns greatly understates the loss of purchasing power that many fixed income investors incurred. Second, during many of these periods, beginning interest rates were much higher than they are today. Today’s “starting” interest rates provide less cushion against interest rate increases.

Using current interest rates and a model to simulate future interest rates over the next year, we examine how a portfolio of short- and intermediate-term bonds might perform. We find that if interest rates were to move up sharply over the next year, the portfolio value would fall by about 5 percent (in inflation-adjusted terms, assuming 2 percent inflation, this would be a decline in purchasing power of approximately 7 percent). While no one enjoys negative returns, the magnitude of the downside risk of the bond portfolio we examined is significantly less than the downside risk of stocks, a point often missed in many of the popular media articles that warn about the risks of rising interest rates.

Finally, fixed income investors in short- and intermediate-term bonds should actually root for increases in real (net-of-inflation) interest rates since higher rates should improve returns for long-horizon investors.

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Assuming a maturity value of $100, the original cost of the two-year bond is $100/1.02^2 = $96.12 and the value of the two-year bond after one year is $100/1.025 = $97.56.

Our implementation methodology, a one-factor Heath, Jarrow and Morton (HJM) term structure model, simulates the evolution of the entire zero-coupon Treasury yield curve forward in time beginning with today’s current yields. After simulating future yields every month over one year, we compute the monthly returns and then the annualized return on a laddered bond portfolio consisting of eight zero-coupon bonds, i.e., one bond for each maturity: 1-year, 2-year, ..., 8-year. With this construction and given current yields, our bond portfolio has a duration of approximately 4.3. After computing the annual portfolio return for each simulation of 100,000 yield curve evolutions by compounding the monthly returns, we analyze the distribution of the annual returns and compute distribution statistics to assess the portfolio’s performance and risk.

To simulate actual yield curve evolutions, we closely follow the simulation algorithm prescribed in Section 3.6 of Glasserman (2004) Monte Carlo Methods in Financial Engineering. For implementation, we first need to identify a reasonable market price of risk for the one-factor driving the uncertainty in the model. For our purposes, we choose the short rate (the interest rate used for short-term borrowing/lending) as a proxy for this quantity. As a second ingredient for the implementation, we need to specify the volatility of returns for Treasury zero-coupon bonds across all available maturities. We estimate these volatilities using historical yield curve rates between January 2004 and December 2013. This historical data is continually updated and freely available on the Federal Reserve website. The methodology used for obtaining these historical yield curves is based upon the academic research carried out by Gurkaynak, Sack, Wright (2006). We also use this Federal Reserve data to obtain the most current Treasury yield curve from which each simulation begins. We utilized the May 20, 2014 yield curve estimate for the initial specification of our simulation.