

YIELD CURVE INVESTING: OPTIMIZING RISK-ADJUSTED RETURNS

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ABSTRACT

This paper investigates how recent changes in market interest rates have affected risk-adjusted returns. Returns are adjusted for duration, a measure of interest rate risk. Prior to the 2007 - 2008 rate decrease, one-year Treasuries offered the best risk/return tradeoff. As a result of the rate decrease, short rates dropped much more than longer rates, rendering the one-year Treasury less competitive. After 2008, the five and seven year Treasury maturities offer the best risk-adjusted returns.

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KEYWORDS: Yield Curve, Duration, Interest Rate Risk, Maturity, Mean Reversion, Risk-Adjusted Return

INTRODUCTION

This paper tracks the relatively low rates of the past forty months, December, 2008 through March, 2012, in contrast with the relatively high rates of the preceding forty months, August, 2005 through November, 2008. The Treasury yield curve has experienced significant change over this time period.

Its changing slope and position has created different risk/return profiles across the maturity spectrum. Prior to the steep rate decline of 2007 – 2008, one-year Treasuries offered nominal returns exceeding three percent, with very little interest rate risk, while thirty-year Treasuries offered little additional yield but with significantly greater interest rate risk. Over the seven year period reviewed, the spread between one and thirty year Treasuries has widened from under 50 basis points to over 300 basis points. Now with rates a whisker above zero, the one-year Treasury offers little return. Longer yields offer significantly higher yields, but with increasing interest rate risk. The question addressed in this paper is at what term-to-maturity the risk/return profile optimized.

The literature on Treasury bond investing strategies largely focuses on the expected future shape of the yield curve, and related trading strategies. This paper focuses specifically on the recent change in optimal risk/return tradeoff caused by a dramatically changed yield curve. The literature on “mean reversion” and “riding the yield curve” trading strategies, as well as the use and limitations of duration, inform this work. After a review of the literature regarding yield curve investing strategies and limitations, methodology and modeling is reviewed, followed by findings, conclusions, and suggestions for further research.

LITERATURE REVIEW

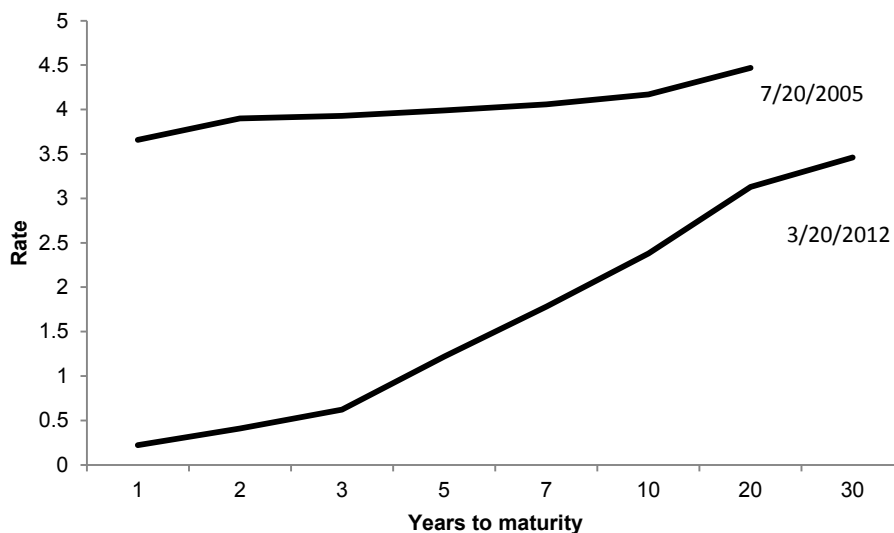
The Treasury yield curve is used as a gauge of market interest rates because Treasury bonds have no perceived credit risk. The yield curve often is used as a barometer to gauge future interest-rate directions and changes. It's also used to help establish investment portfolio strategies.

Additionally, the Treasury yield curve is used in the fixed-income arena to price marketable securities. Obligations of government-sponsored enterprises such as Fannie Mae and Freddie Mac frequently are offered at a spread over a comparable reference Treasury note (Spears, 2005).

Most economists agree two major factors influence the shape (slope) of the yield curve: future interest-rate expectations, related to expectations of future inflation, and the "risk premium" investors expect for investing in longer-term bonds. The yield curve's normal or natural slope is upward. This makes sense because investors should expect to receive higher returns on money invested for longer periods of time due to increasing interest rate risk (Fisher, 2001).

The relative steepness of the yield curve has increased significantly in recent years. Since July 20, 2005, 20-year Treasury rates have dropped some 120 basis points (b.p.), while the 1-year Treasury has plummeted some 324 b.p (figure 1). The combination of a downward shifting, steeper yield curve has implications in terms of relative risk/return tradeoffs along the curve – treasuries of various maturities.

