

# Indian G-Sec Market II: Anatomy of Short Rates

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**Rituparna Das**

Term structure (TS) means the relationship between the time-length between investment in a security akin to zero coupon bond (ZC) and redemption of the same on the one hand and the spot rate of return, yield to maturity (YTM) or simply 'yield' on the same on the other hand. This 'yield' is the rate of discount used in computing fair value or present value (PV) of any security. Similar is the case of computing PV of investment in fixed and capital assets, which is known as capital budgeting in Corporate Finance. Hence TS is alternatively known as yield curve (YC). It is the best understood in the context of Treasury bills (TBs) having residual term to maturity (TTM) from 1 day to 364 days in India. Theoretically it also applies to fixed or discount deposits (FDs) without any intermittent cash flow. For banks, ZCYC is known to be the asset-TS and FDYC is known to be liability-TS. For the same maturity bucket, expectedly harmful differences between asset yield and liability are known as basis risk and expected adverse changes in a particular TS are known as YC risk. But in the case of TBs the maximum TTM is one year whereas, for FDs there is room to stretch beyond ten years. For this reason, long term ZC yield are computed from the dated securities or coupon paying bonds issued by the Central Government of India (GoI) with the methods like bootstrapping. ZCYC gives the risk free rate for a particular TTM because ZCYC is computed with risk free GoI securities. Reportedly ZCYC is also employed in setting yields on loans, corporate bonds and foreign bonds. Basis risk and YC risk have important implications for asset liability management (ALM). ZCYC is everyday computed by the Clearing Corporation of India, the official clearing agency of the Indian debt market. However it is also done by other organizations like FIMMDA (Fixed Income Money Market and Derivatives Associations), Reuters and Bloomberg, and also for internal use, by technologically advanced banks. While ZCYC is

computed on the bases if last traded prices (LTP), FDYC emerges primarily from ALM, which is an internal affairs of every bank unlike ZCYC which is daily available to the public, and secondarily from competition. In this stud dirty price of coupon paying bond on the date of settlement (DoS) would be taken as LTP, wherever available.

It should be added here ZCYC is also calculated for interbank markets like MIBOR and LIBOR which are used as benchmark in interest rate swap (IRS). MIBOR is the offer rate on rupee denominated principals in India whereas LIBOR is the offer rate in the markets outside India on international currencies, e.g. USD LIBOR, pound sterling LIBOR and yen LIBOR. Extracting LIBOR zeroes is a part and parcel of the foreign exchange (forex) treasury.

YC can be derived both for Government securities (G-Sec) as well as corporate bonds. Saunders et al (2006) discussed that spread between YCs across maturity buckets denote the credit default risk premium on corporate bonds.

The shape of YC differs day to day. There are different explanations or theories of shapes of YC. Nag et al (2000) has given a behavioral description of the shape of the yield curve with reference to expectation theories and market segmentation theory. They referred to three versions of expectation theory:

- pure expectation theory – the term structure reflects market expectations about short rates, long rate is the average of short rates; this means if one invests a sum for one year and then rolls it over for next another year his overall expected return is required by this theory to be equal to the return on investment of the same sum for two years; take a simple example, suppose you invest ₹100 for 1 year @ 8%, it grows into ₹108 as per simple compounding and then you invest it @ 9% for next one year, the

compound value at the end of second year is ₹117.72. If you invest ₹100 @ 8.5% for two years, the compound value is same ₹117.72. It should be noted that 8.5% is the geometric average of 8% and 9%. Now suppose you invest ₹100 for 1 year @ 8%, it grows into ₹108 as per simple compounding and then you invest it @ 9% for next two years. The sum grows into ₹128.31. If the sum is invested for 3 years @ 8.66%, it grows into ₹128.27, where 8.66% is the geometric average of 8% and $(9\%)^2$.

- liquidity theory and preferred habitat theory – the shape of the term structure can be explained by liquidity premium and risk premium respectively, this means expected
- market segmentation theory – difference between short term and long term rates can be explained by the borrowers' preference to stick to a particular maturity because of asset liability management reasons.

In the USA context Kessel (1965) found larger number of unequivocal evidences of first and second hypotheses compared to the third. He opined that combination of first and second hypotheses would be ideal to interpret ZCYC.

Nag et al (2000) opines that liquidity considerations modulate short term rate whereas inflation expectations and yield expectations determine medium and long rates.

As per Samuelson in the USA context

- people work towards making present prices approximate closely to average future prices, independently of the dispersion and higher statistical moments of the possible outcomes in line with the expectations

hypothesis on the one hand, while on the other hand, in line with liquidity-preference hypothesis, they behave as if they dislike dispersion and uncertainty but at the same time ready to sacrifice expected monetary gain if they can thereby help hedge uncertainties;

- before harvest investors from producer community face an inverted YC;
- institutional long term investors with investment horizon beyond eight years face a humped YC;

and

- safe playing investors in the circumstances of continuing inflation face declining dividend yields relative to risk free ZC yields[1].

Regarding the determinants of YC in India there are several opinions. Joshi (1999) suggested a long run interlocking of interest rates across markets and a possibility of their common response to changes in expectations about future monetary policy and/or economic fundamentals. This is why in the above report, ET mentioned about rising overnight indexed swap rate (OIS) and the wait of the dealers for information on inflation and industrial output. He noted that the comfortable liquidity situation in 1992-93 as a consequence of significant reductions in the cash reserve ratio (CRR) helped the Reserve bank of India (RBI) to raise government borrowings at reasonable costs at a cut-off yield of 11-11.42 % on 364-day TBs and with a maximum coupon of 13 % on GoI bonds.

Das (2009) mentioned the importance of the behavior of term structure as a major source of interest rate risk which influences the decision making process of the participants in money market and government securities (G-Sec) market.

[1] Kessel (1965)

It should be added here that term structure applies to any fixed income asset like bonds and swaps in practice and also theoretically to loans and deposits. We shall examine the above with the following facts in the market.

Economic Times (ET) reported on 03-aug-10 that swap rates hiked to 6.47% highest after October 2009 and 10 year benchmark bond rate (i.e. YTM or yield to maturity) rose to 7.89% highest after first week of May 2010[2]. Similar things reported by Bloomberg for USA[3]. Authors like Varma (1997), Thomas et al (2000), Dutta et al (2002) and Darbha et al (2003) showed threw light on how to estimate term structure, but they never showed how exactly term structure may be used in decision making in order to enable the practitioners make the best use of their research. Das (2009) tried to touch the issue but could not take it much long. Varma (2008) related it to hedging term structure in Treasury note futures, which do not apply to India.

Bose et al (2005) commented that once the Indian fixed income market becomes mature YTM based constant maturity (CM) yield curve may be used in pricing interest rate swap (IRS) and forward rate agreement (FRA). They also mentioned that an inverted yield curve with the highest rates for short term is a signal of economic downturn and it is a widespread practice among central banks over the world to report the base interest rates of the economy in terms of constant maturity yield curves for default risk free government securities. They defined constant maturity yields for the Indian economy, as the volume-weighted average yields to maturity of all traded securities for any particular maturity. They added that The Nelson-Siegel (NS) and the Fisher-Nychka-Zervos (FNZ) methods remain the two most widely used ways of estimating

2 http://economictimes.indiatimes.com/articleshow/6249857.cms?prtpage=1 accessed on 04-aug-10
3 http://www.bloomberg.com/news/2010-08-07/treasury-two-year-notes-gain-for-10th-week-in-u-s-yield-falls-to-record.html accessed on 04-Aug-2010

yield curves because all central banks reporting zero coupon estimates to the Bank for International Settlements (BIS) use one of these two methods.

EPW Research foundation (ERF) maintained that when industrial output growth slackens long-term rate rises less than short term rate thereby compressing the spread and making the YC flatter and sometimes inverted because monetary policy influences short term rate whereas long term rate is determined by supply and demand in the fund market which in turn are subject to entrepreneurial behavior in the real productive sector of the economy.

CCIL periodically publishes the information on outstanding G-sec. At the time of writing this book the latest of such information was for DoS 20-aug-2010. A glance at such report reveals utilized arbitrage opportunities in the market, e.g. both the securities IN002010X028 91DTB and IN002009Y028 182 DTB have same TTM 0.036, but, refuting the market segmentation[4] theory they were selling in different segments at same price 99.83, similarly IN002010X028 91 DTB and IN002009Z025 364 DTB having same TTM 0.056 selling at same price 99.69, IN002009Y028 182 DTB and IN002010X028 91 DTB having same TTM 0.075 selling at same price 99.56, IN002010X028 91 DTB and IN002009Z025 364 DTB having same TTM 0.094 selling at same price 99.45, IN002010X028 91 DTB and IN002010Y026 182 DTB having same TTM 0.192 selling at same price 98.88, IN002010X028 91 DTB and IN002010Y026 182 DTB having same TTM 0.228 selling at same price 98.63, but side by side, in sharp contrast, there is corroboration of the same by IN002010X028 91 DTB and ISIN IN002010Y026 182 DTB having TTM 0.1528 selling at different prices 99.11 and 99.04 respectively, IN002009Z025 364 DTB and IN002010X028 91 DTB having same TTM 0.194 selling at 99.89 and 99.94 respectively, IN002009Z025 364 DTB and

4 http://www.investopedia.com/terms/m/market-segmentation-theory.asp accessed on 20-sep-10.

IN002010X028 91 DTB having same TTM 0.133 selling at different prices 99.22 and 99.21 respectively, IN002010X028 91 DTB and IN002010Y026 182 DTB having same TTM 0.153 selling at different prices 99.11 and 99.04 respectively, IN002009Z025 364 DTB and IN002010X028 91 DTB having same TTM 0.172 selling different prices 99 and 98.99 respectively, IN002009Z025 364 DTB, IN002010X028 91 DTB having same TTM 0.208 years selling at different prices 99.78 and 99.75 respectively, IN002009Z025 364 DTB and IN002010X028 91 DTB having same TTM 0.247 selling at different prices 98.54 and 98.52 respectively, thereby reflecting upon unutilized arbitrage opportunities[5]. Hence following is the table of short rates:

Table 1

5 In CCIL's daily G-Sec trade report as on 20-aug-10, these two securities were not reported.

| S.N | ISIN | Sec | DoS | DoM | Price | TTM | YTM | Vol (cr) |
|---|---|---|---|---|---|---|---|---|
| 1 | IN002010X028 | 91 DTB | 20-Aug-10 | 27-Aug-10 | 99.94 | 0.019 | 3.09% | 7000 |
| 2 | IN002009Z025 | 364 DTB | 20-Aug-10 | 27-Aug-10 | 99.89 | 0.019 | 5.66% | 1000 |
| 3 | IN002010X028 | 91 DTB | 20-Aug-10 | 3-Sep-10 | 99.83 | 0.036 | 4.76% | 2000 |
| 4 | IN002009Y028 | 182 DTB | 20-Aug-10 | 3-Sep-10 | 99.83 | 0.036 | 4.84% | 1500 |
| 5 | IN002010X028 | 91 DTB | 20-Aug-10 | 10-Sep-10 | 99.69 | 0.056 | 5.68% | 2000 |
| 6 | IN002009Z025 | 364 DTB | 20-Aug-10 | 10-Sep-10 | 99.69 | 0.056 | 5.68% | 2000 |
| 7 | IN002009Y028 | 182 DTB | 20-Aug-10 | 17-Sep-10 | 99.56 | 0.075 | 5.91% | 3000 |
| 8 | IN002010X028 | 91 DTB | 20-Aug-10 | 17-Sep-10 | 99.56 | 0.075 | 5.91% | 2500 |
| 9 | IN002010X028 | 91 DTB | 20-Aug-10 | 24-Sep-10 | 99.45 | 0.094 | 5.89% | 2500 |
| 10 | IN002009Z025 | 364 DTB | 20-Aug-10 | 24-Sep-10 | 99.45 | 0.094 | 5.89% | 1033 |
| 11 | IN002009Y028 | 182 DTB | 20-Aug-10 | 29-Sep-10 | 99.37 | 0.108 | 5.88% | |
| 12 | IN002010X028 | 91 DTB | 20-Aug-10 | 1-Oct-10 | 99.34 | 0.114 | 5.88% | |
| 13 | IN002009Z025 | 364 DTB | 20-Aug-10 | 8-Oct-10 | 99.22 | 0.133 | 5.88% | 2000 |
| 14 | IN002010X028 | 91 DTB | 20-Aug-10 | 8-Oct-10 | 99.21 | 0.133 | 5.99% | 2500 |
| 15 | IN002010X028 | 91 DTB | 20-Aug-10 | 15-Oct-10 | 99.11 | 0.153 | 5.88% | 2500 |
| 16 | IN002010Y026 | 182 DTB | 20-Aug-10 | 15-Oct-10 | 99.04 | 0.153 | 6.34% | 2000 |
| 17 | IN002009Z025 | 364 DTB | 20-Aug-10 | 22-Oct-10 | 99.00 | 0.172 | 5.89% | 2000 |
| 18 | IN002010X028 | 91 DTB | 20-Aug-10 | 22-Oct-10 | 98.99 | 0.172 | 5.92% | 2500 |
| 19 | IN002010X028 | 91 DTB | 20-Aug-10 | 29-Oct-10 | 98.88 | 0.192 | 5.90% | 2854 |
| 20 | IN002010Y026 | 182 DTB | 20-Aug-10 | 29-Oct-10 | 98.88 | 0.192 | 5.90% | 2000 |
| 21 | IN002009Z025 | 364 DTB | 20-Aug-10 | 5-Nov-10 | 98.78 | 0.208 | 5.91% | 2000 |
| 22 | IN002010X028 | 91 DTB | 20-Aug-10 | 05-Nov-10 | 98.75 | 0.208 | 6.08% | 9875 |
| 23 | IN002010X028 | 91 DTB | 20-Aug-10 | 12-Nov-10 | 98.63 | 0.228 | 6.10% | 7550 |
| 24 | IN002010Y026 | 182 DTB | 20-Aug-10 | 12-Nov-10 | 98.63 | 0.228 | 6.12% | 2000 |
| 25 | IN002009Z025 | 364 DTB | 20-Aug-10 | 19-Nov-10 | 98.54 | 0.247 | 6.00% | 2000 |
| 26 | IN002010X028 | 91 DTB | 20-Aug-10 | 19-Nov-10 | 98.52 | 0.247 | 6.07% | 8000 |
| 27 | IN002010Y026 | 182 DTB | 20-Aug-10 | 26-Nov-10 | 98.42 | 0.267 | 6.02% | |
| 28 | IN002009Z025 | 364 DTB | 20-Aug-10 | 3-Dec-10 | 98.31 | 0.286 | 6.02% | |
| 29 | IN002010Y026 | 182 DTB | 20-Aug-10 | 10-Dec-10 | 98.19 | 0.306 | 6.03% | |
| 30 | IN002010Y026 | 182 DTB | 20-Aug-10 | 24-Dec-10 | 97.96 | 0.344 | 6.06% | |
| 31 | IN002009Z025 | 364 DTB | 20-Aug-10 | 31-Dec-10 | 97.84 | 0.364 | 6.07% | |
| 32 | IN002010Y026 | 182 DTB | 20-Aug-10 | 7-Jan-11 | 97.62 | 0.381 | 6.40% | |
| 33 | IN002009Z025 | 364 DTB | 20-Aug-10 | 14-Jan-11 | 97.60 | 0.4 | 6.14% | |
| 34 | IN002010Y026 | 182 DTB | 20-Aug-10 | 21-Jan-11 | 97.48 | 0.419 | 6.16% | |
| 35 | IN002009Z025 | 364 DTB | 20-Aug-10 | 28-Jan-11 | 97.36 | 0.439 | 6.17% | |
| 36 | IN002010Y026 | 182 DTB | 20-Aug-10 | 04-Feb-11 | 97.18 | 0.456 | 6.37% | |
| 37 | IN002009Z025 | 364 DTB | 20-Aug-10 | 10-Feb-11 | 97.14 | 0.472 | 6.23% | |
| 38 | IN002010Y026 | 182 DTB | 20-Aug-10 | 18-Feb-11 | 96.89 | 0.494 | 6.49% | |
| 39 | IN002009Z025 | 364 DTB | 20-Aug-10 | 25-Feb-11 | 96.73 | 0.514 | 6.58% | |
| 40 | IN002009Z025 | 364 DTB | 20-Aug-10 | 11-Mar-11 | 96.64 | 0.558 | 6.23% | |
| 41 | IN002009Z025 | 364 DTB | 20-Aug-10 | 25-Mar-11 | 96.40 | 0.597 | 6.25% | |
| 42 | IN002010Z023 | 364 DTB | 20-Aug-10 | 8-Apr-11 | 96.10 | 0.633 | 6.41% | |
| 43 | IN002010Z023 | 364 DTB | 20-Aug-10 | 22-Apr-11 | 95.91 | 0.672 | 6.34% | |
| 44 | IN0019810020 | 8% 2011 | 20-Aug-10 | 27-Apr-11 | 103.61 | 0.686 | 6.42% | |
| 45 | IN002010Z023 | 364 DTB | 20-Aug-10 | 6-May-11 | 95.66 | 0.711 | 6.37% | |
| 46 | IN002010Z023 | 364 DTB | 20-Aug-10 | 20-May-11 | 95.42 | 0.75 | 6.41% | |
| 47 | IN002010Z023 | 364 DTB | 20-Aug-10 | 3-Jun-11 | 95.22 | 0.786 | 6.39% | |
| 48 | IN002010Z023 | 364 DTB | 20-Aug-10 | 17-Jun-11 | 95.02 | 0.825 | 6.35% | |
| 49 | IN002010Z023 | 364 DTB | 20-Aug-10 | 1-Jul-11 | 94.67 | 0.864 | 6.52% | |
| 50 | IN002010Z023 | 364 DTB | 20-Aug-10 | 15-Jul-11 | 94.59 | 0.903 | 6.34% | |
| 51 | IN002010Z023 | 364 DTB | 20-Aug-10 | 29-Jul-11 | 94.26 | 0.942 | 6.47% | |
| 52 | IN0020032028 | FRB 2011 (5. | 20-Aug-10 | 08-Aug-11 | 100 | 0.967 | 5.99% | |
| 53 | IN002010Z023 | 364 DTB | 20-Aug-10 | 12-Aug-11 | 93.91 | 0.978 | 6.63% | |

DoM: Date of maturity

It is also observed that except for TTM 0.056 years, the appetite for shorter term is stronger.

In Table 1, YTMs, i.e short rates are calculated using the formula "=((Par –

LTP)/LTP)/TTM". This formula is known as RBI formula[6]. It is same for the (Fed) Federal Reserve Systems, USA[7]. A sizeable content of fixed income regulatory structure in India is similar to its USA counterpart. It is relevant to mention here that in USA the bond market is at least a century older than India[8]. Studies on USA bond market found that government securities do not offer protection against inflation and yields of those bonds were supposed to contain inflation expectations of the market participants. The net return to an investor from holding a bond equals market YTM netted off the sum of transaction costs and opportunity costs of bond holding. The aggregate cost facing the borrower is the sum of market yield, transactions and market costs, if any. Market YTMs are available for traded bonds. For non-traded bonds, market yields are decided by polling method and hence the possibility of existence of subjective influence cannot be ruled out. Thus for non-traded bonds the market YTM is the polled average YTM minus subjectivity. Since GoI bonds are of highest quality, they are expected to have the lowest yield in the particular maturity bucket. ZCYC is the relationship between TTM of the highest quality zero and its YTM. ZCYC by convention belongs to traded zeroes. So for non-traded zeroes, ZCYC becomes discontinuous.

There is an alternative formula "=(*ln*(Par/LTP))/TTM" suggested by professional academicians like Hull[9].

Using above formula, we calculate YTM and compare get Table 1a.

6 FAQ 26, http://www.rbi.org.in/scripts/FAQView.aspx?Id=79 accessed on 08-oct-2010
7 http://www.newyorkfed.org/aboutthefed/fedpoint/fed28.html accessed on 08-oct-2010
8 Durand (1942)
9 Hull (2009)

Table 1a

| A | B | C | D |
|---|---|---|---|
| **S.N** | **TTM** | **YTM (RBI)** | **YTM(Hull)** |
| 1 | 0.019 | 3.0876% | 3.0866% |
| 2 | 0.019 | 5.6634% | 5.6603% |
| 3 | 0.036 | 4.7574% | 4.7533% |
| 4 | 0.036 | 4.8408% | 4.8365% |
| 5 | 0.056 | 5.6760% | 5.6671% |
| 6 | 0.056 | 5.6760% | 5.6671% |
| 7 | 0.075 | 5.9095% | 5.8964% |
| 8 | 0.075 | 5.9095% | 5.8964% |
| 9 | 0.094 | 5.8861% | 5.8698% |
| 10 | 0.094 | 5.8861% | 5.8698% |
| 11 | 0.108 | 5.8788% | 5.8601% |
| 12 | 0.114 | 5.8773% | 5.8577% |
| 13 | 0.133 | 5.8766% | 5.8537% |
| 14 | 0.133 | 5.9905% | 5.9667% |
| 15 | 0.153 | 5.8778% | 5.8515% |
| 16 | 0.153 | 6.3445% | 6.3140% |
| 17 | 0.172 | 5.8886% | 5.8589% |
| 18 | 0.172 | 5.9178% | 5.8879% |
| 19 | 0.192 | 5.8984% | 5.8654% |
| 20 | 0.192 | 5.8985% | 5.8654% |
| 21 | 0.208 | 5.9082% | 5.8722% |
| 22 | 0.208 | 6.0823% | 6.0441% |
| 23 | 0.228 | 6.0976% | 6.0556% |
| 24 | 0.228 | 6.1180% | 6.0758% |
| 25 | 0.247 | 6.0029% | 5.9588% |
| 26 | 0.247 | 6.0689% | 6.0239% |
| 27 | 0.267 | 6.0201% | 5.9723% |
| 28 | 0.286 | 6.0231% | 5.9718% |
| 29 | 0.306 | 6.0348% | 5.9798% |
| 30 | 0.344 | 6.0602% | 5.9978% |
| 31 | 0.364 | 6.0737% | 6.0075% |

| | | | |
|---|---|---|---|
| 32 | 0.381 | 6.3964% | 6.3198% |
| 33 | 0.4 | 6.1443% | 6.0700% |
| 34 | 0.419 | 6.1570% | 6.0788% |
| 35 | 0.439 | 6.1701% | 6.0880% |
| 36 | 0.456 | 6.3699% | 6.2792% |
| 37 | 0.472 | 6.2317% | 6.1418% |
| 38 | 0.494 | 6.4880% | 6.3861% |
| 39 | 0.514 | 6.5831% | 6.4742% |
| 40 | 0.558 | 6.2319% | 6.1260% |
| 41 | 0.597 | 6.2498% | 6.1360% |
| 42 | 0.633 | 6.4059% | 6.2794% |
| 43 | 0.672 | 6.3442% | 6.2127% |
| 44 | 0.686 | 6.4207% | -5.1688% |
| 45 | 0.711 | 6.3747% | 6.2344% |
| 46 | 0.75 | 6.4053% | 6.2562% |
| 47 | 0.786 | 6.3893% | 6.2340% |
| 48 | 0.825 | 6.3474% | 6.1868% |
| 49 | 0.864 | 6.5184% | 6.3414% |
| 50 | 0.903 | 6.3401% | 6.1653% |
| 51 | 0.942 | 6.4663% | 6.2771% |
| 52 | 0.967 | 5.9900% | 5.9900% |
| 53 | 0.978 | 6.6269% | 6.4211% |

The differences in YTMs between in Table 1a are more prominent for higher TTMs. But, following RBI's method, we shall use the former formula of YTM calculation of ZC, Indian bankers use it.

While computing the short end of the ZCYC as on 20-aug-10, volume weighted average of those yields (vwaytm) are taken where there are two securities having same TTM but are selling at different prices, i.e. for TTM up to 0.247 except for 0.108 and 0.114. It is shown in Table 2.

