Interest Rate Forecasting and the Yield Curve

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The development of financial market indicators is often connected with expectations about the future path of various macroeconomic variables. The yield curve has long occupied a firm place among such financial indicators. The term structure of interest rates incorporates a wide range of valuable information regarding the future development of inflation, future economic activity, economic cycles and interest rates themselves.

The yield curve, which plots the yield of Gilts against their maturity, is one of the most closely watched financial indicators. Theoretically speaking a yield curve is the graphic or numeric presentation of bond equivalent yields to maturity on debt that is identical in every aspect except time to maturity. In developing a yield curve, default risk and liquidity, for example, are the same for every security whose yield is included in the yield curve. Thus yields on Gilts are normally used to plot yield curves because the credit quality does not change over the life of the sovereign bonds. The relationship between yields and time to maturity is often referred to as the term structure of interest rates. Market observers carefully track the yield curve's shape, which is typically upward sloping and somewhat convex. At times the curve becomes flat or slopes downward (inverted), configurations that many business economists, financial analysts, and other practitioners regard as harbingers of recession. In most of the days of 2000 and 2001, we have witnessed the inverted yield curve in India. But this inversion only remained for the very shorter end where the mismatch of short term asset and liabilities played a very important role for this shape. That could also possibly explain why on many occasions one-day money did cost more than 14-days or 1-month term-money.

Term Structure of Interest Rate

The term structure of interest rates, linking the time until the maturity of a fixed-income debt instrument with its yield, is usually referred to as the yield curve. While developing the framework for plotting the yield curve, we commonly consider only instruments for which default risk is disregarded alongwith convertibility provisions, call provisions, floating rate provisions or differing tax treatment. After plotting the yield to maturity on the vertical axis and the time to maturity on the horizontal axis we get a curve that can take several different shapes.

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Why Consider the Yield Curve?

Yield curves are used to compare yields of different securities, to benchmark rates and to discover yield curve aberrations. The yield curve can have a variety of shapes. Usually, longer term interest rates are higher than shorter term interest rates. This is called a "normal yield curve" and is thought to reflect the higher "inflation-risk premium" that investors demand for longer term bonds. When there is a change in interest rates by the same amount for bonds of all terms, this is called a "parallel shift" in the yield curve since the shape of the yield curve remains the same, although interest rates are higher or lower "across the curve". A change in the shape of the yield curve is called a "twist" and means that interest rates for bonds of some terms change differently from bonds of other terms. Here mostly liquidity factor and availability of floating stocks of the said security would be very important indicators. A small or negligible difference between short and long term interest rates occurs later in the economic cycle when interest rates increase due to higher inflation expectations and tighter monetary policy. This is called a "shallow" or "flat" yield curve and higher short term rates reflect less available money, as monetary policy is tightened, and higher inflation later in the economic cycle. When the difference between long and short term interest rates is large, the yield curve is said to be "steep" that reflect a "loose" monetary policy which means credit and money is readily available in an economy. This situation usually develops early in the economic cycle when a country's monetary authorities are trying to stimulate the economy after a recession or slowdown in economic growth. The low short term interest rates reflect the easy availability of money and low or declining inflation. Higher longer term interest rates reflect investors' fears of future inflation, recognizing that future monetary policy and economic conditions could be much different when the economy achieves stability. Tight monetary policy results in short term interest rates being higher than longer term rates. This occurs as a shortage of money and credit drives up the cost of short term capital. Longer term rates stay lower, as investors see an eventual loosening of monetary policy and declining inflation.

Although the yield curve has clear advantages as a predictor of future economic events, several other variables have been widely used to forecast the path of the economy. Among financial variables, stock prices have received much attention. Finance theory suggests that stock prices are determined by expectations about future dividend streams, which in turn are related to the future state of the economy.