Figure 1: Comparative yield curves, July 20, 2005 and March 30, 2012



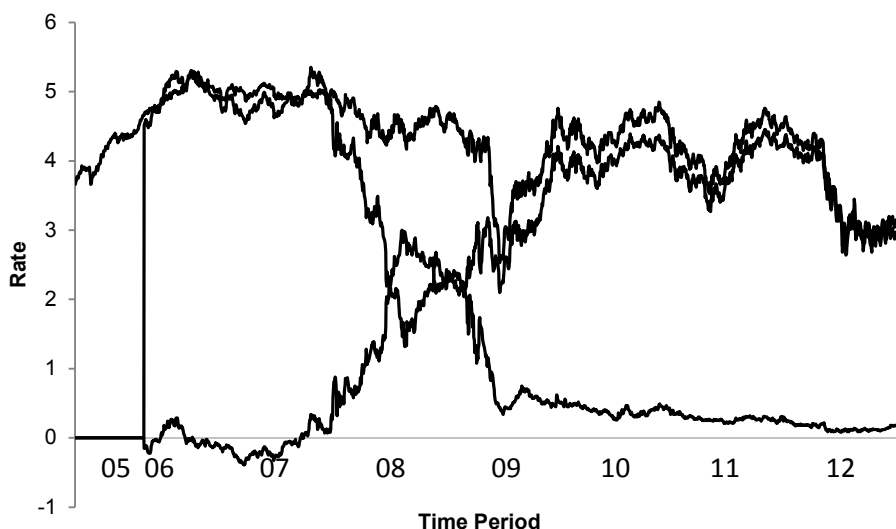
Note: Yield curves for 07/20/2005 and 03/20/2012. Data based on range of Treasury maturities at the time. Thirty-year Treasuries were not traded on 07/20/2005. While rates have dropped for all maturities, the reduction on short rates has been particularly dramatic (www.treasury.gov).

The dramatic decline in Treasury yields took place during 2007 and 2008. The spread between short and long rates widened dramatically (see figure 2.) The literature on yield curve trading dates back to the late 1960s; a sample of the earlier literature includes De Leonardis (1966); Freund (1979); Darst (1975); Weberman (1976); Dyland, Joehnk (1981), and Stigum and Fabozzi (1997). More recent analyses of the subject are found in Jones (1991), Grieves and Marchus (1992), Willner (1996), Mann and Ramanlal (1997), and Palaez (1997).

A well known yield curve investing strategy is termed "riding the yield curve." It involves the purchase of a longer-dated security and selling it before maturity. The purpose of riding the yield curve is to benefit from certain interest rate environments. In particular, if a fixed income manager has the choice between investing in a 1-month deposit or a 12-month money market instrument and selling after 1 month, there are certain rules of thumb as to which strategy might yield a higher return. For instance, when the yield curve is relatively steep and interest rates are relatively stable, the manager will benefit from riding the curve rather than buying and holding the short-maturity instrument. However, there are risks to riding the yield curve, most obviously the greater *interest* rate risk associated with the riding strategy (as reflected by its higher duration). Thus, if one is riding and yields rise substantially, the investor will incur a capital

loss on the riding position (Bieri and Chincarini, 2005). This literature acknowledges the primacy of interest rate risk.

Figure 2: Yield Spread Change: July 20, 2005 and March 30, 2012.



Note: This graph depicts rates before and after the 2007 – 2008 rate decline. Graph compares 1-year Treasury rates with 30-year Treasuries, July 20, 2005 through March 30, 2012. In the early years, yields on long-term and short-term Treasuries were similar. Thirty-year Treasuries were not traded until 02/09/06. More recently, long rates have periodically exceeded short rates by over 400 basis points (www.treasury.gov).

Another area of focus has been the mean-reverting propensity of the yield curve. This view asserts that the yield curve mean-reverts to a historical norm. This market view is consistent with historical experience. For instance, U.S. Treasury bill rates, spreads, and curvature all trade within tight, finite bounds. This suggests that some form of mean-reversion mechanism is at work that prevents the yield curve from drifting to extreme levels or shapes over time. The market view of yield curve mean reversion is also represented in theoretical models of the interest rate term structure—as discussed in Vasicek (1977); Cox et al. (1981,1985), and Campbell and Shiller (1991), for example—that incorporate some form of mean-reversion mechanisms and are based on some form of the expectations hypothesis. In essence, the pure expectations hypothesis of the term structure is the theory that the long-term interest rate is the average of the current and expected short-term rates, so that the yield spread is mean reverting." Interest rates along the yield curve adjust to equalize the expected returns on short- and long-term investment strategies.' Furthermore, by incorporating rational expectations, the pure expectations hypothesis implies that excess returns on long bonds over short bonds cannot be forecasted; hence, they have a zero mean in the case of the pure expectations. This implies that deviations from this pure expectations assumption can be exploited for abnormal profits. Given today's modest inflation forecasts, exceptionally high longer term rates may constitute such an exploitable deviation.