Table 2

| A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| **S.N.** | **ISIN** | **Sec** | **TTM** | **YTM** | **Vol (cr)** | **vwaytm** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | IN002010X028 | 91 DTB | 0.019 | 3.09% | 7000 | |
| 2 | IN002009Z025 | 364 DTB | 0.019 | 5.66% | 1000 | 3.41% |
| 3 | IN002010X028 | 91 DTB | 0.036 | 4.76% | 2000 | |
| 4 | IN002009Y028 | 182 DTB | 0.036 | 4.84% | 1500 | 4.79% |
| 5 | IN002010X028 | 91 DTB | 0.056 | 5.68% | 2000 | |
| 6 | IN002009Z025 | 364 DTB | 0.056 | 5.68% | 2000 | 5.68% |
| 7 | IN002009Y028 | 182 DTB | 0.075 | 5.91% | 3000 | |
| 8 | IN002010X028 | 91 DTB | 0.075 | 5.91% | 2500 | 5.91% |
| 9 | IN002010X028 | 91 DTB | 0.094 | 5.89% | 2500 | |
| 10 | IN002009Z025 | 364 DTB | 0.094 | 5.89% | 1033 | 5.89% |
| 11 | IN002009Y028 | 182 DTB | 0.108 | 5.88% | | |
| 12 | IN002010X028 | 91 DTB | 0.114 | 5.88% | | |
| 13 | IN002009Z025 | 364 DTB | 0.133 | 5.88% | 2000 | |
| 14 | IN002010X028 | 91 DTB | 0.133 | 5.99% | 2500 | 5.94% |
| 15 | IN002010X028 | 91 DTB | 0.153 | 5.88% | 2500 | |
| 16 | IN002010Y026 | 182 DTB | 0.153 | 6.34% | 2000 | 6.09% |
| 17 | IN002009Z025 | 364 DTB | 0.172 | 5.89% | 2000 | |
| 18 | IN002010X028 | 91 DTB | 0.172 | 5.92% | 2500 | 5.90% |
| 19 | IN002010X028 | 91 DTB | 0.192 | 5.90% | 2854 | |
| 20 | IN002010Y026 | 182 DTB | 0.192 | 5.90% | 2000 | 5.90% |
| 21 | IN002009Z025 | 364 DTB | 0.208 | 5.91% | 2000 | |
| 22 | IN002010X028 | 91 DTB | 0.208 | 6.08% | 9875 | 6.05% |
| 23 | IN002010X028 | 91 DTB | 0.228 | 6.10% | 7550 | |
| 24 | IN002010Y026 | 182 DTB | 0.228 | 6.12% | 2000 | 6.10% |
| 25 | IN002009Z025 | 364 DTB | 0.247 | 6.00% | 2000 | |
| 26 | IN002010X028 | 91 DTB | 0.247 | 6.07% | 8000 | 6.06% |
| 27 | IN002010Y026 | 182 DTB | 0.267 | 6.02% | | |
| 28 | IN002009Z025 | 364 DTB | 0.286 | 6.02% | | |
| 29 | IN002010Y026 | 182 DTB | 0.306 | 6.03% | | |
| 30 | IN002010Y026 | 182 DTB | 0.344 | 6.06% | | |
| 31 | IN002009Z025 | 364 DTB | 0.364 | 6.07% | | |
| 32 | IN002010Y026 | 182 DTB | 0.381 | 6.40% | | |
| 33 | IN002009Z025 | 364 DTB | 0.4 | 6.14% | | |
| 34 | IN002010Y026 | 182 DTB | 0.419 | 6.16% | | |
| 35 | IN002009Z025 | 364 DTB | 0.439 | 6.17% | | |
| 36 | IN002010Y026 | 182 DTB | 0.456 | 6.37% | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 37 | IN002009Z025 | 364 DTB | 0.472 | 6.23% | | |
| 38 | IN002010Y026 | 182 DTB | 0.494 | 6.49% | | |
| 39 | IN002009Z025 | 364 DTB | 0.514 | 6.58% | | |
| 40 | IN002009Z025 | 364 DTB | 0.558 | 6.23% | | |
| 41 | IN002009Z025 | 364 DTB | 0.597 | 6.25% | | |
| 42 | IN002010Z023 | 364 DTB | 0.633 | 6.41% | | |
| 43 | IN002010Z023 | 364 DTB | 0.672 | 6.34% | | |
| 44 | IN0019810020 | 8% 2011 | 0.686 | 6.42% | | |
| 45 | IN002010Z023 | 364 DTB | 0.711 | 6.37% | | |
| 46 | IN002010Z023 | 364 DTB | 0.75 | 6.41% | | |
| 47 | IN002010Z023 | 364 DTB | 0.786 | 6.39% | | |
| 48 | IN002010Z023 | 364 DTB | 0.825 | 6.35% | | |
| 49 | IN002010Z023 | 364 DTB | 0.864 | 6.52% | | |
| 50 | IN002010Z023 | 364 DTB | 0.903 | 6.34% | | |
| 51 | IN002010Z023 | 364 DTB | 0.942 | 6.47% | | |
| 52 | IN0020032028 | FRB 2011 (5.99% - 364 day T-Bill) | 0.967 | 5.99% | | |
| 53 | IN002010Z023 | 364 DTB | 0.978 | 6.63% | | |

In an endeavor to draw a smooth short end of the ZCYC Table 2 is modified to Table 3 by replacing rows 1-26 in column E by the column G, except for rows 11-12 after deleting the rows repeating TTM, i.e. 1, 3, 5, 7, 9, 13,15,17,19, 21 and 23.

**Table 3**

| A | B | C | D | E |
|---|---|---|---|---|
| **Column/Row** | **ISIN** | **Sec** | **TTM** | **YTM** |
| 1 | IN002009Z025 | 364 DTB | 0.019444 | 0.034095 |
| 2 | IN002009Y028 | 182 DTB | 0.036111 | 0.047931 |
| 3 | IN002009Z025 | 364 DTB | 0.055556 | 0.05676 |
| 4 | IN002010X028 | 91 DTB | 0.075 | 0.059095 |
| 5 | IN002009Z025 | 364 DTB | 0.094444 | 0.058861 |
| 6 | IN002010X02 | 91 DTB | 0.133333 | 0.059399 |

| | | | | |
|---|---|---|---|---|
| | 8 | | | |
| 7 | IN002010Y026 | 182 DTB | 0.152778 | 0.060852 |
| 8 | IN002010X028 | 91 DTB | 0.172222 | 0.059048 |
| 9 | IN002010Y026 | 182 DTB | 0.191667 | 0.058985 |
| 10 | IN002010X028 | 91 DTB | 0.208333 | 0.06053 |
| 11 | IN002010Y026 | 182 DTB | 0.227778 | 0.061019 |
| 12 | IN002010X028 | 91 DTB | 0.247222 | 0.060557 |
| 13 | IN002010Y026 | 182 DTB | 0.266667 | 0.060201 |
| 14 | IN002009Z025 | 364 DTB | 0.286111 | 0.060231 |
| 15 | IN002010Y026 | 182 DTB | 0.305556 | 0.060348 |
| 16 | IN002010Y026 | 182 DTB | 0.344444 | 0.060602 |
| 17 | IN002009Z025 | 364 DTB | 0.363889 | 0.060737 |
| 18 | IN002010Y026 | 182 DTB | 0.380556 | 0.063964 |
| 19 | IN002009Z025 | 364 DTB | 0.4 | 0.061443 |
| 20 | IN002010Y026 | 182 DTB | 0.419444 | 0.06157 |
| 21 | IN002009Z025 | 364 DTB | 0.438889 | 0.061701 |
| 22 | IN002010Y026 | 182 DTB | 0.455556 | 0.063699 |
| 23 | IN002009Z025 | 364 DTB | 0.472222 | 0.062317 |
| 24 | IN002010Y026 | 182 DTB | 0.494444 | 0.06488 |
| 25 | IN002009Z025 | 364 DTB | 0.513889 | 0.065831 |
| 26 | IN002009Z025 | 364 DTB | 0.558333 | 0.062319 |
| 27 | IN002009Z025 | 364 DTB | 0.597222 | 0.062498 |
| 28 | IN002010Z023 | 364 DTB | 0.633333 | 0.064059 |
| 29 | IN002010Z023 | 364 DTB | 0.672222 | 0.063442 |
| 30 | IN0019810020 | 8% 2011 | 0.686111 | 0.064207 |
| 31 | IN002010Z023 | 364 DTB | 0.711111 | 0.063747 |
| 32 | IN002010Z023 | 364 DTB | 0.75 | 0.064053 |
| 33 | IN002010Z023 | 364 DTB | 0.786111 | 0.063893 |
| 34 | IN002010Z023 | 364 DTB | 0.825 | 0.063474 |
| 35 | IN002010Z023 | 364 DTB | 0.863889 | 0.065184 |
| 36 | IN002010Z023 | 364 DTB | 0.902778 | 0.063401 |
| 37 | IN002010Z023 | 364 DTB | 0.941667 | 0.064663 |
| 38 | IN0020032028 | FRB 2011 (5.99% - 364 day T-Bill) | 0.966667 | 0.0599 |
| 39 | IN002010Z023 | 364 DTB | 0.977778 | 0.066269 |

The short rate chart and probability distribution chart are given in Figure 1 and Figure 2.

Figure 1

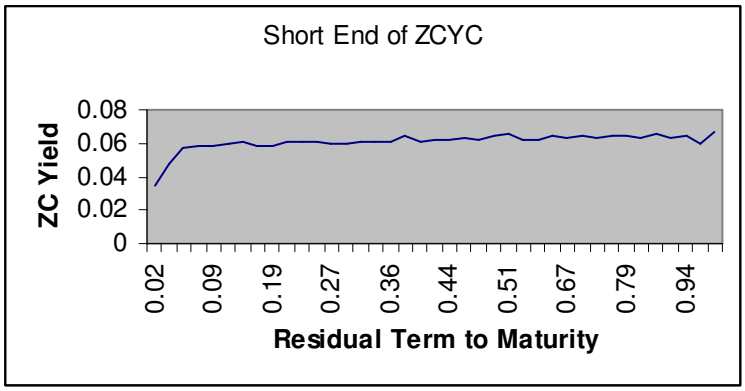
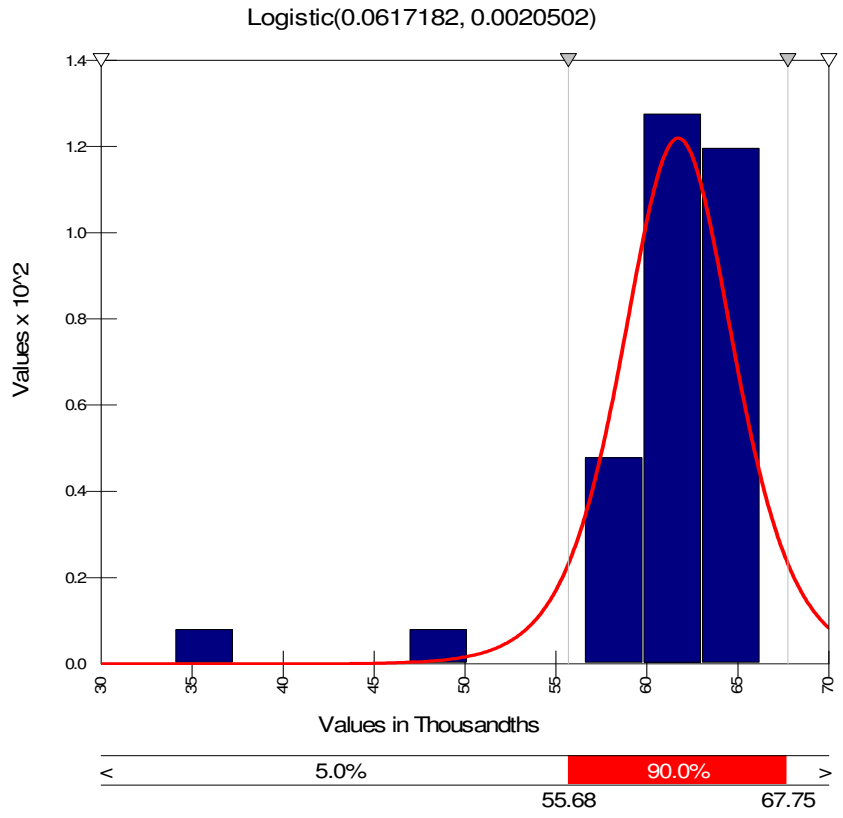



Figure 2




The mean of above distribution is 0.061718 and SD (standard deviation) is 0.003719

At the moment the reasons behind the shape of above curve are not given in detail here except the fact that the CCIL ZCYC as on 20-aug-10 was flatter than that on the previous working day 18-aug-10[10].

