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Interest Rates in India: Information Content of Inflation

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Abstract

The term structure of riskless interest rates represented by the zero coupon yield curve of an economy has varied uses. When looked at using the pure expectations theory of term structure, it is said to have foretelling properties. It can be hypothesized that today's interest rate term structure can give clues of future economic conditions. This study intends to identify information content of future inflation in the term structure of spot rates in India. The work uses regression analyses on time series data to arrive at the results. The results indicate that changes in inflation cannot be deciphered from the term structure spread in the Indian scenario.

Keywords: term structure of interest rates, zero coupon yield curve, inflation

1 INTRODUCTION

The yield curve, a graphical representation of the term structure of interest rates depicts the relationship between interest rates and the term to maturity. Yield curves can be generated by plotting yields of identical securities differing only by time to maturity. Of all the yield curves, the Zero Coupon Yield Curve (ZCYC) derived from government securities (G-secs) has great significance.

This ZCYC is also referred to as the pricing curve. It gives an array of discount rates for different maturities, which can be used to price other G-secs and corporate bonds. Also, securities issued by the Government of a country in its currency are said to be risk-free (at least free of default risk). Therefore, the term structure derived from these G-secs helps us arrive at the risk-free rate, which is an important element of models such as the Capital Asset Pricing Model and the Black-Sholes Model.

Some of the most interesting applications of this yield curve arise from the Pure Expectations Theory of yield curves. Under this hypothesis, the interest rates of today are said to stomach market expectations of the future economic conditions. So, an economy's yield curve can be used to arrive at future expected economic activity or levels of inflation[1]. Fiscal and monetary policymakers can use the information of future economic conditions to take better decisions. Arriving at expected economic conditions for the future can define strategies for investment in equities, real estate, government securities and other asset classes, to take advantage of the expected interest rate levels. Corporate planners can use knowledge of the future economic scenario to position the company in a better position. The yield curve is also said to predict looming crises[2].

1.1 Statement of the Problem

The need for information on future economic conditions is felt in many areas where financial and economic applications can be seen. Lack of reliable tools for forecasting changes in macroeconomic indicators makes decision-making a risky affair.

1.2 Objectives of the Study

The general and specific objectives of the studies carried out are mentioned here.

- To identify the economic information content in the term structure spread.
- To verify the presence of information content of future changes in inflation in the term structure spread in the Indian scenario.

1.3 Scope of the Study

The study is limited to the Indian economy. The zero coupon yield curve data pertained to the trade of secondary G-Secs in the National Stock Exchange (NSE). Data for the Zero Coupon Yield Curve from NSE's database was available only for the period between June 2001 and June 2015 at the time of the study. This limited the scope of the study with regards to the period taken for analysis.

[1] **Mishkin (1990) and Kotlan (1999)**
[2] **Clark (1996)**

2 LITERATURE REVIEW

In this section, summaries of research and literature that provided a better understanding of relevant concepts and methodologies utilized in the work are presented.

Many models are used to fit a relationship between yield and maturity, looking at observed data. There are polynomial or non-parametric models as well as parametric models. The model of interest to us is the Nelson-Siegel model. This is the model used by the National Stock Exchange (NSE) to arrive at the ZCYC[3]. It gives a parsimonious model to come to the yield curve. This model was proposed in **Nelson and Siegel (1987)**. The work introduced a model that is simple and uses only a few parameters to arrive at yield curves. The need for a parsimonious model of the yield curve was said to be felt by Milton Freidman (1997) as cited in Nelson & Siegel (1987). Its potential applications included demand functions, testing of theories of the term structure of interest rates, and a graphical display for informative purposes.

The Nelson-Siegel model is based on the expectations theory of term structure of interest rates. It believes that if the spot rates can be represented by a differential equation, then the instantaneous forward rates that are incorporated in the spot rates can be arrived at as the solution to the second order differential equation. The solution equation used in this model gives *r(m)*, the forward rate at maturity m as:

$$r(m) = \beta_0 + \beta_1 . e^{(-m/\tau)} + \beta_2[(m/\tau). e^{(-m/\tau)}]$$

Where τ is a time constant, and βs are the parameters. The coefficients of the model can be represented as measuring the long, medium and short-term components of the forward rate curve. The long-term component is represented by β_0; the contribution of the short-term component is β_1, and the strength of the medium-term is β_2. The constant τ represents the rate of exponential decay. Smaller values of τ indicate faster decay and higher values of τ signify slower decay.