Duration as an interest rate risk measure does have limitations. Macaulay (1938) derived modified duration as a measure of the average length of time until the promised cash flows of a bond are paid. He did not derive it as a measure of risk. However, Samuelson (1945) used Macaulay's concept to show how to make an institution's solvency "immune" to (perfectly hedged against) interest-rate changes by setting the duration of its assets equal to the duration of its liabilities. Redington (1952) independently rediscovered portfolio immunization, which was of great importance to insurance companies. Fisher and Weil (1971) tested the idea empirically and found that immunized portfolios were much less risky than portfolios in which only average terms to maturity were matched.

The relationships of returns to alternative measures of duration have also been studied (Gultekin and Rogalski, 1984; Ilmanen, 1992). In all of these cases the comparisons of duration were made separately at single points in time. However, as interest rates change, duration as a risk measure may perform perversely. Consider a coupon bond or a portfolio of bonds. Duration is the present value weighted average of the times to payment. Therefore, as interest rates rise, nearby payment dates become increasingly more important than far away dates. Hence, duration falls. But empirically, as interest rates rise, interest rate risk also rises. There are also some contradictions connected with using duration for contemporaneous comparisons of interest-rate risk. For example, corporate bonds are normally considered riskier than Treasury bonds. However, for a corporate bond and a Treasury bond with the same term to maturity and price, the corporate bond has the lower duration because it will have a higher coupon. Another scenario depicting the limitations of duration as an interest rate measure is comparing a tax-exempt and taxable investors (Hessel and Huffman, 1981). Since the taxable investor receives a lower net interest rate, they will believe the bond has a higher duration than the tax-exempt bonds. Yet the taxable investor receives the same or less interest rate risk. It is assumed that interest rate risk is the relevant risk measure for the active bond trader. Acknowledging the limitations of duration, it remains the primary interest risk measure on fixed income investments.

METHODOLOGY

Risk-adjusted returns are measured on 1, 2, 5, 7, 10, 20, and 30-year Treasury bonds over an 80-month period, forty months before, and forty months after, fourth-quarter of 2008. Altogether, 566 risk-adjusted returns were calculated (www.treasury.gov., 2012). The “low rate period” consists of forty months from January 20, 2009 through March 20, 2012. The “high rate period” consists of forty months from July 20, 2005 through September 20, 2008. Forty months is the look-back period from data collection to the time interest rates reached a sustained low. The prior forty months was chosen to ensure term symmetry for the “before and after” comparison. Nominal returns are adjusted for interest rate risk using Macaulay’s duration. Macaulay’s duration measures the interest rate sensitivity of a bond’s value and is derived as follows.

Let r be a bond’s yield to maturity, so that r solves

$$P = \frac{C}{(1+r)} + \frac{C}{(1+r)^2} + \dots + \frac{C}{(1+r)^{T-1}} + \frac{C+F}{(1+r)^T} \quad (1)$$

where C is coupon payment, F is face value, T is maturity and P is the current price of the bond. Macaulay’s duration is defined by the weighted average time to maturity, where the weights are w :

$$D = \sum_{t=1}^T tw_t = \sum_{t=1}^T t \frac{C_t}{P(1+r)^t} = - \frac{\frac{\partial P}{\partial r}}{(1+r)} \quad (2)$$

A one-way analysis of variance procedure is used to perform an analysis of variance to test whether or not the mean risk-adjusted return (RAR) among the Treasury maturities are equal. It assumes all sample means are drawn from normally distributed populations with equal variance. In this case, the data sets comprise 40 months. One-way ANOVA is an extension of the two-sample t-test, which yields the same result when the factor variable has two levels. ANOVA was chosen over multiple t-tests to overcome type I errors. This analysis consists of seven levels, corresponding to the different maturities: 1, 2, 5, 7, 10, 20, and 30-year maturities.

The ANOVA is conducted on mean RAR for each maturity term for both the “low rate period,” and for the “high rate period.” Additionally RAR is compared for like maturities between the two rate periods. The null hypothesis is that there are no significant differences among different maturities within a rate period, and that there is no significant difference between the two rate periods for the same maturity term. Risk-adjusted returns are defined as a Treasury bond’s nominal rate of return (r) divided by the bond’s duration (D): $RAR = r / D$. The calculation of duration is based on the assumption of equal coupon and market rates. This model is conceptual similar to measurement models used to find risk-adjusted returns of mutual funds. With the Sharpe approach (Sharpe, 1966), excess returns on a portfolio are compared with the portfolio standard deviation. The Treynor approach (Treynor, 1965) compares excess returns with portfolio beta. In both cases, excess return is defined as the difference between total portfolio return and the risk-free rate of return.