Now we should find out the YTMs as on the next coupon dates (NCDs) since the interval between settlement and next coupon is maximum 6 months. For the securitiesIN0019820128 8.75% 2010 and IN0019980344 12.32% 2011(Pvt. Placement) the next coupon dates are 13-dec-2010 and 29-jan-2011 respectively, the TTMs are 0.314 and 0.4417, the redemption amounts are 104.38 and 106.16 and prices are 100.83 and 102.70 respectively. Following RBI formula their YTMs can respectively be computed with equations 1 and 2:

1. The process starts with the security with the DoM nearest to and in six months of DoS 20-aug-10. It is IN0019820128 8.75% 2010 with DoM 13-dec-2010 and TTM 0.314, LTP 102.46, redemption value 104.375. Following the formula of ZC pricing ZCYTM "=((Redemption-LTP)/LTP)/TTM", the YTM is obtained to be 5.95% (entry 1 in Table 2).

2. Next comes in queue IN0019980344 12.32% 2011(Pvt. Placement) with DoM 29-jan-11, TTM 0.4417, LTP 103.41. The ZCY comes to be

$$\frac{106.16-103.41}{103.41} \div \frac{1}{0.4417}$$ = 6.02% (entry 2 in Table 2)

3. Next in queue is IN0020032028 FRB 2011 (5.99% - 364 day T-Bill) with DoM 8-aug-11. Though it is a coupon paying bond, it is treated as ZC since it is repriced every six month as if it is a fresh ZC. So, for TTM = 0.9667, yield is 0.599 (entry 3 in Table 2)

10 http://www.ccilindia.com/ArchiveZCYCNSS.aspx?SubSectionID=111&SegmentID=1 accessed on 29-sep-10

4. Next in queue is IN0020020213 6.57% 2011(Pvt. Placement) DoM 24-aug-2010 and NCD 24-feb-2011 i.e. NCD comes after 3 days or 0.0111 years. But there is no rate available for TTM below 0.0194. Hence one needs to employ regression technique following Cohen (1966).

In the yield curve regression independent variable is D, viz, TTM in terms of days, and $(\log D)^2$ dependent variable is YTM. The estimated relationship is as follows:

$y = -0.00026D + 0.0225(\log D)^2$

(-9.3) (20.18) Adjusted $R^2 = 0.95$

The YTM for D = 3 days is found to be 0.0043 (entry 4 in Table 4)

i.e.

=(0.00026*3)+0.0225*(POWER(LOG(3),2))=0.0043 in xls.

Given LTP = 99.80, if '$a$' is the YTM of redemption

$$99.80 = \frac{3.29}{(1+0.0043)^{0.0111}} + \frac{103.29}{(1+a)^{0.5111}} \quad \text{..... equation (1)}$$

Solving above for '$a$' gives $a$ = 0.142899 (entry 5 in Table 4)

Let us interpret this result in terms of the forward rate mechanism. There are two options before an investor. Assume the investment amount is ₹1 – (i) invest for TTM = 0.5111 @0.142899, (ii) invest for TTM = 0.111 at a forward rate φ such that $(1.142899)^{0.5111} = (1.0043)^{0.0111} \times (1 + \varphi)^{0.5}$ in the no-arbitrage situation. Solving it for φ gives φ = 0.1461. Hence 0.142899 is the geometric average of 0.0043 and 0.1461. Since 0.5111 year short rate 0.14289 is the average rate,

0.5 year short rate needs to be higher than the average given the fact that 0.0111 year rate is lower than the average.

There is another way of explaining the above forward rate in the line of reasoning offered by Litterman (1991)[11]. The preceding 0.0111 year short rate was 0.0043. Given the SD of short rate 0.003719, following term premium theory the next 0.5 year short rate could go up to 0.0043 + 0.003719 = 0.0080 or down to 0.0043 - 0.003719 = 0.0006 with equal probabilities. Hence the PV (present value) of investment ₹1 is

$$0.5\times(\frac{1}{(1+0.0008)^{0.5}}+\frac{1}{(1+0.0006)^{0.5}})=0.9993$$

If $\zeta$ is the 0.5 year forward rate between 24-aug-2010 and 24-feb-2010, the following equality should work

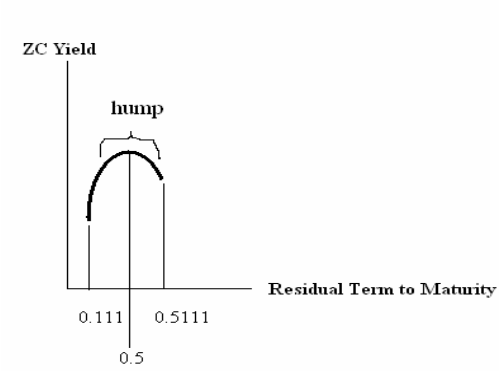
$$(1+0.0043)^{0.0111}\times\frac{1}{0.9993}\times(1+\zeta)^{0.5}=(1+0.14289)^{0.5111}$$

Solution to the above gives $\zeta$ = 0.1446, which is higher than 0.14289.

This means the yield curve has a hump like Figure 3 at maturity point 0.5 and between the points of maturity 0.0111 and 0.5111.

**Figure 3**

[11] It is also seen in Varma (1996).




5. Next comes IN0019989014 10% NAT BKS (NT) SPL SEC 2011 with LTP 102.11 DoM 24-mar-2010 and NCD 24-sep-2010. The TTM for NCD is 0.0944 for which there is already existing yield 0.0589. If the stripped yield for the last cash flow of this bond is denoted by '*b*',

$$102.11 = \frac{5}{(1+0.0589)^{0.0944}} + \frac{105}{(1+b)^{0.5944}} \quad \text{.....equation (2)}$$

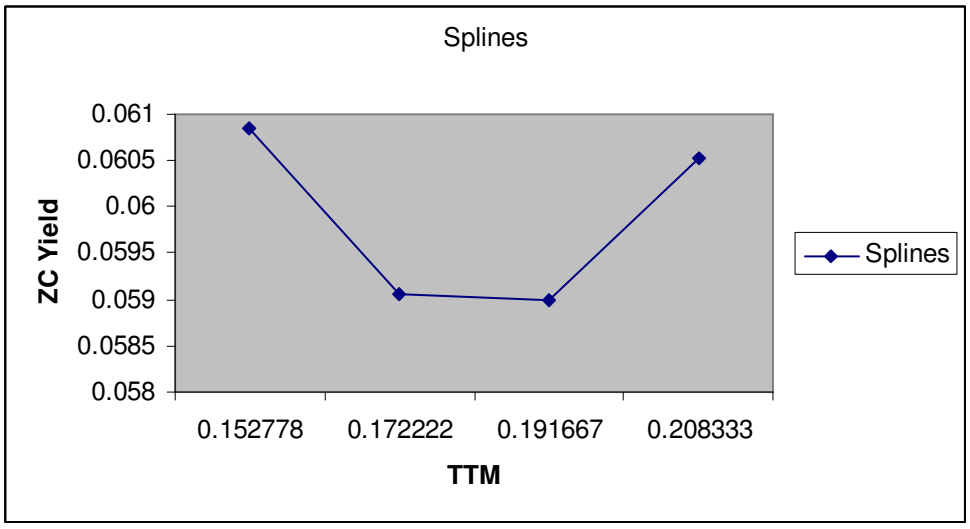
Solving gives $b = 0.1399$ (entry 6 in Table 4).

**Table 4**

| Column/Row | ISIN | Sec | TTM | YTM | |
|---|---|---|---|---|---|
| | IN0020020213 | 6.57% 2011 coupon | 0.0111 | 0.0043 | 4 |
| 1 | IN002009Z025 | 364 DTB | 0.0194 | 0.0341 | |
| 2 | IN002009Y028 | 182 DTB | 0.0361 | 0.04793 | |
| 3 | IN002009Z025 | 364 DTB | 0.0556 | 0.05676 | |
| 4 | IN002010X028 | 91 DTB | 0.075 | 0.0591 | |
| 5 | IN002009Z025 | 364 DTB | 0.0944 | 0.05886 | |
| 6 | IN002010X028 | 91 DTB | 0.1333 | 0.0594 | |
| 7 | IN002010Y026 | 182 DTB | 0.1528 | 0.06085 | |
| 8 | IN002010X028 | 91 DTB | 0.1722 | 0.05905 | |
| | IN0019810020 | 8% 2011 coupon | 0.186 | 0.05877 | 7 |
| 9 | IN002010Y026 | 182 DTB | 0.1917 | 0.05899 | |
| 10 | IN002010X028 | 91 DTB | 0.2083 | 0.06053 | |
| 11 | IN002010Y026 | 182 DTB | 0.2278 | 0.06102 | |
| 12 | IN002010X028 | 91 DTB | 0.2472 | 0.06056 | |
| 13 | IN002010Y026 | 182 DTB | 0.2667 | 0.0602 | |
| | IN0020000041 | 10.95% 2011 coupon | 0.277 | 0.60123 | 9 |
| 14 | IN002009Z025 | 364 DTB | 0.2861 | 0.06023 | |
| 15 | IN002010Y026 | 182 DTB | 0.3056 | 0.06035 | |
| | IN0019820128 | 8.75% 2010 redemption | 0.314 | 0.0595 | 1 |
| 16 | IN002010Y026 | 182 DTB | 0.3444 | 0.0606 | |
| 17 | IN002009Z025 | 364 DTB | 0.3639 | 0.06074 | |
| | IN0020010057 | 9.39% 2011 | 0.3667 | 0.06126 | 11 |
| 18 | IN002010Y026 | 182 DTB | 0.3806 | 0.06396 | |
| 19 | IN002009Z025 | 364 DTB | 0.4 | 0.06144 | |
| 20 | IN002010Y026 | 182 DTB | 0.4194 | 0.06157 | |
| | IN0020040021 | 6.10% UTI Spl. Bonds 2011 coupon | 0.425 | 0.06149 | 13 |
| 21 | IN002009Z025 | 364 DTB | 0.4389 | 0.0617 | |
| | IN0019980344 | 12.32% 2011 | 0.4417 | 0.062 | 2 |
| 22 | IN002010Y026 | 182 DTB | 0.4556 | 0.0637 | |
| | IN0019910044 | 11.50% 2011 coupon | 0.4583 | 0.06405 | 15 |
| 23 | IN002009Z025 | 364 DTB | 0.4722 | 0.06232 | |
| 24 | IN002010Y026 | 182 DTB | 0.4944 | 0.06488 | |
| | | 6.57% 2011 redemption | 0.5111 | 0.1429 | 5 |
| 25 | IN002009Z025 | 364 DTB | 0.5139 | 0.06583 | |
| 26 | IN002009Z025 | 364 DTB | 0.5583 | 0.06232 | |
| | IN0019989014 | 10% NAT BKS (NT) SPL SEC 2011 red | 0.5944 | 0.1399 | 6 |
| 27 | IN002009Z025 | 364 DTB | 0.5972 | 0.0625 | |
| 28 | IN002010Z023 | 364 DTB | 0.6333 | 0.06406 | |
| 29 | IN002010Z023 | 364 DTB | 0.6722 | 0.06344 | |
| 30 | IN0019810020 | 8% 2011 redemption | 0.6861 | 0.10455 | 8 |
| 31 | IN002010Z023 | 364 DTB | 0.7111 | 0.06375 | |
| | IN0020000041 | 10.95% 2011redemption | 0.8777 | 0.8712 | 10 |
| 32 | IN002010Z023 | 364 DTB | 0.75 | 0.06405 | |
| 33 | IN002010Z023 | 364 DTB | 0.7861 | 0.06389 | |
| 34 | IN002010Z023 | 364 DTB | 0.825 | 0.06347 | |
| 35 | IN002010Z023 | 364 DTB | 0.8639 | 0.06518 | |
| | IN0020010057 | 9.39% 2011 redemption | 0.8667 | 0.08422 | 12 |
| 36 | IN002010Z023 | 364 DTB | 0.9028 | 0.0634 | |
| | IN0020040021 | 6.10% UTI Spl. Bonds 2011 redemptior | 0.925 | 0.07294 | 14 |
| 37 | IN002010Z023 | 364 DTB | 0.9417 | 0.06466 | |
| | IN0019910044 | 11.50% 2011 redemption | 0.9583 | 0.07223 | 15 |
| 38 | IN0020032028 | FRB 2011 (5.99% - 364 day T-Bill) | 0.9667 | 0.0599 | 3 |
| 39 | IN002010Z023 | 364 DTB | 0.9778 | 0.06627 | |

6. Next comes IN0019810020 8% 2011 with DoM 27-apr-2011, NCD 27-oct-2010. For NCD, TTM = 0.186 which does not exist in Table 3. Further, 0.186 lie between the TTM points 0.172 and 0.192. Maturity points before 0.172 and after 0.192 are respectively 0.153 and 0.208 respectively in Table 3. Drawing an yield curve consisting of these maturity points and the respective yield provide a picture like Figure 4, which indicates the possibility of existence of cubic splines.

