9

Fixed income derivatives for India

Vijayan Subramani
and
Ananth Narayan G.

1 Introduction

Over the years, there have been significant reforms in the realm of interest rates in India. Structural rigidities such as administered rates, mandated floors and caps on deposit and lending rates, guaranteed high yields on government owned funds and tax-free bonds are now increasingly things of the past. Additionally, the market for interest rate derivatives (IRD) in the Indian rupee has grown rapidly since it began in June 1999, giving CFOs and Treasurers much more flexibility in managing their interest rate exposures.

Flexible market determined interest rates and the tools to implement interest rate views bring about new challenges to the Indian CFO. In the past, she would largely be concerned with managing the liquidity risk of funding her company's operations. Committed funding came in linked to practically static benchmarks such as bank Prime Lending Rate (PLR). The ability of the CFO to reduce interest costs by anticipating market movements or by astute funding and gapping was limited.

Today, besides managing the liquidity risk of funding the balance sheet, the Indian CFO is increasingly accountable for actively managing the cost of such funding. For this, she firstly has to clearly identify and monitor the holistic rate exposures of her balance sheet, a process that requires robust metrics and systems. To understand the opportunities at her disposal and to take cogent directional views, she needs to be completely abreast of domestic and international fixed income, foreign exchange and interest rate markets. She then has to choose an overall interest rate strategy striking a balance between the risks she takes in relation to the actual benefits she hopes to achieve. To support her operations, and to instill confidence amongst stakeholders in her organization, she requires robust control, accounting and risk management systems to be in place.

IRD in India has seen prolific growth over the past three years, both in terms of volumes as well as the breadth of products. To an extent, this growth has almost gone unnoticed: unlike the case of equity derivatives, where the growth has been reasonably well tracked and documented. Even now, one hears Finance Managers and academicians lamenting the lack of depth in the IRD market, a comment that would have been justified in 1999, but would be less than accurate today.

This paper first describes the various IRD products now available in India, from plain vanilla inter-bank traded products, to some popular exotic structures. We will also try and address frequently asked questions about this market: features of the Indian market that puzzle domestic as well as foreign observers.

This paper is unapologetic about using basic mathematical expressions and formulae wherever relevant. The author firmly believes that dealing any kind of derivatives is not for the mathematically faint hearted. As a Finance Manager, unless one can price and understand the hedging dynamics of derivatives, one could end up as easy prey for zealous (and sadly, sometimes devious) traders.

2 Interest Rate Derivative Products in India

Interest rate swaps (IRS) and Forward rate agreements (FRA) in the rupee made their entry in July 1999, following guidelines issued by the RBI (RBI circular MPD.BC. 187/07.01.279/1999-2000 dated July 7, 1999). The RBI does not as yet allow any volatility (option) products on the rupee IRD side: thus caps/floors/barriers etc. cannot be structured on to any IRD. As readers would be aware, IRS and FRA are derivatives that permit players to move between fixed interest rates and floating rates linked to standard benchmarks.

In a typical example, a company issuing fixed rate long tenor bonds, but expecting medium term softness of interest rates would receive a fixed rate against a floating benchmark set at an appropriate frequency (say six months). The swap along with the underlying bonds would effectively convert their fixed rate borrowing into floating rate borrowings where the rates are reset every six months.

The RBI permits corporate customers to hedge interest rate risks on both the asset and liability side, using rupee IRD. Customers need to identify and earmark genuine exposures against each IRD, ensuring that the tenor and the notional of the hedge does exceed that of the underlying. Banks dealing with customers must also satisfy themselves that the customer has genuine underlying exposures. Rupee IRD undertaken by customers can be freely cancelled and rebooked.

In the Indian case, over the years, three basic benchmarks have dominated the inter-bank market for swaps: those based on the overnight call rate benchmark (Mumbai Inter-bank Offer Rate or MIBOR published by the NSE), those based on the rupee rates implied in the US$/INR foreign exchange (FX) market (Mumbai Inter-bank Forward Offer Rate or MIFOR & Mumbai Inter-bank Tom Offer Rate or MITOR) and those based on the Government of India (GOI) bond market. Other benchmarks such as the 3-month commercial paper (CP) rate have also been used in a few swaps, but no inter-bank market exists for such instruments.

Table 9.1 provides an overview of the IRS inter-bank market under these benchmarks including the description of the standard tenors for which quotes are generally available, standard lot sizes, some estimates on the volumes traded in the market and bid-ask spreads. Table 9.2 summarizes some of the other structured swaps that are popular in the market, typically between authorized dealers and their customers.

2.1 The MIBOR OIS Market

When the RBI opened the IRD markets, it gave the participants freedom to choose any floating rate benchmark from the rupee money and debt markets. Out of sheer lack of any other credible money market benchmark, the overnight inter-bank call rate was a natural first choice.