The spot rate, *R (m),* can be got as an average of the forward rates:

$$R(m) = 1/m \int_0^m r(x)\, dx$$

Thus, the function that results is:

$$R(m) = \beta_0 + (\beta_1 + \beta_2). \left[1 - e^{(-m/\tau)}\right]/(m/\tau) - \beta_2 . e^{(-m/\tau)}$$

As *m* gets large, the function is limited by β_0, and as m gets small, the limiting value of *R (m)* is ($\beta_0 + \beta_1$). This hints at how the long-term component is that of β_0. Also, if one looks at the components of the forward rate curve, the long-term component represented by β_0 stays constant throughout. The short-term component decays rapidly to zero. The medium-term component starts with a value of zero, increases and decays to zero eventually.

Nelson & Siegel (1987) presented an empirical study performed to test the potency of the model to arrive at the yield curves for U.S. Treasury Bills. In the paper, the description of how the model was used to fit the curves for 37 datasets is given. The model for the spot rates is parameterized for the sake of fitting the curve, as:

$$R(m) = a + b. \left[1 - e^{(-m/\tau)}\right]/(m/\tau) + c. e^{(-m/\tau)}$$

Across a grid of values for τ, the best fitting values for the other three parameters, *a, b* and *c* are found for each value of τ, using linear least squares. This process is repeated to arrive at the best fitting values of τ, *a, b,* and *c*. It was observed that for lower values of τ, curvature in the short-term was better fitted; but, the curve remained flat for longer maturities. In contrast, when higher values of τ were used, curvature in the longer term was better fitted than in the short-term.

Another notable point was that this parsimonious model aimed at smoothness rather than precision in curve fitting. An attractive feature in conceptual terms was the ability of this model to generate humped shapes. Also, the happening of a major change in monetary policy could be discerned from the curve. The ability of the model to predict yields and hence prices beyond the range of maturities in the sample was explained by the correlation between the present values of bonds got using the fitted curve and the actual prices of the bonds.

Darbha, et al. (2000) explains the estimation of the Zero Coupon Yield Curve in the Indian scenario. It was prepared to help understand the daily estimates of the term structure provided by the National Stock Exchange (NSE). After elaborating on the major reforms in the Indian government securities market since 1991 and explaining some of the uses of the term structure derived from government securities, the empirical specification and econometric methodology of the Nelson-Sigel model is given. The methodology follows from what was explained in Nelson & Siegel (1987). Nevertheless, a practical explanation of the same is presented. The steps in the estimation procedure to arrive at the two sets of results - the model prices derived from the spot rate function and the yields to maturity of the bonds therefrom, are explained.

Some data and estimation issues were also presented. The authors mention the sources of data on secondary trades in government securities and the rationale behind using the NSE-WDM data (it was reported to constitute 70 percent of secondary market volume then). Issues such as semi-annual coupon payments and market conventions for accrued interest were discussed. Another issue that was discussed was the use of

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[3] **(Darbha, et al., 2000)**

prices for the individual trade of every bond against value weighted prices in a relatively illiquid bond market like India where there were negotiated deals. The issues of settlement dates and the T+5 system that involves differences in trade day prices and settlement day prices, and how the expectation of changes in interest rate by the time the deal is settled is built into the contract were discussed.
The paper along with the Excel Worksheet could be used of understand the methodology for arriving at the estimates of parameters and plotting of the graph.