Bond Market Information

Bond market information is very important for developing the yield curve as well as the estimation of implied forward rates out of the price data. People in the bond market trade not only on the basis of the present short term interest rate but also on expectation of future interest rate movements. Central banks and market practitioners use interest rates prevailing in the government bond market to extract certain information, the most important of which is implied forward rates. These are an estimate of the market's expectations about the future direction of short-term interest rates. Forward rates may be calculated using the discount function or spot interest rates. If spot interest rates are known, the bond price equation can be set as:

$$P = \frac{C}{(1+rs_1)} + \frac{C}{(1+rs_2)^2} + \dots\dots\dots + \frac{(C+M)}{(1+rs_n)^n} \qquad (1)$$

where

C is the coupon

M is the redemption payment on maturity (par)

rst is the *spot interest rate* applicable to the cash flow in period *t* (*t*=1, ..., *n*).

The bond price equation is usually given in terms of *discount factors*, with the present value of each coupon payment and the maturity payment being the product of multiplying them by their relevant discount factors. This allows us to set the price equation as:

$$P = C \sum_{t=1}^{n} df_t + df_n M \qquad (2)$$

where *dft* is the *t*-period discount factor (*t*=1,...., *m*) given by (3) below.

$$df_t = \frac{1}{(1+rs_t)^t}, \qquad t = 1, \dots\dots, m \qquad (3)$$

A discount factor is a value for a discrete point in time, whereas markets often prefer to think of a continuous value of discount factors that applies a specific discount factor to any time *t*. This is known as the *discount function*, which is the continuous set of discrete discount factors and is indicated by $df_t = \delta(t_t)$.

The discount function relates the current bond yield curve with the spot yield curve and the implied forward rate yield curve. From (3) we can set:

$$df_t = (1 + rs_t)^{-t}.$$

As the spot rate *rs* is the average of the implied short-term forward rates *rf*1, *rf*2, ...*rft*
we state:

$$
\begin{aligned}
1/df_1 &= (1+rs_1) = (1+rf_1) \\
1/df_2 &= (1+rs_2)^2 = (1+rf_1)(1+rf_2) \\
1/df_n &= (1+rs_n)^n = (1+rf_1)(1+rf_2)\ldots\ldots(1+rf_n) \\
1/df_t &= (1+rs_t)^t = (1+rf_1)(1+rf_2)\ldots\ldots(1+rf_t)
\end{aligned} \qquad (4)
$$

Implied forward rates indicate the expected short-term (one-period) future interest rate for a specific point along the term structure; they reflect the spread on the marginal rate of return that the market requires if it is investing in debt instruments of longer and longer maturities. In order to calculate the range of implied forward rates we require the term structure of spot rates for all periods along the continuous discount function. This is not possible in practice because a bond market will only contain a finite number of coupon-bearing bonds maturing on discrete dates. While the coupon yield curve can be observed, we are then required to "fit" the observed curve to a continuous term structure. For reasons of liquidity, analysts prefer to use a fitted yield curve (the *theoretical* curve) and compare this to the observed curve.

Expectations Hypothesis and Implicit Forward Rates

Economists and financial academics have developed theories to explain the shape of the yield curve as we have discussed on the paragraphs above. The "expectations" theory states that since short term bonds can be combined for the same time period as a longer term bond, the total interest earned should be equivalent, given the efficiency of the market and the chance for arbitrage (speculators using opportunities to make money). This theory tells us that a short term Government bond is no way different from long term bond as combination of shorter periods add upto the longer period. Mathematically, the yield curve can then be used to predict interest rates at future dates.

While seeking an answer to question why the yield curve is able to predict future interest rates we need to return our attention to the expectations theory. The pure expectations theory can be summarized by simply saying that any long-term yield is a combination of expected short-term yields during the life of the long-term instrument. This may be expressed mathematically as:

$$R_{t,n} = \frac{1}{k}\sum_{i=0}^{k-1} E_t R_{t+mi,m}; k = \frac{n}{m} \quad (5)$$

where the yield of the long-term bond $R_{t,n}$ in time t with n-periods to maturity is equal to arithmetical average of expected yields of the short-term bonds ($E_t R_{t+mi,m}$). E_t denotes expectations in time t and m is the maturity of the short-term bonds, where k is an integer. In other words, the return from holding a long-term bond to maturity is equal to the return an investor would gain from rolling over the short-term bond throughout the period until the long-term bond matures. This signifies that the current difference between the yield of the long-term bond and the yield of the short-term bond (the spread) contains a forecast of the future yield of the short-term bond.