Thus the first rupee IRD was in the MIBOR Overnight Indexed Swap (OIS). In this swap, the floating rate is the daily compounded call rate (accrued over holidays). For short tenor swaps (up to 1–year), settlements occur on the maturity of the swap. In case of longer tenor swaps, settlements generally occur every six months. The net settlement would be computed by the following equation:

$$N \times \left[\prod_{i=1}^{t} (1 + \frac{m_i \times a}{365}) - (1 + \frac{R \times t}{365}) \right] \tag{9.1}$$

Here, N is the notional of the swap, m_i is the MIBOR setting on the i^{th} day, a is the number of days for which m_i is accrued, t is the tenor of the swap in days, and R is the fixed rate of the swap.

A few points about this product that would be relevant to mention at this stage:

(a) On October 18, 2002, the market for 1-year OIS closed at 5.80/5.85 (bid/ask). A customer looking to receive fixed against overnight MIBOR could therefore receive 5.80 percent. It is important to note that on account of the sleight of compounding inherent in this product, the bet in this case is *NOT* that the average MIBOR over the life of the swap would be at or lower than 5.80 percent. In fact, it can be shown using equation 9.1 above that the bet is actually that the average call would be at or lower than 5.64 percent.

    In this case, the daily compounding effect has knocked off 16 basis points (bps) from the fixed rate to arrive at the average expected MIBOR inherent in the price.

(b) The same sleight of compounding can also provide a very misleading picture about the slope of the OIS yield curve. If on the same day, the 6-month OIS closed at 5.75/5.80, seen against the 1-year quote of 5.80/5.85, the OIS yield curve appears to be slightly upward sloping. In fact, the average 6-month MIBOR implied by a 6-month OIS rate of 5.75 percent (again using equation 9.1) is actually 5.65 percent, slightly above the 5.64 percent implied by the 1-year market. This implies that the market is fact imputing in a lower average MIBOR rate in the latter half of the year, the hallmark of a downward sloping yield curve.

Table 9.1 Features of the standard IRD products in India today

	MIBOR OIS	MITOR OIS	MIFOR Swaps	MIOIS	GOI (INBMK/INCMT)
Definition	Fixed rate (money market rate) versus daily compounded (accrued over holidays) MIBOR offer setting	Fixed rate (money market rate) versus daily compounded (accrued over holidays) MITOR offer setting	Fixed rate (money market rate) versus floating MIFOR 6 monthly setting (offer side)	Fixed rate (money market rate) versus floating MIOIS 6 monthly setting (mid)	Fixed rate (money market rate) versus floating INBMK/ INCMT 1-Year annualized YTM
Basis	Actual/365, annual (till 1yr), semi (>1 year)	Actual/365, settlement on maturity (upto 1year)	Actual/365, annual (till 1yr), semi (>1 year)	Actual/365, settlement semi-annual	Act/365, settlement annual
Tenors traded	one-, two-, three-, six-month, one-, two-, three-, five-year	one-, two-, three-, six-month, one year, greater than one year is not quoted	two-, three-, five-, seven-, ten-years	two-, three-, five-years	Upto ten years
Market volumes	800 crores/day	100 crores/day	200 crores	Negligible	Negligible

(Continued. . .)

Table 9.1 Features of the standard IRD products in India today

	MIBOR OIS	MITOR OIS	MIFOR Swaps	MIOIS	GOI (INBMK/INCMT)
Underlying cash market volumes	Call money - 20,000 crores/day	Estimated at 3000 crores/ day	US$/INR forwards - Estimated at 9,000 crores/day	Call money - 20,000 crores/day	Estimated at 5,000 crores/day
Spreads	Three month : 10-20 bps, Six month: 5-10 bps, One year: 5 bps, Two-Five years: 10-20 bps	Upto three months: 10-30bps, Six month 5-20 bps, One year: 5-20bps	10-20 bps	10-20 bps	20-30bps
Lot Size	25 crore	25 crore	25 crore	25 crores	INR 25 crores
Circular/Regulations	July 7, 1999 MPD.BC.187/07.01. 279/1999-2000 RBI Circular	April 27, 2000 MPD.BC.197/07.01. 279/1999-2000	April 27, 2000 MPD.BC.197/07.01. 279/1999-2000	July 7,99 MPD.BC.187/07.01. 279/1999-00 RBI Circular	July 7,99 MPD.BC.187/07.01. 279/1999-00 RBI Circular