Financial and Special Studies Division, Economics Department, Monetary Authority of Singapore, 1999 tests the Pure Expectations Theory of the Term structure of interest rates. According to it, the forward rates indicate expectations of future spot rates assuming there is no liquidity risk. The analysis used the Nelson-Siegel model.
In the paper, the term structure of interest rates in Singapore was estimated using inter-bank interest rates (for shorter maturities) and interest rate swap (IRS) rates (for longer maturities). An IRS is explained to be similar to a par bond of a similar risk bond, and its fixed rate is similar to the coupon rate of the bond. The term structure was estimated using the Nelson-Siegel methodology which was said to produce a better fit than the Svensson model, an extension of the Nelson-Siegel model. The instantaneous forward rate curve used is as in Nelson & Siegel (1987). For two dates, the 15th of June 1998 and the 28th of June 1999, the spot rate curves were fit and forward rates curves for one and three-month rates were extracted. The spot curve on 15th June 1998 was inverted and the forward rate curve appropriately had a downward slope. For 28th June 1999, the spot rate curve was relatively normal and the forward rate curve was upward sloping.
Then, the ability of the forward rate curve to forecast corresponding future spot rates was tested. This was done by assuming that there were rational expectations and risk neutrality. A forecast error was used. The first difference form of the model was used to circumvent non-stationarity. A test of the power of the three-month forward rate to forecast spot rates was done for a month, two months and three months from the trade date. It was observed that on an average, the extracted forward rates could forecast future spot rates two and three months ahead.

Mishkin (1990) examines the information content of inflation in the longer end of the term structure of interest rates. The study was performed using data from Treasury bonds in the United States. The author mentions that the study will have implications for policymakers since, inflation was a major concern.
The methodology used this equation to test the forecasting ability of the term structure:

$$\pi_{t,m} - \pi_{t,1} = \alpha_m + \beta_m(i_{t,m} - i_{t,1}) + \varepsilon_m$$

Where, $(\pi_{t,m} - \pi_{t,1})$ is the m-year inflation rate minus the one-year inflation rate;
$(i_{t,m} - i_{t,1})$ is the spread between *m*-year interest rate and one-year interest rate.
A statistically significant β_m, the slope coefficient, was said to indicate the presence of information content of inflation in the interest rate spread.
Monthly data for 34 years, i.e., from 1953 to 1987 was used for bonds of different maturities, (*m*=2, 3, 4, 5). All of them referred to long-term interest rates. An explanation of the treatment of data was given in the paper. The paper showed that there was evidence of information in the long-term interest rates about future inflation.

Koedijk & Kool (1995) conducted the same study to check for the information of inflation in the term structure spread for these countries: the United States, Japan, Germany, Switzerland, France, Belgium and the Netherlands. Duration of bonds taken for the interest rates was from 1 to 5 years.
Results showed that the yield curve does not always have information content of inflation. It was said to depend on the sample chosen for the study. Reasons given were that it depends on how well the financial markets predict the future inflation. These expectations are built into the yield curve. A financial market without the ability to accurately predict interest rates will make the yield curve lose the property of a forecasting tool. Further, the monetary policy of a country also has a role to play. Thus, we can conclude that the term structure may not always be a good tool to forecast the rate of change in inflation.

Kotlan (1999) used a similar methodology to test for the information content of inflation for different kinds of spreads in the term structure. It was based on the hypothesis that term structure spread has in it expected real rate change and also expected inflation change along with term premium differential. So, if most of the variation in term structure was due to changes in expected inflation, the spread can help predict future changes in inflation.
The methodology introduced in Mishkin (1990), tested and refined by many others was used to check whether spread between *m*-period and *n*-period interest rates at present includes information content of changes in inflation between *m* and *n* periods.

The equation used was:

$$\pi_{t,m} - \pi_{t,n} = \alpha_{m,n} + \beta_{m,n}(i_{t,m} - i_{t,n}) + \varepsilon_{m,n}$$

This is similar to the one used by Mishkin (1990). Two assumptions, necessary for OLS estimation were made in Kotlan (1999). The first one was that the forecast error of inflation was not predictable using all information at time, *t*. The second one being, the slope of the real term structure is constant over time.

It was explained that if the hypothesis, $\beta_{m,n} = 0$ was statistically rejected, the slope of the nominal term structure, $(i_{t,m} - i_{t,n})$ contained information about the change in inflation rate between periods, *n*, and *m*. If however, the hypothesis $\beta_{m,n} = 1$ was rejected, then, the slope of nominal term structure was said to contain no information of inflation change.

