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YIELD CURVE

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ABSTRACT

This paper provides a brief survey of the relationship between the yield curve and future changes in interest rates and inflation. The expectations hypothesis of the term structure indicates that when the yield curve is upward sloping, future short-term and long-term interest rates are expected to rise. Empirical evidence finds that as predicted by the expectations hypothesis, yield spreads are positively correlated with future changes in short-term interest rates, particularly at long horizons. However, yield spreads are negatively correlated with next period's change in long-term interest rates, the opposite prediction of the expectations hypothesis. Empirical evidence also suggests that the yield curve has almost no ability to forecast future inflation changes for short horizons: however, at horizons of a year or greater, the yield curve contains a great deal of information about the future path of inflation.

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The yield curve is a plot of the interest rate yields on bonds with differing terms to maturity, but with the same risk, liquidity, and tax considerations. In other words, the yield curve is a description of the term structure of interest rates. Typically, yield curves are upward sloping -- i.e., long-term interest rates are above short-term interest rates -- but at other times they are flat or downward sloping. The basic question about yield curves is what determines their slope. Why do we more often see upward sloping yield curves, but sometimes see downward sloping ones?

The basic theory of the yield curve is called the expectations hypothesis of the term structure of interest rates, and put most simply, it states that the interest rate on a long-term bond will equal an average of short-term interest rates expected to occur over the life of the long-term bond. In the case of continuously compounded interest rates on pure discount bonds, the expectations hypothesis can be written down as:

(1) $$R_t^n = (1/n)\, E_t[r_t + r_{t+1} + r_{t+2} + \ldots + r_{t+n-1}]$$

where,

R_t^n = the interest rate on a n-period bond at time t,

r_{t+i} = the one-period interest rate at time t + i,

E_t = expectations at time t.

The expectations hypothesis is derived from the assumption that bonds of different maturities are perfect substitutes so that the expected return from holding one-period bonds must equal the expected return from holding the n-period bond.

The slope of the yield curve can be examined by looking at the spread between the long-term and the one-period, short-term interest rate, which is denoted as $S_t^n = R_t^n - r_t$. Through algebraic manipulation of equation (1), the yield spread, S_t^n, can be written down as the expectation of a weighted average of future changes in short-term interest rates as follows:

(2) $$S_t^n = E_t S_t^{n*}$$

$$S_t^{n*} = (1/n)\ [(n-1)\Delta r_{t+1} + (n-2)\Delta r_{t+2} + \ldots + \Delta r_{t+n-1}]$$

where,

S_t^n = the yield spread = $R_t^n - r_t$.

S_t^{n*} = a weighted average of the realized future interest rate changes.

What this equation tells us is that S_t^n should be positive and the yield curve upward sloping when future short-term interest rates are expected to rise in the future. In this case the average of future short-term rates, and hence the long-term rate, will be above the current short rate, leading to the positive yield spread. A downward yield curve slope would only arise when short-term interest rates are expected to fall in the future.

Manipulation of the expectations hypothesis equation in (1) also enables us to derive the relationship between the yield spread, S_t^n, and the expected change in the yield on the long-term bond as follows:

(3) $$S_t^n = (n-1)\ E_t[R_{t+1}^{n-1} - R_t^n]$$

This equation tells us that the yield spread will be positive when the long-term interest rate is expected to rise next period. This follows from the assumption in the expectations hypothesis that expected returns on short and long-term bonds must be equal. If the long-term bond is not expected to have a capital loss when the spread is positive, the return on a long-term bond would be greater than the return on a short-term bond. Hence in order for the expected returns on short and long-term bonds to be equal, the long-term interest rate must be expected to rise so that there is an expected decline in long-term bond prices and a capital loss.

Campbell and Shiller (1989) outline equations (2) and (3) which apply to pure discount bonds. For coupon bonds, Shiller (1979) demonstrates that the expectations hypothesis implies the long-term coupon-bond rate equals an exponentially declining weighted average of the expected future short-term interest rates. The resulting derivations of equations (2) and (3) for coupon bonds in Shiller, Campbell and Schoenholtz (1983) and Shiller (1989) lead to equations with slightly different weights, but which generate the same conclusions described above.

Equations (2) and (3) not only provide an explanation of what determines the slope of the yield curve, but if we are willing to assume that expectations are good forecasts of the future, equations (2) and (3) indicate that the slope of the yield curve contains information about future interest rate movements. Specifically, a positive yield spread should predict future rises in the short-term interest rate as well as a rise in the long-term interest rate next period.