Table 9.2 Innovations in IRD products and their descriptions

Currency Swap	A typical currency swap would involve exchange of equivalent amounts of two currencies, and the interest payments (fixed/ linked to floating benchmarks) on them. A liability in US$ can be swapped into a spot equivalent liability in INR, with an exchange of MIFOR and US$ LIBOR based interest coupons on the INR and US$ notional amounts respectively. At times, based on supply demand and technical factors, the swap may be from US$ LIBOR (on the US$ notional) to MIFOR + a spread (on the INR notional). This spread is referred to as a 'basis' spread. These swaps are governed under FEMA.
Principal only (POS)	This is an FCY/INR swap where no interest payments on the FCY side take place. The FCY and INR principal (equivalent in spot terms) would be exchanged on maturity, and the forward premium would be recovered through a series of periodic INR payments (fixed/ floating on the INR notional). These swaps are governed under FEMA.
Coupon Swap	This is a currency swap where only the interest payments are swapped between counterparts, and the principals themselves are not exchanged. A stream of US$ LIBOR interest payments can be exchanged into a INR payments at a fixed (or floating) rate on an equivalent INR notional. It can be shown that a coupon swap combined with a POS is a currency swap. These swaps are governed under FEMA.
Constant Maturity Treasury swaps (CMTs)	These are INBMK/INCMT swaps, where the floating rate benchmark is of a tenor which is different from the settlement tenor itself. An example would be a 5-year swap with annual resets, where the floating rate benchmark is the 5-year GOI bond, as opposed to a 1-year bond. Popular benchmarks for CMT swaps are 3Y, 5Y and 7Y GOI benchmarks. These swaps offer carry for receivers of fixed rates, depending on the steepness of the underlying yield curve. The swap also involves convexity and volatility exposures: receivers of fixed rate are short convexity and volatility, whereas the payers of fixed are long on both counts.

(Continued. . .)

Table 9.2 Innovations in IRD products and their descriptions

Quantos	These are swaps where the floating rate benchmark is of a currency different from the currency of the swap. An example of such a swap is an INR IRS, where a fixed rate is exchanged for US$ LIBOR benchmark, applied to an INR notional principal.This is a product that cannot be hedged by the provider a priori and instead needs to be delta rebalanced constantly. Quantos have a cross-gamma risk: this means that those dealing in this carry volatility risks on the US$ swap curve, the US$/INR outright forward curve, and have exposures on the correlation between the two factors.
Notes on OTC deals - Advance /arrears /average settings:	Floating rate benchmarks can be set one reset period prior to the settlement date (set in advance), at the time of settlement (in arrears) or as an average over the reset period (set in average). Average and arrears settings offer pickup to receivers of fixed, depending on the steepness of the underlying curve, but can present difficulties in hedging.

(c) In the case of MIBOR OIS beyond 1-year tenor, since the swap is settled every six months, the fixed rates are quoted on a semi-annual basis. Periodic settlements help to reduce the credit exposure inherent in these swaps.

(d) In the OECD world, the OIS for 1-year would typically quote at a rate lower than the actual money market rate for the same tenor. For example, in the case of the US$, the US$ 1-year OIS (against overnight fed funds rate) would be lower than the 1-year US$ LIBOR. Part of the reason for this basis spread lies on the credit risk inherent in the cash US$ LIBOR curve. Being an actual inter-bank cash market rate, the US$ LIBOR rate would include the credit risk spread inherent in the exchange of the principal amount. The OIS on the other hand, does not involve any exchange of the principal amount. In an IRS, the principal is merely a notional amount used in the computation of the fixed and floating cashflows that does not have to be exchanged upfront.

(e) OIS as a class of products are not very popular overseas: for example, the volumes in the US$ OIS would typically be a small fraction of volume of swaps using 3-month US$ LIBOR as the floating benchmark. In the case of the Indian market, the popularity of the MIBOR OIS can be largely attributed to the absence of a term money market, and therefore the absence of reliable term money benchmarks. In the next section, however, we shall try and demonstrate that the much maligned and misunderstood MIFOR benchmark performs remarkably well as a surrogate term money benchmark.

(f) A frequently asked question relates to cancellation of existing contracts, and the computation of the net settlement in such cases. This has been addressed separately in the risk section, as a natural offshoot of the building of the zero-curve for this product.

2.2 The MITOR/MIFOR Swap Market

When RBI first allowed trading in IRS and FRA, participants were given the freedom to choose any mutually acceptable benchmark from the INR debt and money markets. As discussed earlier, there still is no rupee term money market to speak of in India, and therefore benchmarks linked to the money markets were necessarily linked to the overnight call rate. However, banks, institutions and corporate entities have for some time now accessed a surrogate inter-bank term money market for INR, using the US$/INR forwards market.

The US$/INR forwards market is fairly liquid up to the 1-year segment, with estimated daily volumes ranging between US$ 150 to 250 crores. It is usually assumed that the bulk of these volumes would be on account of foreign exchange hedging activities: say by exporters and importers crystallizing their future foreign currency cashflows. In fact, a large proportion of the volumes are actually from money market players looking to either raise or deploy their rupee liabilities using this route.

Foreign banks with a large NRI deposit base frequently use the US$/INR swap market to switch their FCNR(B) based US$ funds into INR, to fund their rupee assets. INR surplus banks unable to raise adequate INR assets of acceptable credit quality, swap their INR funds into US$ using the forwards market and invest the US$ locally or overseas. Clearly, seen holistically, the INR surplus banks have simply lent the INR funds in a surrogate INR term money market, using the US$/INR swap market as a via media.