**Figure 4**




Hence interpolation for TTM = 0.186 will take place as per Choudhry (2005). The securities in above spline with their respective details are in Table 5.

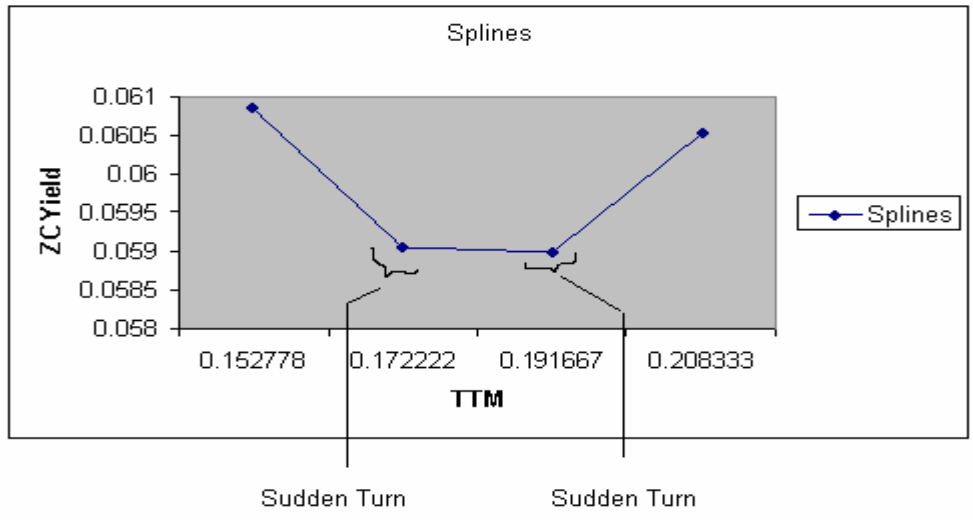
**Table 5**

| ISIN No. | Security | DoM | LTP | Yield | TTM |
|---|---|---|---|---|---|
| IN002010X028 | 91 DTB | 15-Oct-10 | 99.11 | 5.7759% | 0.1528 |
| IN002010X028 | 91 DTB | 22-Oct-10 | 98.99 | 5.8239% | 0.1722 |
| IN002010X028 | 91 DTB | 29-Oct-10 | 98.88 | 5.8142% | 0.1917 |
| IN002010X028 | 91 DTB | 5-Nov-10 | 98.75 | 5.9244% | 0.2083 |

The real life yield curve does not have sudden turns as are there in Figure 4.

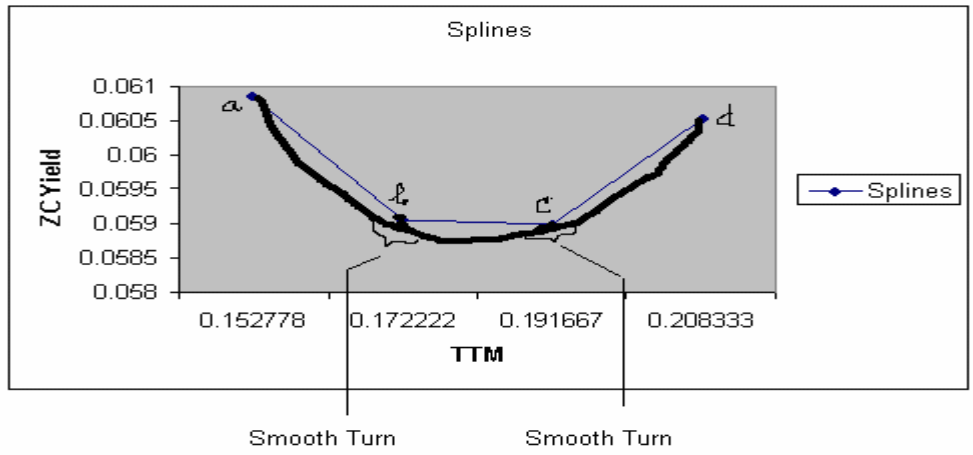
The sudden turns in Figure 4 are shown in a more revealing manner in Figure 5.

**Figure 5**



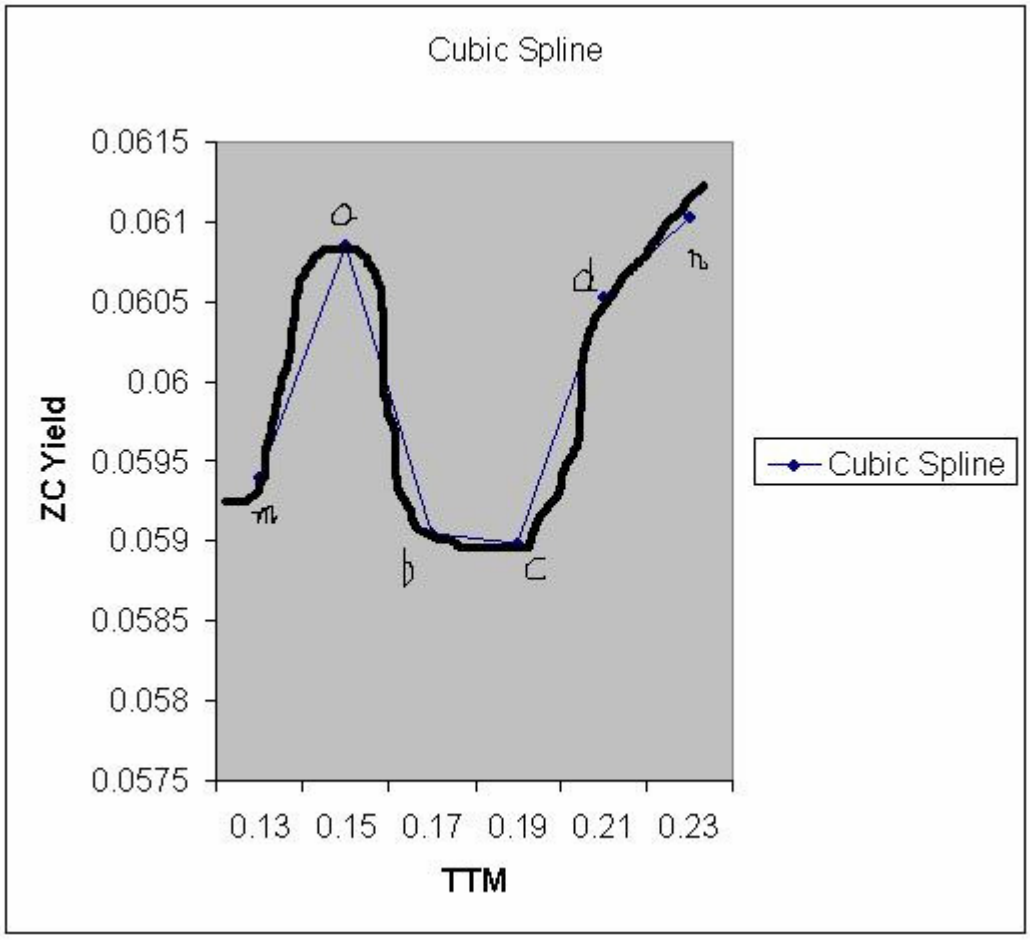

The real life yield curve may look like Figure 6, where straight line segments ‘ab’ and ‘bc’ have taken sudden turns at points ‘b’ and ‘c’ respectively.

Figure 6



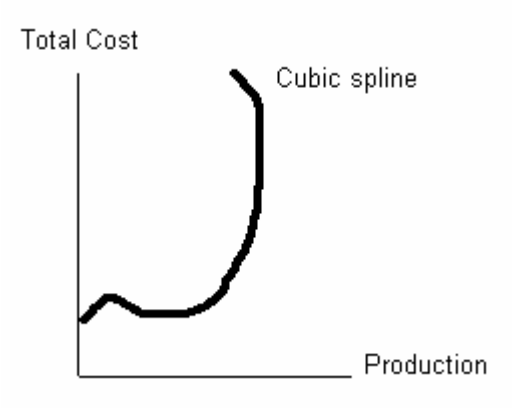

But again, there is no exact linear segment in a real life yield curve, ‘ab’ and ‘bc’ may be curvilinear segments like thickened black lines connecting the nodes ‘a’ and ‘b’, ‘b’ and ‘c’, and ‘c’ and ‘d’. Each of these thick lines is called ‘spline’. Three such lines together can involve two turns, while there might be a turn at ‘a’ and/or at ‘d’; then this is called cubic spline. This is evident in Figure 7.

Figure 7




If sudden turns are replaced, in realistic sense by smooth turns then the shape of above yield curve segment resembles to total cost curve as far as thin straight line segments between ‘m’ and ‘d’ are concerned while the total cost curve looks like the thickened black curve in Figure 7. In a more intelligible expression, one should look at Figure 8 - it is a clear case of cubic spline.

Figure 8




Once the co-ordinates of four points in a cubic spline are known, interpolation can be performed with help of cubic spline function in xls "=CubicSpline(range of TTM values, range of corresponding ZC yields, new TTM value)". For TTM = 0.186, the ZC yield is found to be 0.05877 (entry 7 in Table 4).

For the redemption yield of IN0019810020 8% 2011 with DoM 27-apr-2011 with LTP 101.1, the following equality should hold:

$$101.1 = \frac{4}{(1+5.877)^{0.186}} + \frac{104}{(1+c)^{0.686}}$$

Solving gives $c$ = 10.4549% (entry 8 in Table 4)

5. Next comes IN0020000041 10.95% 2011 with DoM 30-may-2011. The next coupon date is 30-nov-2010. So we need to find the ZC yield for the coupon. This coupon date 30-nov-2010 is located between 26-nov-2010 and 03-dec-2010 with corresponding TTMs 0.267 and 0.286 and ZC yields 6.0201% and 6.0231% respectively. One needs to interpolate the yield for TTM 0.27778 as on 30-nov-2010. The table of the relevant splines are in Table 6.