The future interest rate implied by the current yield curve is called *implicit forward rate*. Let us now define implicit forward rate $F(t,t+n,t+m+n)$ as an offer rate in time t for a loan from time $t+n$ to time $t+m+n$. For instance F(t,t+3,t+6) indicates an interest rate in time t for a loan that starts in three months and is to be repaid in six months (i.e. 3-months rate in three months). From the definition of the pure expectations hypothesis in equation (1) it follows that:

$$F(t, t+n, t+m+n) \equiv \frac{(m+n)* R(t, t+m+n) - n* R(t, t+n)}{m} \quad (6)$$

If we continue this illustration then implicit 3-month forward rate in three months is calculated as a difference between two times the spot 6-months rate and the spot 3-months rate:

$$F(t, t+3, t+6) = \frac{(3+3)* R(t, t+3+3) - 3* R(t, t+3)}{3} = 2* R(t, t+6) - R(t, t+3) \quad (7)$$

From the expectations hypothesis it follows that an investor is indifferent between an investment of Rs.100 for 6 months and a rolled investment for three months. Thus, for example if the current 6-months rate R(t,t+6) is 10% and the current 3-months rate R(t,t+3) is 9% and if the pure expectations hypothesis holds, the 3-months rate in three months must equal to 10.76%:

$105 = 102.25 + 102.25*(\text{Forward rate})*(3/12)$

The assumption of the implicit forward rate being equal to the actual future interest rate is, however, rarely fulfilled in practice. The difference between the implicit forward rate and the corresponding future interest rate is called a "term premium" (also "risk premium" or "liquidity premium") and the version of the expectation hypothesis including the term premium is called the liquidity preference theory. The term premium, simply said, compensates risk-averse investor for holding a bond with longer time to maturity.

Observations on Yield Curves

The previous section set out the justification for using the government bond market yields as indicators of expected future interest rates. It showed that as the current spot term structure reflects the market's view of future interest rates, practitioners and analysts may use it to calculate implied forward interest rates. These may then be taken to be the market's prediction of future short-term interest rates. The conventional explanation behind the *shape* of the yield curve is that it reflects the long-term interest rate to be the geometric average of expected future short-term rates, so that a positively sloped yield curve will result whenever the market expects future short-term rates to rise, and an inverted yield curve will result when investors expect short-term rates to fall. Interest-rate expectations themselves are a function of future rates of inflation. Coupled with the *liquidity preference theory*, which states that the long-run trade-off between the desire of borrowers to trade at the long-end and lenders to trade at the short-end is a positively sloping yield curve, this is the main market argument why a yield curve may assume a certain shape.

Finally the existence of "humps" along certain points is explained by the *segmentation hypothesis*, and there is evidence to suggest that the investment preferences of specific groups of investors, who will be interested in particular points of the curve, results frequently in the certain parts of curve being expensive relative to other parts, resulting in humps along the curve. A negative yield curve is generally interpreted as signaling a recession, during (or ahead of) which the central bank will ease the money supply in an effort to boost economic activity. The market prices debt instruments based on its belief that future short-term interest rates will decline, hence the inverted curve.

Advantages

In fact, forecasting with the yield curve does have a number of advantages. Financial market participants truly value accurate forecasts, since they can mean the difference between a large profit and a large loss. As deregulation of interest rate in India has paved the way for the market to determine the true cost of money, by some measures, the yield curve should be an even better predictor now than it has been in the past. Widespread use of the yield curve makes assessing its accuracy a worthwhile exercise for all. But policymakers too need an accurate and timely predictor of future economic growth and indicator of monetary policy directions. The central bank of the country should need it more as the yield curve provides him the indicative rates at which the government securities are going to be issued in auction.