There was a time when the RBI frowned upon this use of the US$/INR swap market as a surrogate INR term money market. In January 1998, for instance, when the RBI had to intervene to protect a rapidly depreciating rupee, they actually spoke of clamping down on ‘arbitrage’ between the FX and money markets: presumably commenting on the already prevalent practice of banks deploying INR in the FX markets, and thereby reducing the forward premium to be paid by importers of US$. Arguably, by denying interest rate parity, the RBI was at that time trying to keep a lid on actual domestic interest rates, while at the same time protecting the rupee from excessive depreciation by keeping the US$/INR forward premia high. The high premia would in turn deter buyers of US$, provide an incentive to sellers of US$ and keep the cost of banks and corporate entities holding speculative long US$/short INR positions high.

When the first RBI IRS/FRA circular was issued in June 1999, there was actually a report of two banks concluding a deal between themselves using a ‘money market’ benchmark that was the derived from the US$/INR swap market. The RBI was at that time quick to disallow this benchmark, thereby clarifying that it did not consider the FX and money markets to be completely integrated. However, in the credit policy statement of April

27, 2000, the RBI Governor indicated that "with a view to providing more flexibility for pricing of rupee interest rate derivatives and to facilitate some integration between the money and foreign exchange markets, the use of interest rates implied in the foreign exchange forward market as a benchmark would be permitted in addition to the existing domestic money and debt rates."

This was the genesis of the Reuters (term) MIFOR and (overnight) MITOR benchmarks, and the market for swaps based on them. The computation of this rate draws on the classical interest rate parity formula:

$$F = S \times \frac{(1 + \frac{r}{365} \times t)}{(1 + \frac{d}{360} \times t)} ....r = \left\{ \frac{F}{S} \times (1 + \frac{d}{360} \times t) - 1 \right\} \times \frac{365}{t} \quad (9.2)$$

Here F is the forward rate of 1 US$ in INR terms, S is the current spot US$/INR rate, r is the implied rupee interest rate, d is the US$ LIBOR rate for the tenor and t is the relevant time period.

With our foreign currency reserves swelling since then, and further liberalization by the RBI on borrowing and lending of foreign currency by authorized dealers, the integration between the money and FX markets is far more comprehensive today. This leads us to believe that in the absence of true term MIBOR benchmarks (though MIOIS swaps labeled in Table 9.1 stake a claim), the long tenor MIFOR benchmarks act as an adequate surrogate. Entities looking for a rupee equivalent of the 3-month US$ LIBOR benchmark would do little wrong in selecting the 3-month MIFOR as the closest answer.

Since a MIBOR OIS market already existed, the participants quickly found a counterpart for this product with an FX based benchmark: the MITOR based INR OIS. The product closely mirrors the MIBOR OIS market, with the same net settlement formula (equation 9.1), with the exception that m_i would now be the daily MITOR setting as opposed to the MIBOR setting. Note that there is a MIBOR setting on Saturdays, with the rupee call money market operating on that day. With the FX markets being closed however, no MITOR setting occurs on Saturdays.

The standard MIFOR swap is for 2,3,5,7 and 10-year tenors, with the 6-month MIFOR as the benchmark, settled semi-annually on an actual/365 basis.

A few points about the MITOR/MIFOR swaps:

(a) The benchmarks are what we like to call reverse interest rate parity benchmarks. In the G7 world, the underlying term money markets would be deep, and the FX forward rate would simply flow out of the term money rates, under the interest rate parity theorem. In the Indian case, however, the FX market is far more liquid than the INR term money market is. In a sense, currently, the FX forward and the US$ LIBOR rate determine where the appropriate INR term money rate stands at.

(b) Note the basis difference between US$ LIBOR (actual/360) and INR (actual/365), which introduces a critical factor in the MIFOR/MITOR computation.

(c) The MIFOR swap rate would also indicate where cross currency swaps involving INR should quote. If the current 5-year MIFOR rate is 6.70/6.80, then it would be reasonable to expect that a corporate looking to swap from INR to US$ or US$ to INR against flat US$ LIBOR (floating) would expect to see a price of 6.70/6.80.

    A word of caution though: even in the US$/JPY markets, there is a basis swap between US$ LIBOR and JPY LIBOR. This means that flat US$ LIBOR can be swapped not into flat JPY LIBOR, but into a spread over JPY LIBOR. This is a function of the demand/supply mismatch in the underlying currency swap markets, and the fact that cross currency swaps usually involve exchange of principals, and therefore impact liquidity. A similar phenomenon was observed in the Indian markets, say in end May 2002. The 5-year MIFOR was then quoting at 8.80/9.00, whereas US$/INR currency swaps for the same tenor were quoting at 8.90/9.10 against floating US$ LIBOR for the same tenor.