The study was conducted using data of headline and net inflation (only unregulated products) in the Czech Republic scenario. The detailed methodology of how the inflation rates were got, Unit Root tests performed and Newey-West correction procedure was used, was given. The conclusion was that interest rate spreads in the Czech inter-bank market contained information regarding future changes in net inflation for the spreads between twelve and six months, and twelve and nine months.

Caporale & Pittis (1998) tests the term structure apart from interest rate differentials as predictors for changes in inflation. The part of the study that is of interest to us is the term structure one. In this study too, the same assumptions as those described in Kotlan (1999) were used. The analysis was similar to the one performed in Mishkin (1990), and the results of that paper were reinforced. However, the author concludes that the yield curve must not be used as a tool for taking monetary policy decisions. This is because the predictive power depends on the amount of variation in the term structure due to inflation alone. These were the understandings from Caporale & Pittis (1998).

These were some of the studies that provided an understanding and basis for the work. This study will add to the scant literature on yield curves in the Indian scenario apart from meeting the objectives of the work mentioned.

3 METHODOLOGY AND DESIGN OF THE STUDY

This section contains details of the methodology and the data used for the analysis done, apart from mentioning the nature and objectives of the study. Treatment of the data taken from secondary sources to make it amenable to analysis and limitations of the study are also mentioned.

3.1 Nature of the Study

The study conducted was quantitative in nature. Statistical methods were used on time-series, secondary data to arrive at the results.

3.2 Methodology

The methodology introduced in Mishkin (1990) and explained in Kotlan (1999) was used in the study. It is based on the assumption that the spread in the term structure – the difference between long-term interest rates and short-term interest rates has in it the changes in expected real interest rates and the changes in expected inflation.

Kotlan (1999) investigated whether the spread between *m*-period and *n*-period rates includes information about changes in inflation between *m* and *n* periods. The equation used for the study can be derived in the following manner (Kotlan, 1999).

The fisher's equation can be expressed as:

$$i_{t,m} = E(\pi_{t,m}) + rr_{t,m}$$

Where, $i_{t,m}$ is the nominal interest rate at time t, for a maturity *m*;

$E(\pi_{t,m})$ is the expected inflation at time *t*, over next *m* periods;

and, $rr_{t,m}$ is the ex-ante real interest rate expected at time *t* for a maturity of *m*.

Another equation explains inflation as:

$$\pi_{t,m} = E(\pi_{t,m}) + \varepsilon_{t,m}$$

Where $\varepsilon_{t,m}$ is the error term, the actual inflation over expected inflation.

Combining the equations gives:

$$\pi_{t,m} = i_{t,m} - rr_{t,m} + \varepsilon_{t,m}$$

To identify information content of change in inflation in the interest rate spread, we subtract another such equation for period *n*, where *n<m.* This gives us:

$$\pi_{t,m} - \pi_{t,n} = (i_{t,m} - i_{t,n}) - (rr_{t,m} - rr_{t,n}) + \varepsilon_{m,n}$$

Or

$$\pi_{t,m} - \pi_{t,n} = \alpha_{m,n} + \beta_{m,n}(i_{t,m} - i_{t,n}) + \varepsilon_{m,n}$$

Performing Ordinary Least Squares (OLS) estimation on the equation using time series data, we arrive at the necessary results. Here, if the hypothesis $\beta_{m,n}$=0 is rejected, then, there isn't sufficient information to disagree that the nominal interest rate spread contains information about the change of inflation for periods *m* and *n*. If the hypothesis $\beta_{m,n}$=0 is not statistically rejected, then, the nominal interest rate spread does not contain information about the changes in inflation for periods *m* and *n*.

3.3 Data

This section indicates the sources of the data used in the studies. Explanations for the usage of the particular data over other available data is also given.

Monthly Wholesale Price Index (WPI) data, taken from Reserve Bank of India's Database on Indian Economy (DBIE), was used to calculate inflation. WPI, and not Consumer Price Index (CPI), was taken as a measure of inflation as it was felt that it would represent the general and stable price levels in the economy, unlike the latter.