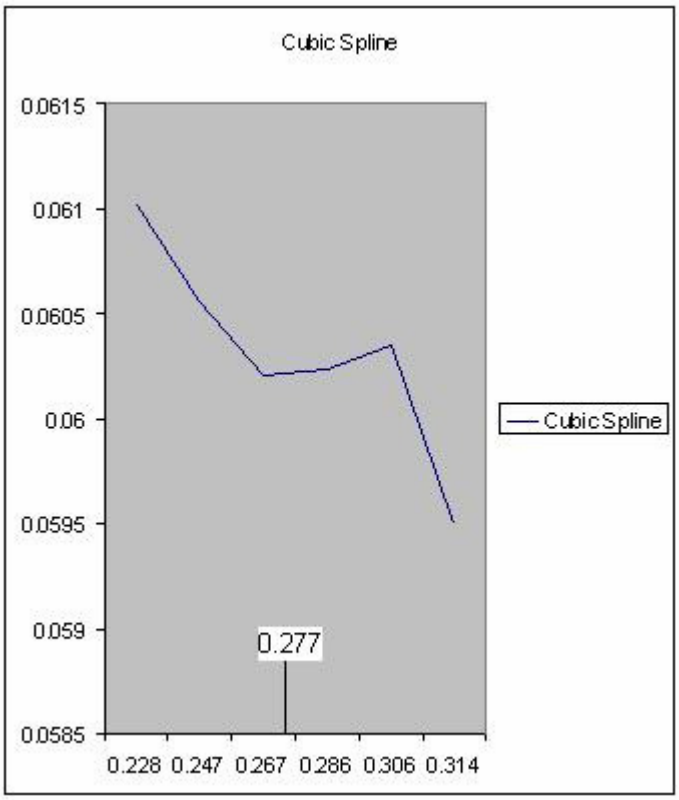
**Tale 6**

| ISIN | Sec | TTM | YTM |
|---|---|---|---|
| IN002010Y026 | 182 DTB | 0.2278 | 0.06102 |
| IN002010X028 | 91 DTB | 0.2472 | 0.06056 |
| IN002010Y026 | 182 DTB | 0.2667 | 0.0602 |
| IN002009Z025 | 364 DTB | 0.2861 | 0.06023 |
| IN002010Y026 | 182 DTB | 0.3056 | 0.06035 |

| | | | |
|---|---|---|---|
| IN0019820128 | 8.75% 2010 redemption | 0.314 | 0.0595 |

The graph is Figure 9.

**Figure 9**




The yield for TTM = 0.277 is found 6.0123% (entry 9 in Table 4). The differences between the shapes of yield curve segments such as those in Figure 5 and Figure 8 would be explained later in terms of forward rates and designing of fixed income portfolio strategies.

The equality for redemption yield '*d*' is

$$103.41 = \frac{5.475}{(1+6.0123\%)^{0.277}} + \frac{105.475}{(1+d)^{0.777}}$$

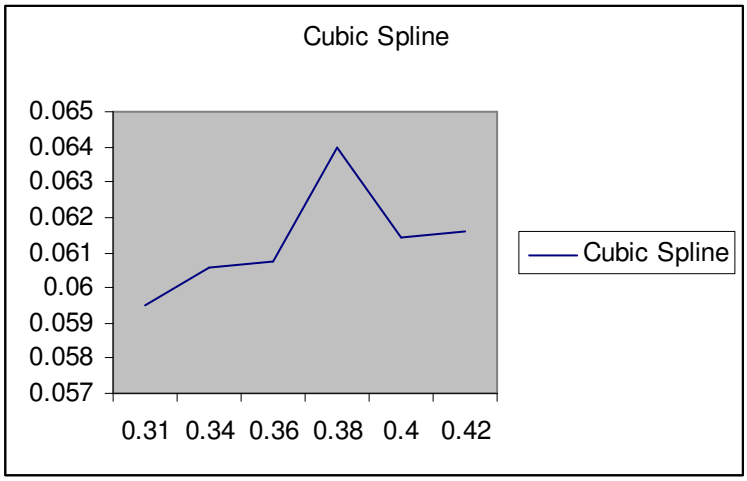
Solving $d$ = 9.8893% (entry 10 in Table 4).

6. Next comes IN0020010057 9.39% 2011 with DoM 02-Jul-11 and LTP 102.5. NCD 02-Jan-11 means TTM = 0.3667. The relevant yield curve segment data are in Table 7 and the related splines are in Figure 10.

**Table 7**

| ISIN | Sec | TTM | YTM |
|---|---|---|---|
| IN0019820128 | 8.75% 2010 redemption | 0.314 | 0.0595 |
| IN002010Y026 | 182 DTB | 0.3444 | 0.0606 |
| IN002009Z025 | 364 DTB | 0.3639 | 0.06074 |
| IN002010Y026 | 182 DTB | 0.3806 | 0.06396 |
| IN002009Z025 | 364 DTB | 0.4 | 0.06144 |
| IN002010Y026 | 182 DTB | 0.4194 | 0.06157 |

Figure 9




The interpolated rate for TTM = 0.3667 is 6.126% (entry 11 in Table 4).

The equality for redemption yield '*f*' is

$$102.5 = \frac{4.695}{(1+6.126\%)^{0.3667}} + \frac{105.475}{(1+f)^{0.8667}}$$

Solving gives $f = 8.0422\%$ (entry 12 in table 4).

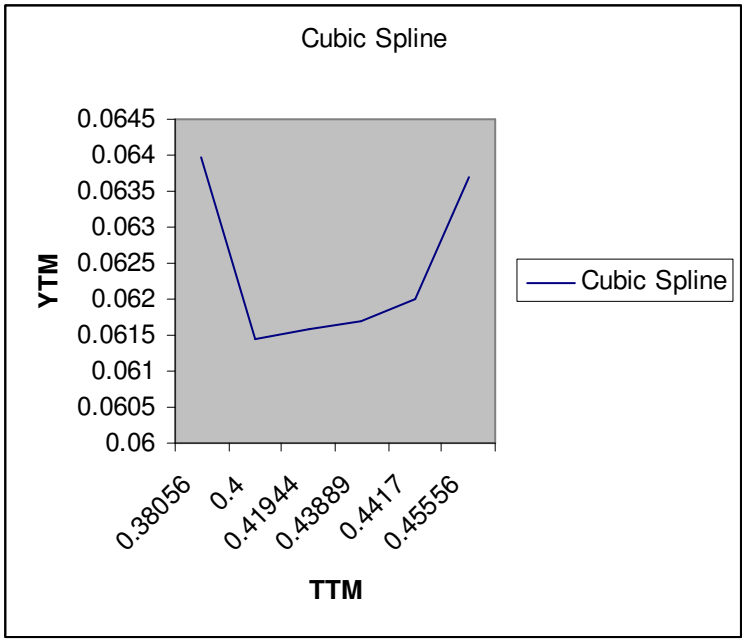
7. Next comes IN0020040021 6.10% UTI Spl. Bonds 2011 with DoM 23-jul-11, and LTP 99.56. Here NCD is 23-jan-11, i.e. TTM = 0.425. it is also in splines. The relevant data and graph are in Table 8 and Figure 10.

**Table 8**

| ISIN | Security | TTM | Y |
|---|---|---|---|

| | | | |
|---|---|---|---|
| IN002010Y026 | 182 DTB | 0.381 | 0.064 |
| IN002009Z025 | 364 DTB | 0.4 | 0.061 |
| IN002010Y026 | 182 DTB | 0.419 | 0.062 |
| IN002009Z025 | 364 DTB | 0.439 | 0.062 |
| IN0019980344 | 12.32% 2011 | 0.442 | 0.062 |
| IN002010Y026 | 182 DTB | 0.456 | 0.064 |

**Figure 10**




The YTM for TTM 0.425 is 6.1493% (entry 13 in Table 4). If '*g*' is the redemption TTM,

$$99.56 = \frac{3.05}{(1+6.1493\%)^{0.425}} + \frac{103.05}{(1+g)^{0.925}}$$

Solving gives $g$ = 7.2935% (entry 14 in table 4).

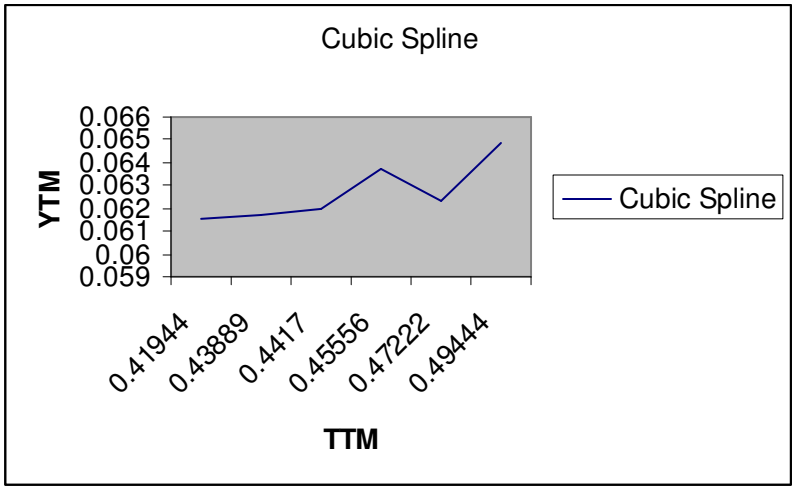
8. The dated security with the latest DoM in the short end of the yield curve is IN0019910044 11.50% 2011 with DoM 5-aug-2011, LTP 104.56. The NCD is 5-feb-2011 having TTM 0.4583.

The relevant data and graph are in Table 9 and Figure 11.

**Table 9**

| ISIN | Security | TTM | Y |
|---|---|---|---|
| IN002010Y026 | 182 DTB | 0.419 | 0.062 |
| IN0020040021 | 6.10% UTI Spl. Bonds 2011 coupon | 0.439 | 0.062 |
| IN002009Z025 | 364 DTB | 0.442 | 0.062 |
| IN0019980344 | 12.32% 2011 | 0.456 | 0.064 |
| IN0019910044 | 11.50% 2011 | 0.472 | 0.062 |
| IN002009Z025 | 364 DTB | 0.494 | 0.065 |

**Figure 11**




The YTM for TTM 0.4583 is 6.4045% (entry 15 in Table 4). If the redemption YTM for TTM 0.9583 is ‘h’

$$104.56 = \frac{5.75}{(1+6.4045\%)^{0.4583}} + \frac{105.75}{(1+h)^{0.9583}}$$

Solving gives $h$ = 7.223% (entry 16 in Table 4).

Thus Table 4 provides the YTMs of 52 two cash flows having TTMs up to one year belonging to 37 outstanding TBs, 9 dated securities maturing in 1 year and 1 FRB maturing in one year as on 20-aug-2010. This is the short end of the yield curve and has the shape of Figure 11. There are 55 number of data points including the outliers and dropping the outliers give Figure 12, which is a variant of the daily yield curves provided by the agencies and Institutions like Reuters, Bloomberg, FIMMDA and CCIL.