(d) A frequently asked question is, what is the basis on which dealers quote term MIFOR swap rates? The easiest (and correct) answer is that there is a reasonably liquid inter-bank market that deals on a two-way price. However, the following events contribute to movements in the MIFOR rates:

    - Movement in US$ swap rates. A large number of Indian entities have in the past raised US$ (and other foreign currency liabilities) through the external commercial borrowing (ECB) route. Some of them sold these funds outright in the spot FX market, and have yet to completely hedge the US$ interest and principal payable in the future. If US$ swap rates were to harden, with little or no change in the MIFOR swap rates, the implied cost of purchasing their forward US$ would reduce considerably and the POS rate would reduce considerably. Entities taking advantage of this would bring paying pressure into the MIFOR market, through the US$/INR currency swap or outright forward route.

- On the converse side, current regulations also permit domestic entities to swap their INR liabilities into US$ liabilities. Exporters with expected future streams of foreign currency flows watch the spread between long tenor US$ swap rates and the MIFOR rates. If the spread was to widen on account of a dip in US$ swap rates, the POS rate could imply a depreciation of the rupee to an extent greater than that expected by the exporter. This would ultimately lead to receiving pressure on the MIFOR rate through the long tenor currency swap/outright forward premia route.
- As an interesting offshoot of the discussions above, several astute corporate entities have in the past managed to raise US$ funds at extremely competitive rates through a combination of rupee borrowing and an INR to US$ currency swap. Today if a company can raise 5-year rupee funds at 7.00 percent (semi) through a bond issuance, it can choose to swap it into US$ (through a currency swap) to approximately US$ LIBOR + 25 bps.

  If the same corporate had dealt in June 2002, using the same route, it would have raised US$ funds at US$ LIBOR - 30 bps. This is clearly a far more competitive rate than most local corporate bodies can command if they were to raise funds through the ECB route. In addition, ECB also has added hidden costs on account of withholding tax. Therefore, corporate spread is a factor that determines where the MIFOR swaps deal.
- Finally, like corporate spreads, the swap market also measures itself as a spread over the underlying sovereign curve, in our case, the GOI bond market. It can be argued that this swap spread has a measure of the risk of dealing in the inter-bank market, as opposed to dealing in the risk-free Treasuries for

the same tenor. It must be noted, however, that unlike corporate bonds, interest rate swaps do not involve risk on the principal amount. True, the underlying 6-month MIFOR or US$ LIBOR are cash curve measures that incorporate inter-bank credit risk, but the 5-year MIFOR or US$ LIBOR swap does not by itself involve any principal exchange. At any rate, MIFOR based swaps offer excellent price risk hedging tools for banks, institutions and other corporate entities alike. Like in the US$ and other G7 swap markets, increasingly, MIFOR swaps are seen as pure INR term interest price risk hedging and speculating tools, which brings about flows far more than those arising on account of foreign exchange underlying exposures.

2.3 The GOI Swap Market

The last of the inter-bank benchmarks is the Government of India bond market (GOI) rates. A few points to note about the GOI swap markets:

(a) Since shorting of GOI bonds is not allowed in India, offering FRA quotes or hedging GOI swaps in the cash market can be tricky. Invariably, authorized dealers are left with some portion of the risk from these swaps that cannot be hedged completely.

(b) As will be discussed in the section on pricing and valuation, GOI swaps present some unique mathematical issues in creation of the zero curves and estimating the value of future floating rates. Invariably, GOI based swaps will not be valued correctly by most systems and algorithms, and adequate care has to be taken to reserve for these differences. Most systems assume the bonds are par bonds (i.e., with a price of 100 today, with coupon cashflows equal to the current YTM), and are also unable to adjust for the fact that the coupon dates do not coincide for different benchmark bonds.

(c) The GOI swap market quotes at a spread over (or under) the cash GOI curve, For instance, while the benchmark 5-year GOI bond may be at 6.35 percent (annualized), the 5-year swap (floating 1-year GOI) can quote at 6.30/6.50 (T-5/T+15). When this market first began in August 2000, the first set of deals were actually dealt at T-15, while in May/June 2002, this spread actually climbed to T+30/T+50. Paying the fixed rate on this swap provides banks with an oblique way of actually shorting the GOI bond, something otherwise disallowed by regulations. In a sense, the spread over the cash curve is a measure of what banks are willing to pay to be able to, in a sense, short the GOI bond.

2.3.1 Building Pricing and Valuation Systems

Having touched upon the various basic building blocks of rupee IRD, a few points on their valuation and pricing of non-standard derivatives.

The building block to any valuation system is the building of the tenor wise zero discount factors (ZDF) for each curve. ZDFs are simply the factor by which a cashflow occurring sometime in the future needs to be multiplied by, to arrive at its net present value. For tenors up to 1 year, MIFOR ZDF can be easily determined using the logic used above. However, for the longer tenors, where swap rates quote on semi-annual settlement basis, the matter becomes a little more involved. The easiest way to proceed is to follow the concept of bootstrapping, where starting from the nearest quoted tenors, we build all the way up to the farthest tenor, each time solving for one unknown variable. If we had the 18 month (semi-annual) MIFOR quote as r_{18}, for instance, we could solve for the unknown 18-month ZDF z_{18}, using our prior knowledge of the 6-month and 12-month ZDF (z_6 & z_{12} respectively) solving the equation:

$$r_{18} \times z_6 \times y_6 + r_{12} \times z_1 2 \times y_{12} + (1 + r_{18}) \times z_{18} \times y_{18} = 1 \qquad (9.3)$$

The y_6, y_{12}, y_{18} represent the fraction of the year for the period in question using the appropriate basis (actual/365 in the case of rupee swaps).