For the interest rate spread, the Nelson-Siegel parameters from the ZCYC reports published by the National Stock Exchange (NSE) in the Debt Market segment were used. Trading in the secondary market takes place in other markets such as the Bombay Stock Exchange's Wholesale Debt Market and the Negotiated Dealing System maintained by Clearing Corporation of India Ltd. (CCIL). The share of NSE's Wholesale Debt Market (WDM) segment in the total turnover of Non-Repo Government Securities in the secondary market ranged from 72.10 percent in 2000-01 to 52.3 percent in 2012-13[4]. Since, data for the ZCYC parameters were only available from June 2001 up to June 2015, the scope of the study was limited to this period.

3.4 Treatment of the Data

This section describes the adjustments and calculations made on the data, to arrive at variables relevant for the analyses.

Monthly WPI data from RBI's database for the period before 2005-06 was available only for the old base year, 1993-94. To incorporate the new base year, 2004-05, forward splicing of the data was done using the geometric mean of the monthly WPI data in 2004-05.

The *n* month inflation rate was then calculated as:

$$\pi_{t,n} = (\frac{WPI_{t+n}}{WPI_t})^{1/n} - 1$$

Thus, the 3-month inflation rate at January of 2002 can be expressed as:

$$\pi_{Jan,3} = (\frac{WPI_{April}}{WPI_{Jan}})^{1/3} - 1$$

The n-month inflation rates were calculated for *n* = 1, 3, 6 and 12. These rates were then annualised. $(\pi_{t,m} - \pi_{t,n})$ was then calculated for these pairs of *m* and *n* (as in Kotlan (1999)): (3, 1) and (12, 6).

To, calculate the interest rate spreads, end of the month (excluding trading holidays), Nelson-Siegel parameters as calculated and reported by NSE were used. The interest rate for *n*-month term to maturity for *n* = 1, 3, 6 and 12 was calculated using the formula (like the one given by NSE):

$$i_{t,n} = \beta_0 + (\beta_1 + \beta_2).\frac{\left[1 - e^{\left(-\frac{n/12}{\tau}\right)}\right]}{(n/12)/\tau} - \beta_2.e^{\left(-\frac{n/12}{\tau}\right)}$$

This gave us the annualized nominal interest rate. Here too, $(i_{t,m} - i_{t,n})$ was calculated for the same pairs of *m* and *n*: (3, 1) and (12, 6).

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[4] **(National Stock Exchange, 2014)**

3.5 Limitations of the Study

A few limitations and de-limitations identified for this study are presented here.

Data for the ZCYCs was taken from the NSE's reports which are based on data from trades in the NSE. Firstly, NSE's data, though representative of the Indian G-Sec market, isn't a perfect image of the total market. Secondly, another source of variation could in the usage of the NSE's ZCYC parameters. The yield curve reported by NSE uses the Nelson-Siegel model which is a parsimonious model and involves estimations. This may suggest the zero coupon yields taken in our study are not replicas of the actual market ones. Another assumption made in the studies was that the ZCYC for the end of the period represented the behavior of the market in that period.

Taking of averages in the study like in the case of the splicing of data, brings the downsides of using such statistical measures along with them. Another limitation for the study was the unavailability of data, as mentioned in a previous section, for variables beyond some points in time. This led to a limited scope for the study. Data for longer periods of time could have made the analysis richer.

4 DATA ANALYSIS AND INTERPRETATION

The results of the analyses done using the methodology mentioned in the previous chapter are presented here. Interpretations of the results are also given. To look for the information of changes in inflation in the yield curve, two regressions were run; one for the short-term interest rates and the other, for the longer term.

For the short-end of the yield curve, the regression of the difference between the three-month and one-month inflation on the lagged difference between the three-month and the one-month spot interest rates for the period between June 2001 and June 2015 yielded the results presented in Table 5.2. The dependent and independent variables were taken at levels after they were seen to pass the Unit Root test, a test for stationarity. A dummy variable had to be included in the regression to account for an outlier. The Newey-West correction procedure to estimate standard errors was used.