The ready availability of term-structure data ensures a timely prediction, but accuracy is another question. Central bankers have an added incentive to understand the yield curve, since the reference rates like Bank Rate and Discount Rate are themselves interest rates. And most of the time policies are undertaken using interest rates as an indirect tool by the central bank. Aside from the knowledge gained about the curve itself, there are several reasons as why understanding the workings and utility of a true and accurate yield curve is important. Simple predictions may serve as a check on more complex models, perhaps highlighting when assumptions or relationships need rethinking. There has been considerable debate in the market place as to whether spot curve (zero coupon yield curve) should be more increasingly used by market participants for enacting trading strategies, valuation, etc. Money and Bond market traders have been increasingly reposing their faith on the YTM based curves to decide on their trading strategies. Agreement between predictions increases confidence in the results, while disagreement signals the need for a second look. A simple, popular indicator also provides some insight into market sentiment. Of course, it's always a good idea to check whether the expensive and complicated forecasts actually do perform better. For a trader, it makes economic sense to use a YTM based curve or a zero coupon curve if only it correctly reveals the market term structure otherwise there will be mis-pricing which may result into large costs for him.

As explained by the expectations hypothesis of the term structure of interest rates, the typical yield curve gradually increases relative to maturity. That is, in normal economic conditions short-term rates are somewhat lower than longer-term rates because a person needs to be compensated for loss of liquidity. In a recession the entire yield curve shifts downward as interest rates generally fall and rotates indicating that short-term rates have fallen to much lower levels than long-term rates. In an economic expansion accompanied by inflation, interest rates tend to rise and yield curves shift upward and rotate indicating that short-term rates have increased more than long-term rates. If low interest rates are associated with recessions, then an inverted term structure—

implying that upcoming rates will be lower— predicts a recession. If policymakers act to reduce short-term interest rates in recessions, market participants who expect a recession would also expect low rates.

The yield curve also picks up the financial market's estimate of future policy. Another possibility is that current monetary policy may shift the yield curve. For example, tight monetary policy might raise short-term interest rates, flattening the yield curve and leading to slower future growth. Conversely, easy policy could reduce short-term interest rates, steepen the yield curve, and stimulate future growth. The risk premium provides another reason why the yield curve may be a useful predictor: the premium itself holds information. As a simple example, consider that recessions may make people uncertain about future income and employment, or even about future interest rates. The risk premium on a longer-term bond reflects this. In conjunction with changes working through the expectations hypothesis, the yield curve may take some very strange twists indeed, becoming inverted, humped, or even u-shaped. These explanations provide an additional motivation for investigating yield curve predictions.

Conclusion

The liquid and risk-free characteristics of the government bond market are primary reasons why traded yields and the spot term structure are used to derive implied forward rates, which are then used as an indication of the market's expectation of future interest rates. In rapid economic expansion accompanied by inflation, interest rates tend to rise and yield curves shift upward and rotate clockwise indicating that short-term rates have increased more than long-term rates.

With the existence of large-scale macroeconometric models and the judgmental assessments of knowledgeable market observers, why should we care about the predictive ability of the yield curve? There is no question that judgmental and macroeconometric forecasts are quite helpful. Nevertheless, the yield curve can usefully supplement large econometric models and other forecasts for the following reasons. First, forecasting with the yield curve has the distinct advantage of being quick and simple. With a glance at the ten-year bond and 91-day T-bill rates on the computer screen, anyone can compute a probability forecast of recession almost instantaneously by using a spreadsheet. Second, a simple financial indicator such as the yield curve can be used to double-check both econometric and judgmental predictions by flagging a problem that might otherwise have gone unidentified. For example, if forecasts from an econometric model and the yield curve agree, confidence in the model's results can be enhanced. In contrast, if the yield curve indicator gives a different signal, it may be worthwhile to review the assumptions and relationships that led to the prediction.

With powerful computers and mathematical techniques, investors and academics are constantly striving to build models which explain the shape of the yield curve and hopefully provide insight into the future direction of interest rates. This has given rise to "yield curve" strategies which are employed by bond managers to add value to their portfolios.