The above method would be carried forward to the 2-year point and so on, using the previously calculated ZDF rates and the next swap rate, to obtain the next unknown ZDF. For dates between the standard quoted tenor points (say the 2.3 year date from today), some assumptions have to be made on the interpolation methodology to be followed. There is a large array of such methods available: simple linear interpolation of zero-yields, linear interpolation of the ZDF, exponential interpolation of zero-yields, cubic-spline etc. to name a few. Often, there is no ‘right’ answer as to which method is best suited for which curve. Practitioners will need to choose the methodology that they feel best captures the way in which the particular market operates.

Once the ZDFs for each market curve have been determined, valuation of swaps and their cashflows is relatively simple. Floating rates are simply those implied by the underlying curve. Care must be taken to ensure that the floating rates are estimated on the correct side: for example, MIFOR resets are on the offer rate, whereas MIOIS resets are on the mid, depending on market convention for settlement. Knowing the 6-month and 1-year discount factors, one can calculate the 6-month floating rate at the end of 6 months (i.e., the 6×12 FRA as follows)

$$(1 + r_{6\times12} \times y_{6\times12}) \times z_{12} = z_6$$
$$r_{6\times12} = (\frac{z_6}{z_{12}} - 1)/y_{6\times12} \tag{9.4}$$

Where $y_{6\times12}$ is again the fraction of the year appropriate to the period 6 months over 12 months, using the calculation basis (actual/365 in the case of MIFOR).

Once all the floating rates have been estimated, any swap simply becomes a series of net cashflows occurring at discrete points of time. Usually, this series would simply be present valued on the same curve using its discount factors.

Where the markets operate on large bid/ask spreads, adequate care needs to be taken to ensure the correct side rates have been taken into account for computation of the ZDF, and in the valuation process itself. For banks running a large portfolio of swaps, valuation can be done on the mid-curve, with an additional portfolio level cost to close reserve, arising on account of the bid/ask spreads that need to be crossed in closing out the gaps.

Curves such as the GOI bond curve present a separate unique set of problems.

(a) Firstly, shorting of actual GOI bonds is not allowed in the market. The basic assumption in building the ZDF and FRA rates would be that shorting is permitted. One way to get around this problem is to assume that long bond positions arising from GOI swaps would be liquidated in the swap market itself. In making such assumptions, however, one needs to bear in mind the large bid/ask spreads of the GOI swap market, which would then need to be crossed.

(b) The GOI benchmark bonds are not par bonds (i.e., their price today is different from the face value), and benchmark on-the-run bonds across different tenors have different coupon dates. However, most zero-curves built for this product class, assume that the bonds are par bonds, and that the coupon flows for all bonds happen on the same set of dates.

This produces anomalies in the GOI zero curve. The easiest test for this would be to introduce a set of cashflows that mimic the actual cashflow of a long tenor bond, with the same coupons, cashflow dates and principal repayment. If the curve was accurate, the present value of these cashflows ought to be the correct market price of the bond. Invariably, there is a difference that crops up, that is sometimes seriously significant. Involved software is available, that minimizes differences of this nature. In the absence of such software, however, manual corrections and reserves may need to be introduced to provide for the differences.

(c) As mentioned earlier, it is important to note that the GOI based swaps quote at a spread over (or under) the cash curve. Several banks continue to value their GOI swaps portfolio on the cash GOI curve itself. Such a valuation needs to be adjusted for this swap spread, with appropriate portfolio level adjustments on the impact of the large bid/ask spreads inherent in the market.

(d) The floating rate for GOI swaps is the YTM of the benchmark bond on the reset date. Most valuation systems calculate the underlying as a zero-rate (as in the case of equation 9.4 above). If the reset benchmark is a long tenor bond (e.g. a 5-year underlying), this can make a very significant difference.

2.4 Exotic Interest Rate Derivative Products in India

Worldwide "exotic" interest rate derivative structures generally have their origins in the following:

(a) Unusual slope of yield curves

(b) Unusual spreads between different yield curves

(c) Unusual volatilities implied on interest rate options

In India, the last alternative cannot be traded, since swaptions, caps, floors etc. are not permitted in IRD. The first two have however spurred a few products with a twist.