An important modification to the expectations hypothesis of the term structure is the preferred habitat theory described by Modigliani and

Shiller (1973). If bonds of different maturities are not perfect substitutes, then a bond at one maturity might be preferred to a bond at another maturity, so that their expected returns might not have to be equal. The preferred habitat theory therefore suggests that a term premium should be added to the expectations hypothesis equation (1). Indeed, since it is likely that investors prefer to hold short rather than long-term bonds, the term premium in (1) would rise as the maturity of the long-term bond increases. This explains why yield curves are more often found to be upward sloping rather than downward sloping.

If the term premium is constant at each maturity, then equations (1)-(3) only need to be modified by adding constant terms in each. This means that a positive yield spread no longer necessarily implies that future short-term rates are expected to rise and the long-term rate is expected to fall. However, the following basic conclusion from the expectations hypothesis still holds: a rise in the yield spread, and hence a steeper slope of the yield curve, indicates expectations of larger rises in future short-term as well as long-term interest rates. On the other hand, if the term premiums vary over time, then the variation in the yield spreads may reflect variation in the term premium rather than expectations of future interest rate changes. Hence time-varying term premiums may obscure the information in the yield spread about future short and long-term interest changes.

Empirical evidence finds that as the expectations hypothesis predicts in equation (2), the yield curve does contain information about future short-term interest rate changes. Although Campbell and Shiller (1987, 1989) find evidence of time-varying term premiums, the yield spread has a significant positive correlation both with the actual realization of the weighted average of the future short rate changes, S_t^{n*}, and with vector autoregression forecasts of this weighted average. Although this positive correlation is significant when *n* equals two or three months, it declines until *n* equals nine to twelve months and then rises substantially until the correlation is most positive and statistically significant for the largest *n*. Fama (1984) and Fama and Bliss (1987) use a somewhat different approach than Campbell and Shiller but obtain similar conclusions. They regress individual future short rate changes on the forward-spot spread (the difference between the forward rate, which is derived from adjacent maturity interest rates, and the current (spot) short rate.) They also find that the yield curve has significant forecasting ability at long horizons for future short rate changes, but has no forecasting ability for horizons less than a year and greater than a few months.

The other implication of the expectations hypothesis [in equation (3)] that a higher yield spread indicates a greater rise in the long-term interest rate next period does not fare well in the data. Indeed, the evidence points to the opposite conclusion. As is found in Shiller, Campbell and Schoenholtz (1983), Mankiw and Summers (1984) and Campbell and Shiller (1987, 1989), the regression coefficient in a regression of the change in the long rate on the spread is significantly different from $1/(n-1)$, the implied value from the expectations hypothesis equation (3) if expectations are rational. This result thus provides additional evidence for the presence of time-varying term premiums. Furthermore, this regression coefficient even has the wrong negative sign, indicating that when the spread is high the long rate will fall rather than rise as the expectations hypothesis suggests.

To summarize the conclusions on the relationship between the yield spread and future changes in interest rates: as predicted by the expectations hypothesis, yield spreads are positively correlated with future changes in short-term interest rates, particularly at long horizons; however, yield spreads are negatively correlated with next period's change in long-term interest rates, the opposite prediction of the expectations hypothesis.

The information in the yield curve can also be examined from a somewhat different perspective. Fama's (1975) classic study on interest rates as predictors of inflation suggests that movements in interest rates primarily reflect fluctuations in expected inflation rather than changes in real interest rates. Subsequent work supports this conclusion for the postwar United States except for the period of the change in Federal Reserve operating procedures from October 1979 until October 1982. [See for example, Nelson and Schwert (1977), Mishkin (1981), Fama and Gibbons (1982) and Huizinga and Mishkin (1986).] This evidence along with the evidence that the yield curve contains information about future short-term interest rate movements suggests that the yield curve might also contain information about the future path of inflation.

Fama (1990) and Mishkin (1990a, 1990b) examine the ability of the yield spread to forecast changes in future inflation. They find that the yield curve has almost no ability to forecast future inflation changes for short horizons; however, at horizons of a year or greater, the yield curve contains a great deal of information about the future path of inflation. The evidence indicates that, at longer maturities, the yield curve can be used to help assess future inflationary pressures: when the yield curve steepens, it is an indication that the inflation rate will rise in the future and when the slope falls, it is an indication that the inflation rate will fall. The results here also lend support to using the yield spread between long (over two years) and short-term interest rates to assess the credibility of anti-inflation policies (as in Blanchard [1984]).

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