Figure 11

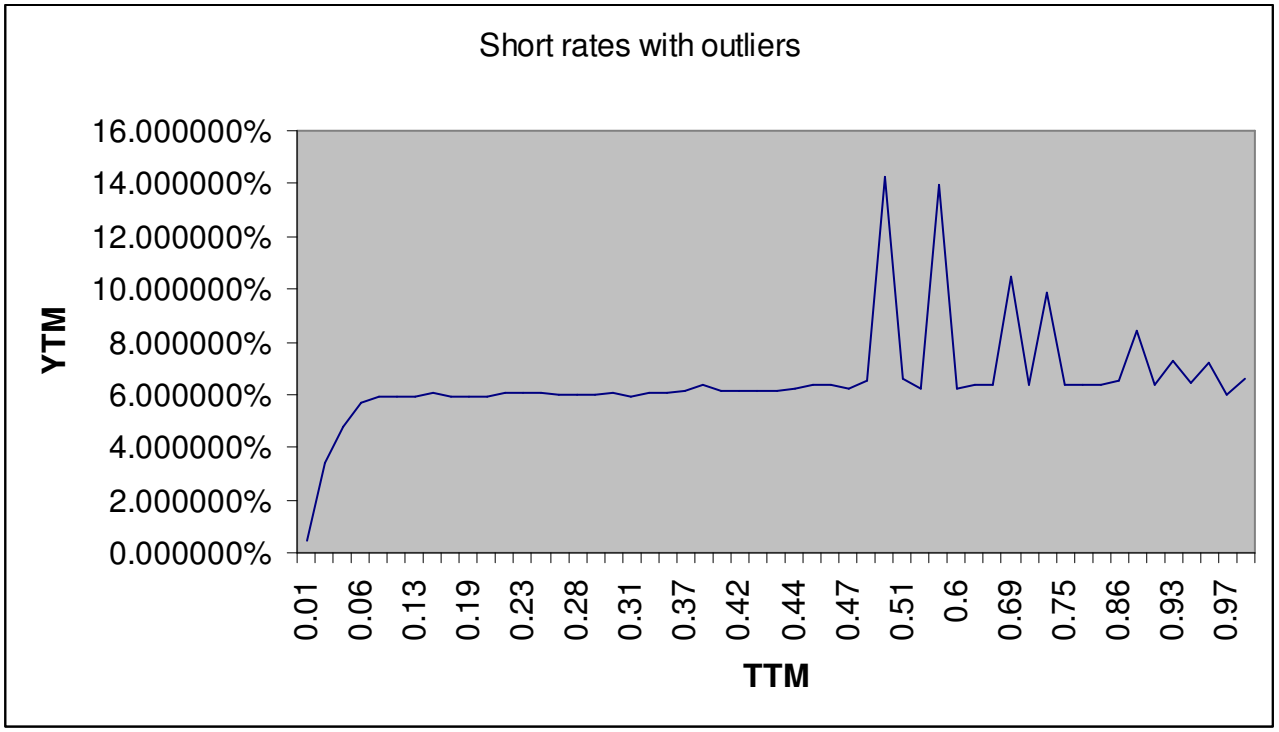
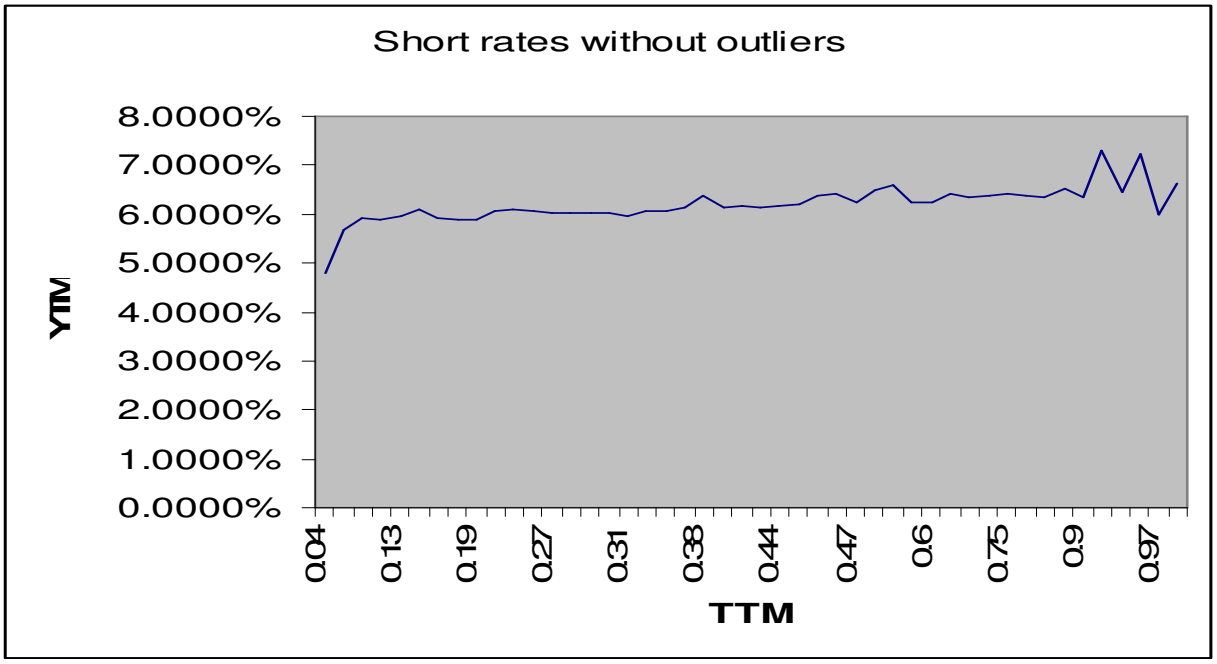


Figure 12




There are two issues at this point –

1. how far does the above curve reflect the market scenario?
2. what are portfolio management implications of above curve?

Answers: The market scenario on and around 20-aug-2010 was as follows:

- On the close of 18-aug-10 Wednesday Bonds fell, the yield on the 7.80% note due in May 2020 rose six basis points to 7.94% at the close of trade on Wednesday, driving 10-year yields to the highest level in more than three months, as inflation hovering at almost double the pace of RBI's target deters investors; the notes dropped for a third day, the longest losing streak in more than two weeks, before the government's Rs 12,000 crore ($2.6 billion) sale of debt on 20-aug-2010 Friday, reported by ET.
- At 9:15 a.m. on 20-aug-2010 Friday the yield on the 10-year benchmark paper was at 7.92 per cent, down 2 basis points from Wednesday's close, reported by Economic Times (ET).

- US Treasuries rose on Thursday, with two-year yields hitting record lows after dismal factory and jobless claims data signaled new trouble for the economy and the likelihood of prolonged low interest rates reported by ET.
- India currency, bonds, cash and overnight indexed swap markets are closed on Thursday for a local holiday but the stock market was open, reported by ET.
- Sensex rose to its highest level in two-and-a-half years early on 19-aug-2010 Thursday; the 30-share BSE index was up 0.38 percent at 18,326.72 points; It climbed as high as 18,345.16, its best since February 2008, the 30-share BSE index closed 1.2 percent higher at 18,257.12 points, reported by the Financial Express.
- On 18-aug-2010 Wednesday, the partially convertible rupee closed at 46.555/565 per dollar, 0.2 percent stronger than 46.64/65 at close on 17-aug-2010 Tuesday reported by ET.
- On 18-aug-2010 Wednesday the benchmark five-year swap rate ended at 7.09/12 percent, above its previous close of 7.00/7.03 percent; the overnight interbank call rate ended at 5.70/80 percent, compared with 17-aug-2010 Tuesday's close of 5.65/75 percent and off the day's high of 5.85 percent, Thomson Reuters data showed, reported by ET.
- Inflation has averaged 10.5% in the first seven months of this year, compared with 1.5% in the year-ago period, reported by ET.
- The wholesale-price index rose 9.97% from a year earlier in July, after a 10.55% gain in June, the government reported on Monday, dipping below 10% for the first time in six months, reported by ET.

There is a point of to note that during the period around 20-aug-2010 there are instances of monetary policy rate hikes by RBI. Das (2010) researched out the

strong sensitivity of short end of the yield curve to monetary policy rate, of which 3 month MIBOR was taken by Das (2010) as proxy. Here there is a further opportunity of running time series regression of short rates on 3 month MIBOR and one dummy variable for the news of RBI's auction of dated securities.

Secondly, in the circumstances of monetary policy rate hike and buoyant equity market the short end of the yield curve is almost flat in Figure 12 with meager changes in slope (Figure 13) and curvature (Figure 14) except at the end of the curve.

**Figure 13**

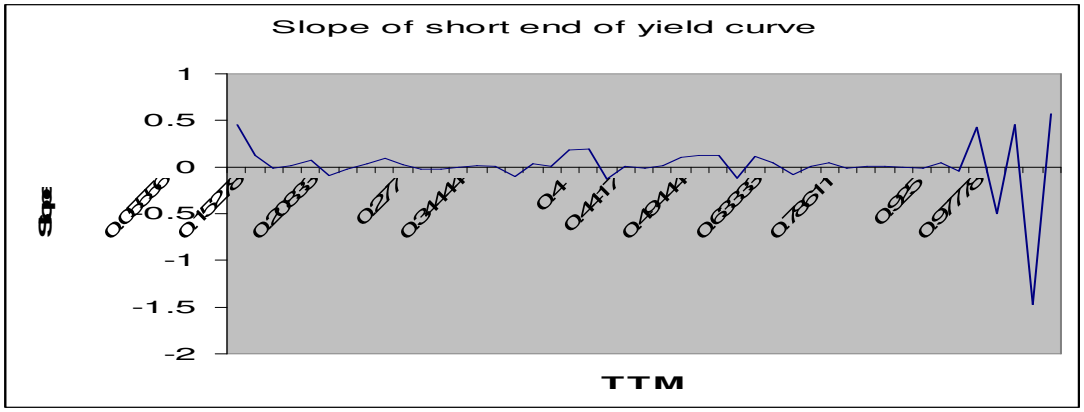
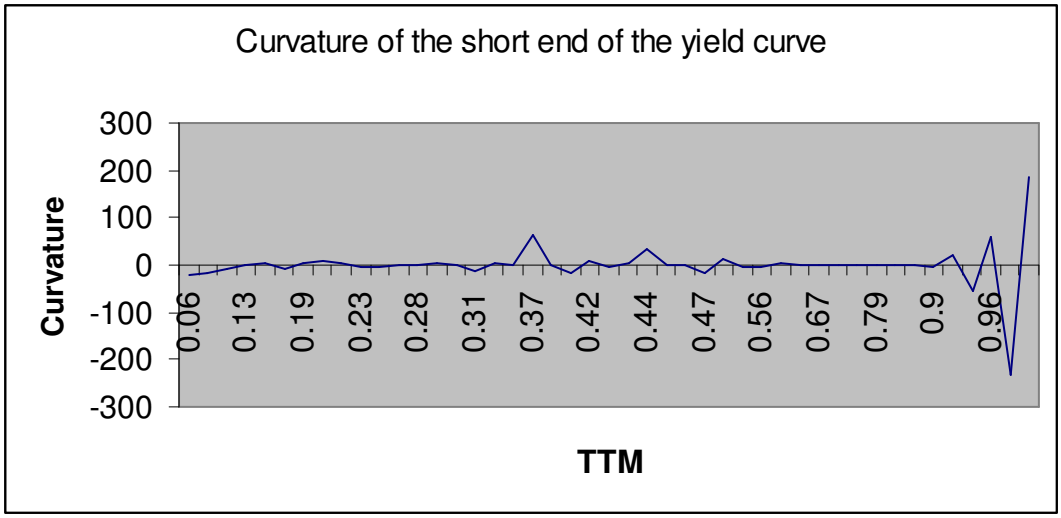
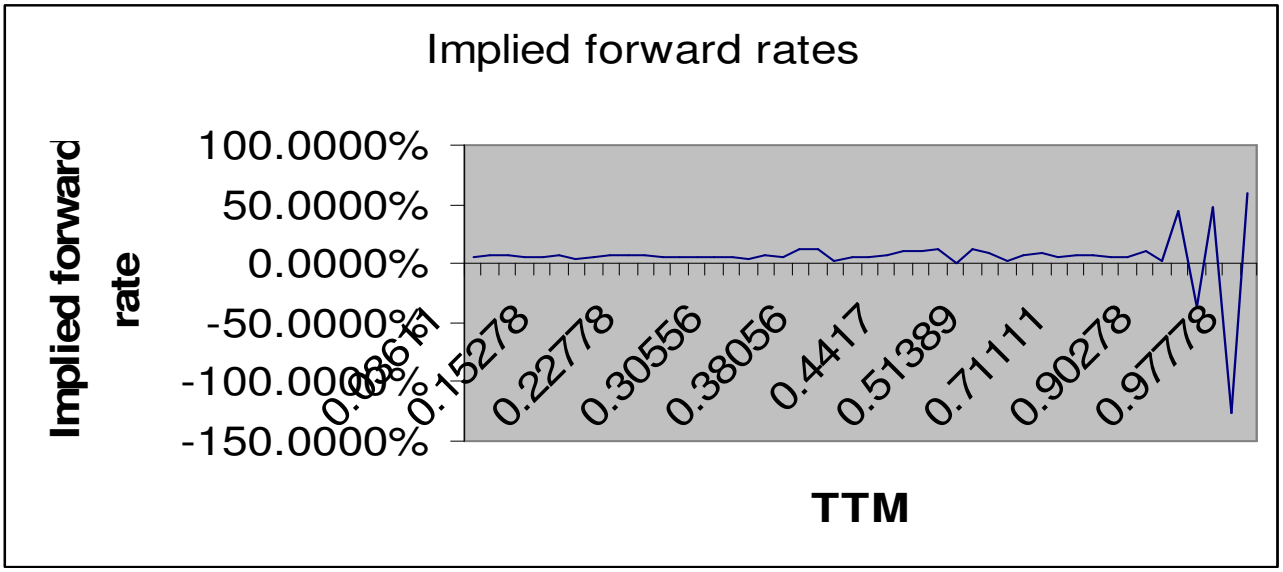



**Figure 14**



Changes in the slope of the yield curve have some forward rate implications. If level and slope of the yield curve are flat, forward rate structure becomes reasonably flat as is in Figure 15.