2.5 Setting Variations: advance/arrears/average

Swaps in the inter-bank are dealt on an advance-reset basis. In such cases, reset dates lag the actual cashflow dates by a settlement period. Thus in the case of a 5-year MIFOR (semi-annual), resets would be decided 6 months prior to the actual exchange of the cashflow. In the case of inter-bank FRA deals, the cash-flow occurs immediately after the start date, so that the reset date and the cashflow date almost coincide. But in a FRA, the settlement is actually deemed to happen at the end of the FRA period, and the net settlement that happens close to the start period is actually calculated by present valuing this deemed cashflow. To that extent, even inter-bank FRA deals are essentially on an advance reset basis.

Steep yield curve slopes can imply FRA rates that rapidly accelerate as one moves along the yield curve. Corporate customers looking for additional 'carry' therefore, may prefer to set on an arrears or average basis. For instance, this year several customers dealt in 1-year INR/US$ coupon swaps, where the floating rate was the 1-year US$ LIBOR, set in arrears. In doing this, the customers were betting that the actual 1-year US$ LIBOR at the end of 1-year from the trade date, would be lower than that implied by the 12×24 FRA on the trade date.

These trades carry a convexity risk. This means that the swap cannot be hedged completely at inception: as the market moves, the hedge itself would need to be adjusted. This is best explained through an example. Take the case of a bank which has done a 1 year US$ swap with a customer, where it agrees to pay a fixed rate I, and will in turn receive US$ 1-year LIBOR set in arrears. To hedge the US$ side, assume it enters into a FRA with another bank. Note that the FRA will be settled on an implicit advance basis, since the net settlement in the FRA will be computed on NPV-ed terms. The cashflow of the deal and the hedge, from the bank's perspective, therefore looks as follows:

$$X = N \times (i - I) + \frac{N_f \times (I - i)}{(1 + i)} \tag{9.5}$$

Here, X is the total cashflow for the bank at the end of 1 year, N is the notional of the customer swap, N_f is the notional of the hedge FRA, i is the US$ 1-year LIBOR at the end of 1 year. This is assuming that the same I rate has been passed on tot the customer: however, any difference in the rates can also be easily accommodated in the analysis that follows. It can now be shown that the delta of the cashflow, with respect to small changes in the 12×24 US$ LIBOR is as follows:

$$\frac{\partial X}{\partial i} = N - \frac{N_f}{(1+i)^2} \tag{9.6}$$

To start with, the bank might want a hedge so that this delta is at zero. Therefore, the notional of the FRA chosen by the bank would be

$$N_f = N \times (1 + i^2) \tag{9.7}$$

Notice that the hedge FRA notional is not constant, but varies with changes in the 12×24 rates itself. In essence, as i increases, the FRA notional must increase, and as i drops, the notional decreases. Clearly, under this rule, as the LIBOR FRA moves up and down, the bank eventually ends with a positive P&L impact. The converse is the case with the customer: if the implied US$ LIBOR for the reset period were to show large volatility, from a hedge sense, the customer would actually be losing out.

To quantify the convexity benefit (or cost), therefore, one would need to take a view on the volatility of the underlying US$ LIBOR curve. Statistically, it is possible to estimate this element, by making a few assumptions about US$ LIBOR time series. The derivation of this formula would be beyond the scope of this book.

2.5.1 Constant Maturity Treasury Swaps (CMT)

The first set of 'different' swaps began with a flurry of CMT swaps during 2001. (Table 9.2 has a brief description of this product.) The most popular CMT was a 5X5: i.e. a 5-year swap, with annual/semi-annual resets, where the benchmark was the floating 5-year GOI YTM from INBMK. In addition, 3, 7 and 10-year bonds have also been used as benchmarks.

The swap owed its popularity to the steep slope of the GOI curve at that time. The spread between the 5-year GOI and 10-year GOI was then close to 150 bps. While the 5-year bonds was at 7.5 percent and the 10-year bond was at 9.00 percent, the yield curve implied that the 5-year bond YTM at the end of 5 years (or the 5-year over 10-year FRA) was in excess of 12 percent. Customers who thought that this was well above their expectations of where the market for 5-year at the end of 5 years would actually settle, received the fixed CMT against the floating 5-year INBMK benchmark.

To an extent at least, the subsequent narrowing of the 5×10 GOI spreads can be attributed to banks and their corporate customers receiving fixed rates on the CMT products. From a closing peak of 161 bps seen towards the end of October 2001, the spread narrowed to as low as 37 bps in July 2002. It currently is at close to its historical average at about 85 bps.

Like in the case of arrears/average structures, it must be borne in mind that this product has convexity and volatility embedded in it. The payer of the fixed rate would be long convexity/volatility, whereas the receiver of the fixed rate would be short convexity volatility. The analysis of this would be very similar to those of equation (9.5, 9.6, 9.7), with a small difference arising on account of the bond element in CMT.