Dependent Variable: INFL
Method: Least Squares
Sample (adjusted): 2001M07 2015M06
Included observations: 168 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001434	0.003795	-0.377953	0.706
IR(-1)	-0.036392	0.02503	-1.453928	0.1479
DUM	0.192907	0.003798	50.7873	0

R-squared	0.078212	Mean dependent var	-0.00189
Adjusted R-squared	0.067038	S.D. dependent var	0.05866
S.E. of regression	0.056656	Akaike info criterion	-2.88594
Sum squared resid	0.529635	Schwarz criterion	-2.83016
Log likelihood	245.419	Hannan-Quinn criter.	-2.8633
F-statistic	6.999932	Durbin-Watson stat	1.80655
Prob(F-statistic)	0.001208		

Table 4.1: Regression of the Difference between 3-Month and 1-Month Inflation on the Difference between 3-Month and 1-Month Spot Interest rates

The D-W statistic (1.807), a parameter for autocorrelation is within the acceptable limits of 1.5 to 2.5. The low values of R-squared and F-statistic is not a problem, since, we are just checking for the information content of inflation in the term structure spread, and not developing a robust econometric model. However, the p-value (0.1479) of the slope coefficient suggests that we reject the hypothesis of its significance at a 10 percent level of significance. Thus, we can infer that there isn't sufficient evidence to accept that the short-end of the yield curve contains information of inflation.

The second regression looks at the information content of inflation in long-term spot interest rates. Here the dependent variable was taken to be the difference between the twelve-month and six-month inflation. The explanatory variable was the lagged difference of six-month spot interest rates from twelve-month spot interest rate. After performing the Unit Root test for stationarity, the former had to be taken at its second difference. The independent variable was stationary at levels. In this case too, the Newey-West corrected standard errors were used. Two dummy variables for two outliers respectively had to be included in the estimation. The output for the regression performed with these variables for the period between June 2001 and October 2014 is presented in Table 5.3.

Dependent Variable: D(D(INFL))
Method: Least Squares
Sample (adjusted): 2001M08 2014M10
Included observations: 159 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000278	0.001298	-0.213915	0.8309
IR(-1)	0.006122	0.004155	1.473576	0.1426
DUM1	0.062024	0.0013	47.70296	0
DUM2	0.05198	0.001363	38.12508	0

R-squared	0.101584	Mean dependent var	-0.00016
Adjusted R-squared	0.084195	S.D. dependent var	0.0208
S.E. of regression	0.019909	Akaike info criterion	-4.97045
Sum squared resid	0.061437	Schwarz criterion	-4.89325
Log likelihood	399.1509	Hannan-Quinn criter.	-4.9391
F-statistic	5.841929	Durbin-Watson stat	2.52674
Prob(F-statistic)	0.000831		

Table 4.2: Regression of the Difference between 12-Month and 6-Month Inflation on the Difference between 12-Month and 6-Month Spot Interest rates

The D-W statistic (2.527) is almost equal to 2.5 and as explained in the earlier case, the values of R-squared and F-statistic is not a matter of concern. Though, in this case, the sign of the slope coefficient has changed to positive, its p-value (0.1426) indicates that there isn't sufficient evidence to conclude that information of inflation can be deciphered from the long-term interest rate spread at even a 10 percent level of significance.
Thus, we can conclude that the ZCYC in the Indian scenario does not contain information content of inflation in both the short and longer ends. This is unlike the results in Mishkin (1990) and Kotlan (1999) where the information content of inflation could be identified in long-term interest rates.

5 Conclusions

The study that was described in this report led to the following conclusions.
The study, using regression analyses shows that information content of inflation couldn't be made out from term structure spread in the Indian case. This study has a few limitations such as: the under-developed debt markets in India leading to the possibility of inaccurate yields and prices; unavailability of data beyond a point in the past; lack of access to relevant data and; the deficiencies of statistical measures built into the study. Nevertheless, an attempt has been made to add to the limited research literature on the yield curve in the Indian scenario. Improvements to the study by gaining access to appropriate data and using more sophisticated statistical tools and models can lead to very useful findings. Also, such studies in deeper government security markets will yield valuable results. Future research in this area can involve building models that can almost accurately predict future economic conditions given the properties of the yield curve.

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