**Figure 15**




Thirdly, whether the impact of the news of rise in sensex on fixed income management decision can be ignored because of SLR (statutory liquidity ratio) requirement in India or be analyzed with decoupling theory (Alloway 2010) which came up just the previous day, a local holiday for the bond market – it can be considered in this paper with a comment that those Institutions having excess SLR securities and/or bearing a risk-lover's attitude may liquidate some government papers and buy equities, but they may not be prompted to take such decision because of the auction expected in the afternoon of 20-aug-2010, for the replacement securities may be the new dated securities.

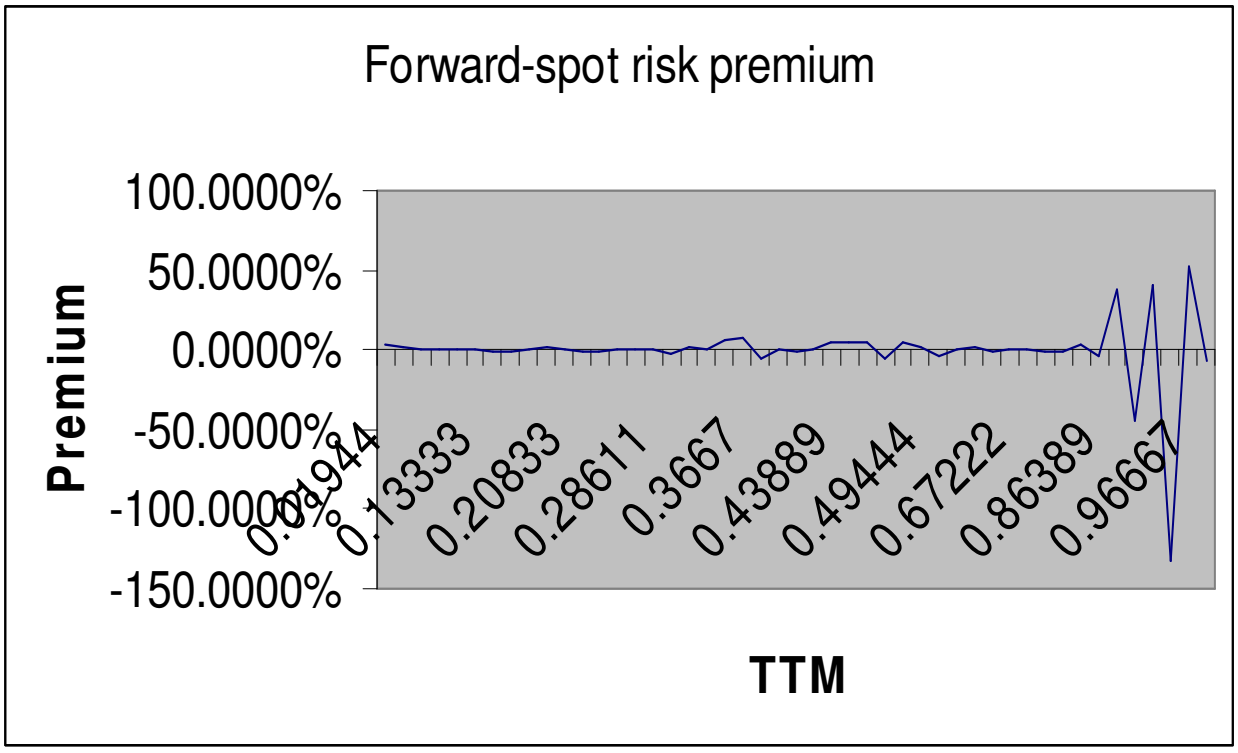
Fourthly, high rate of inflation triggered by whatsoever driver factors including GDP growth is not an encouraging news for a fixed income market manager

(Yemen 2004).

Fifthly, there is no short rate having TTM below 7 days. Money market products relevant to arbitrage like market repo and CBLO trades for one day or three days. Hence arbitrage cannot take place in short horizon.

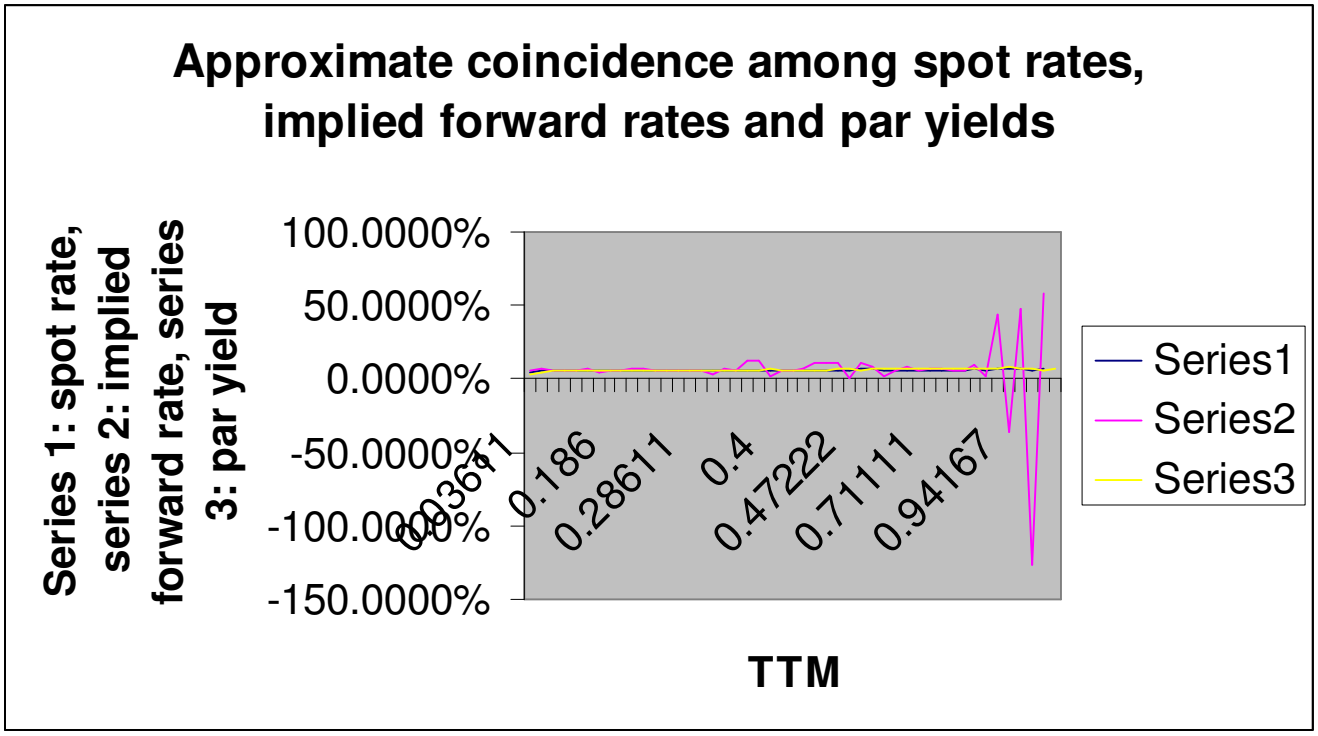
Finally the forward-spot risk premium $(f_{n-t,n} - s_t)$[12] across maturities within the short end seems to be flat (Figure 16) indicating risk neutral behaviour pattern of the fixed income market participants and as a natural corollary, approximate coincidence among spot rates, forward rates and par yields (Figure 17)[13].

**Figure 16**




[12] Salomon Brothers 1995f
[13] Salomon Brothers 1995a

**Figure 17**




Next let us look at the portfolio management aspect of the flat short rate curve in Table 12 with the help of scenario analysis. Let us assume that an investor who wants to invest ₹1000 crore in T-bills. Suppose she prefers a TTM 0.5, which she can do in either way – buy (i) the paper with spot price ₹ 96.9396 and TTM 0.49 with entire ₹1000 cr, i.e. 10.32 units, or (ii) buy the papers with spot prices 99.9348 and 93.9188 and TTMs 0.02 and 0.98 respectively employing ₹500 crore in each case, i.e. 5 crore units of the former and 5.32 crore units of the latter.

A. **Bear position**

**Scenario I**: There is 10 basis point upward shift of the curve. After the yield

hike, her loss in the case of the former is ₹ (0.04498 x 10.32) crore = ₹0.4642 crore and in the case of the latter is ₹ (0.0094 x 5 + 0.4578 x 5.32) crore = ₹0.4672 crore. So the loss is larger in the case of the latter to the extent of ₹29608.09.

**Scenario II**: There is 5 basis points upward shift of the upper end and 10 basis points upward shift of the lower end of the curve. In the former case there is loss ₹ (0.0224 x 10.32) crore = ₹0.2322 crore. In the latter case there is loss ₹ (0.86 x 5.32 + 0.0009 x 5) = ₹0.4625 crore. In the case of the latter loss is higher by ₹2302787.

**Scenario III**: : There is 10 basis points upward shift of the upper end and 5 basis points upward shift of the lower end of the curve. In the former case there is loss ₹ (0.04498 x 10.32) crore = ₹0.4642 crore. In the latter case there is loss ₹ (0.04304 x 5.32 + 0.00094 x 5) = ₹0.4625 crore. In the case of the latter the loss is lesser by ₹2258116.

B. **Bull position**

**Scenario I**: There is 10 basis point downward shift of the curve. After the yields fall, her gain in the case of the former is ₹ (0.045043 x 10.32) crore = ₹0.464839 crore and in the case of the latter is ₹ (0.00188 x 5 + 0.86204 x 5.32) crore = ₹0.458607 crore. So the gain is larger in the case of the latter to the extent of ₹31680.4.

**Scenario II**: There is 5 basis points downward shift of the upper end and 10 basis points downward shift of the lower end of the curve. In the former case there is loss ₹ (0.022513 x 10.32) crore = ₹0.232338 crore. In the latter case

there is loss ₹ (0.86205 x 5.32 + 0.00094 x 5) = ₹0.463306 crore. In the case of the latter gain is higher by ₹2309679.

**Scenario III**: : There is 10 basis points upward shift of the upper end and 5 basis points upward shift of the lower end of the curve. In the former case there is loss ₹ (0.045043 x 10.32) crore = ₹0.464839 crore. In the latter case there is loss ₹ (0.043082 x 5.32 + 0.00188 x 5) = ₹0.229197 crore. In the case of the latter the gain is lesser by ₹2262418.

In above analysis, the latter portfolio can be compared with a biased barbell where the weight is more on the side of TTM 0.98 and less on the other side of TTM 0.02. The impact on portfolio value is reinforced by the contribution of the paper with TTM 0.98.

## Conclusion

This paper demonstrates how, without mechanically applying any formula like Nelson-Siegel or Nelson-Siegel-Svensson straight cut, a short term yield curve can intuitively be constructed with traded securities and then plugging the gaps with regression and cubic splines on case by case basis, which contains market information and gives enough room to scenario analysis for designing portfolio strategies. Opportunity of short run arbitrage is found non-existent. In terms of further research there is scope of running time series regression of short rates on 3 month MIBOR and one dummy variable for the news of RBI's auction of dated securities. The patterns of spot rates, forward rates and par rates are similarly flat because the market participants seem not take any trade decisions on the eve of RBI auction and inflationary information content.

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