Assume a simple CMT for 1-year tenor, on a notional N, where a bank pays a customer a fixed rate, and receives a floating 5-year INBMK YTM set in arrears (i.e. at the end of 1 year). Assume that as a hedge, the bank purchases a 6-year bond today, for settlement 1-year in advance (clearly not permitted today, but this would be the ideal hedge). In that case, the total payoff X for the bank, set to occur one year down the road will be:

$$X = N \times (y - F) + N_b \times p \times \{p(y) - p\} \tag{9.8}$$

Here N_b is the number of (forward) bonds purchased, p is the fixed price at which this was purchased, and $p(y)$ is the current (floating) price of the bond. To make this cashflow delta neutral with respect small changes in the forward YTM of the bond, we need

$$\frac{\partial X}{\partial y} = N - N_b \times p \times D_m = 0$$

$$or, N_b \times p = \frac{N}{D_m} \tag{9.9}$$

Here, D_m is the forward modified duration of the bond. Clearly, as yields change, this forward modified duration will change, and the hedge will need to be rebalanced. As the bond's forward YTM increases, the duration will decrease, as will the current price of the bond. Therefore, as yields increase, the bank will need to purchase successively more bonds. Conversely, it can be shown that as the yields drop, the bank will need to sell its holding stock. This is clearly a win-win situation for the bank; i.e. a long convexity position. How much it actually makes from this convexity clearly depends on the volatility of the YTM movement: the more volatile the curve is, the more it stands to gain. This is clearly a long volatility position for the bank.

On the other hand, for the customer who has received the rupee fixed rate, this represents a short convexity and short volatility position.

The benefit from the long volatility position, in the absence of a proper volatility market, is relatively marginal for the bank, given the huge transaction costs and bid/ask spreads involved in all rupee swaps. To achieve the theoretical gain from the convexity, the bank must cross these spreads. On the other hand, the cost being borne by the receiver of the fixed rate is for real, and is a factor that must be taken into account should the customer desire to unwind or cancel his swap.

2.6 Quanto Products

This is a rupee IRD with a twist: while the notional principal currency is in rupees, the floating benchmark is not a rupee benchmark, but that of another currency. The only quanto swaps reported in the market have a US$ LIBOR underlying. In a sense, the payoff is similar to a rupee coupon swap, which customers generally use to move from an INR rate to a US$ interest rate. However, a plain coupon swap carries a US$/INR FX risk, since the customer needs to pay the interest in US$. For customers looking to assume US$ LIBOR risk without the attendant FX risk, the Quanto is the ideal product.

From a regulatory angle, one could argue as to whether this is strictly allowed, since the RBI has only allowed rupee benchmarks to be used as floating resets. However, banks have argued that if coupon swaps can be permitted, then quantos, which have the same interest rate risks, without the attendant FX rate risk, should also be permitted. Also, since MIFOR is an accepted rupee benchmark that is computed as a function of the US$ LIBOR and the US$/INR forward FX points, in a sense, a quanto is a MIFOR swap with the premia points fixed beforehand.

Hedging a quanto poses issues for banks. In essence, the basic hedge on a rupee quanto where the bank has paid a fixed rate is for the bank to receive a fixed rate in the US$ LIBOR swap market for the same tenor. However, the notional of this hedge US$ swap will change as the USD/INR outright forward rate changes. It can be shown that if the US$/INR outright forward rate increases, the bank will need to reduce its US$ swap hedge.

In the interim, if the US$ swap rate has increased, the bank will stand to lose money on its hedge. If however, the US$ swap rates have declines, the bank makes money on its delta rebalancing. The converse will be true if the US$/INR forward rate declines.

This phenomenon is expressed in terms of a cross-convexity (or cross-gamma), where the correlation coefficient between the US$/INR outright forward rate and the US$ swap curve becomes critical. As the previous passage shows, if this correlation were to be positive, the bank (having paid the fixed rate on the quanto) would tend to lose money in its process of delta rebalancing.

To price in the quanto element (arising from the cross gamma, which has a monetary impact depending on the volatility of the underlying US$/INR forward curve and the US$ swap curve), the floating cashflows of the quanto need to be adjusted by the following factor:

$$Q_i = e^{-\rho \times \sigma_{US\$(i)} \times \sigma_{forwards(i)} \times t_i} \tag{9.10}$$

Where Q_i is the factor for the i^{th}period, t is the time to the reset,

ρ = correlation between US$/ INR forwards and US$ interest rates for period i,

$\sigma_{US\$(i)}$ =lognormal volatility of the US$ interest rate curve for period i, and

$\sigma_{forwards(i)}$ = lognormal volatility of the US$/ INR forward rates for period i.

3 Conclusion

This paper merely provides a snapshot of a growing traded market of INR Interest Rate Derivatives. It has been silent on the following critical issues:

(a) The risk management of derivatives in the Indian context: covering market, credit, legal, systems and accounting risks.

(b) Synthesizing an objective approach to managing balance sheet risk: correctly identifying the risks, developing the 'correct' risk management strategy and using derivatives to implement it.

These are beyond the scope of this paper. However, the importance of the above cannot be overemphasized. Before we take the next leap forward and introduce trading in interest rate volatilities and options, it might be in order to take stock of these issues and ensure that Indian entities do not fall prey to some of the derivatives based scandals that have hit the headlines over the past two decades in the developed markets.