The focus on duration as a risk measure is particularly applicable to bond traders. (Buy-and-hold investors are generally more interested in inflation risk, the erosion in purchasing power over time). For the trader, price change risk is measured as the product of duration and the expected change in interest rates:

$$\% \Delta P \approx - DUR \times \Delta i / 1 + I, \tag{3}$$

Where

$$\% \Delta P = (P_{t+1} - P_t) / P_t = \text{percent change from } t \text{ to } t + 1$$

DUR = duration

i = interest rate

FINDINGS

For all maturities, risk-adjusted returns were significantly reduced from before to after fourth quarter of 2008. In the earlier period, from July 20, 2005 through September 20, 2008, risk-adjusted returns were significantly different among all terms to maturity (see Table 1). The greatest return, relative to risk, is on the one-year treasury, with a risk-adjusted return averaging 3.988 for the period. The poorest risk/return tradeoff is on the 30-year treasury, with a risk-adjusted return of 0.2894. Note that even while the yield curve is rather flat (figure 1 above), when adjusted for duration the risk-adjusted returns become quite different, dropping significantly with increasing maturities.

Table 1: Risk-adjusted Treasury Bond Returns, July 20, 2005 - September 20, 2008

<u>Maturity (N)</u>	<u>Mean risk-adjusted return**</u>
1	3.986
2	2.025
5	0.9000
7	0.6905
10	0.5705
20	0.3985
30	0.2894

***Returns are significantly different among all terms at .05 level. These values reflect average risk-adjusted returns for forty months, from July 20, 2005, through September 20, 2008.*

In the more recent period, from January 20, 2009, through March 20, 2012, the greatest return relative to risk is on the seven-year treasury at 0.3715, although the five-year treasury is not significantly less at 0.3695. The least attractive risk/ return tradeoff is again on the 30-year treasury, with a risk-adjusted return of 0.2265

Table 2: Risk-adjusted Treasury Bond Returns, January 20, 2009 - March 20, 2012

<u>Maturity (N)</u>	<u>Mean Risk-Adjusted Return</u>
1	0.2950
2	0.3275
5	0.3695**
7	0.3715**
10	0.3415
20	0.2705
30	0.2265

***Differences are not significant (.05 level) between 5 and 7-year maturities. These values reflect average risk-adjusted returns for forty months, from January 20, 2009, through March 20, 2012.*

The only maturities for which the differences between means is not significant are the 5 and 7 year maturities for the January 20, 2009 to March 20, 2012 period. The P-value of .932 is far greater than the alpha level of significance (.05), so the null hypothesis is not rejected; that is, the mean RAR for the 5 and 7-year RARs are the same. See table 3.

Table 3: ANOVA Summary

	<u>Sum of Squares</u>	<u>df</u>	<u>Mean Square</u>	<u>F</u>	<u>P-value</u>
Between Groups	0.000	1	0.000	.007	.932
Within Groups	0.859	78	0.011		
Total	0.859	79			

Note: The critical F(1,78) value from the F-table with alpha = 0.05 is 1.38. The computed F value of .007 is well below the critical F. The p-value is greater than 0.05. Therefore, we do not reject the null hypothesis and conclude that there is no difference between the 5 and 7-year mean RAR.

CONCLUSION

Interest rates on treasury bonds of all maturities have dropped significantly in the past seven years. With the new, lower interest rate environment, the relative risk versus return tradeoff, as measured by risk-adjusted return, has likewise changed. The objective of this paper is to identify the maturity date for which the optimal return to risk is found. An ANOVA test was used to distinguish among average risk-adjusted returns for seven different Treasury maturity terms. For the forty month period before and during the 2007/2008 rate decline, the one-year treasury offered the best RAR. More recently, however, lower market interest rates for all maturities, and much lower rates on bonds with the shortest maturities, has stripped the one-year treasury of its RAR superiority. The five and seven year terms now offer a better risk/return tradeoff. The steeper yield curve provides incremental returns exceeding the increased duration risk with these maturities. The 30-year bond, while offering the greatest nominal yield for all months when traded, is also subject relatively high interest rate risk, rendering the 30-year a poor value on a risk-adjusted basis.

Limitations of duration as an interest rate risk measure have been noted. This paper's objective is limited to identifying the return/risk profile for a variety of published terms to maturity for Treasury securities. Subsequent research into how trading or hedging strategies could benefit from this information would be useful. For example, "riding the yield curve" may seem imprudent in terms of interest rate risk incurred in this buy and sell strategy.

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BIOGRAPHY

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