Liquidity Issues in Indian Sovereign Bond Market

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Abstract

Liquidity is one of the most important factors after credit risk that affects the bond yields. The paper uses various measures of liquidity to understand their determinants in Indian sovereign bond market. The Liquidity measured by parameters like Turnover Ratio and Amihud Illiquidity Indicator show that these parameters not only have instantaneous relationship with bond yield but contemporaneous relationship with themselves. Impact Cost is not found to have any explanatory power. Financial crisis had marginal impact on the Indian sovereign bond market. It functioned well during the crisis period without much deterioration in general market liquidity condition as RBI injected large amount of liquidity to the system within a limited time period to ensure stability in the financial markets in India. However, the notion of flight to safety was evident as traders started investing largely in Government bonds shunning credit products as the credit quality in general started to dip. This was duly supported by large issuances of Government bonds. The study also finds that the electronic order matching system for government bonds has been successful in improving liquidity and reducing volatility in the market.

Keywords: liquidity, liquidity premium, bond yield, Indian Sovereign Bonds, Impact Cost, Turnover Ratio, NDS-OM, Liquidity Adjustment Facility

JEL Classification: G12, C58, E43

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Liquidity Issues in Indian Sovereign Bond Market

Golaka C Nath[2]

Liquidity is a major issue in bond markets in emerging countries like India. Corporate bond markets suffer from higher level of illiquidity vis-à-vis Government bond market in emerging market economies. Liquidity may have many different things for interpretation. For financial market, we generally define liquidity as the ease of trading a financial product. If the trading results in substantial value loss for the asset vis-à-vis its intrinsic value, then we consider the market for the security as illiquid. If the price loss is marginal or negligible, we consider the market for the product as liquid. There are many measures of liquidity – volume traded, number of trades, frequency of trades, bid-ask spread, transaction-by-transaction market impact, etc. However, finer liquidity estimation using some of these concepts will require high frequency microstructure data that may not be easily available. Hence, we need to use some simple concept to measure liquidity over a long period of time.

There are several factors that affect the liquidity – information availability, reliability and quality of transaction costs, price impact, and search costs, among others. Liquidity affects the asset prices as investors would require additional compensation to have the inventory of the illiquid assets which have higher transaction cost vis-à-vis a liquid asset. Amihud and Mendelson (1986, 1989) have demonstrated that lower liquidity in assets resulted in significantly higher average returns, after controlling for risk and other factors.

The current study examines the liquidity of the Government securities market in India. The Government securities market is viewed as one of the most important financial market as it links economic activity to interest rate. Central banks use the market to perform domestic monetary operations like infusing liquidity to the system or absorbing excess liquidity in the system through Repo windows or Open Market Operations (OMO). They use the market to extract

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information on forward interest rates and inflation expectations. The market also provides benchmarks to the traders to use it for corporate credit. Liquidity of this market is important to all stake holders. The market liquidity has an impact on a central bank's policy making specifically when the central bank has additional responsibility of ensuring the smooth borrowing programme for the Government. There are three distinct channels through which we can study this impact. (a) Liquidity has an impact on monetary policy formulation of the central bank as the decision to follow a tight or easy monetary policy depends on the available liquidity in the system. Financial asset price information (Bond prices) provide valuable clue not only on current market condition, they also provide vital information on future monetary conditions and hence this can be used in the formulation and implementation of monetary policy by the central bank. Market liquidity affects price of assets as illiquid securities add significant cost of holding an asset inventory to its price. As liquidity has cost, its gets built into the price. Liquidity condition in the market also affects the transmission of monetary policy actions. Central Banks conduct OMO to easy liquidity condition in the market so that the interest rate is moderated to targeted levels. Market liquidity has a more direct impact on monetary policy implementation. (b) Market liquidity may at times cause systemic disruption and put pressure on Governments and central banks to act. Financial crisis of 2007-09 was accentuated more due to tight market liquidity as funds dried up in the market and many firms had to face liquidation as they did not have sufficient liquidity options to survive the tight condition. Depending on the level of market liquidity, at times, liquidity issues give rise to solvency problems at key financial intermediaries. The liquidity problems can lead to systemic failure in payment systems (liquidity risk) and lead to the collapse in credit allocation. During recent financial crisis, most of the central banks around the world worked overtime to inject liquidity to the financial system through banking and near-banking channels to avoid systemic payment collapse. Hence, insufficient market liquidity will have resultant impact on a central bank's activities both as a lender of last resort and in its supervision of financial stability. An inadequate liquidity situation may lead to inaccurate estimation of market risk and may create disruption in the market discipline posing serious challenge to the central bank's ability to supervise through prudential regulation. (c) In the aftermath of financial crisis, it was observed that most of the Governments around the world have very high level of outstanding debt because of their support to the financial system during the crisis and after. A liquid secondary market results in lower borrowing cost for the

Governments. A central bank would always work in close coordination with the Government to enhance the integrity and efficiency of the Government securities market. Central banks around the world released funds to the monetary system by following easy monetary policy regimes so that transmission effect results in smooth credit and market risk environment and to obviate bankruptcy issues. Most of the central banks used bond buying programmes to pump liquidity to support the market.

A market is liquid if traders can execute their trades immediately, and where large deals have little impact on current and subsequent prices or bid-ask spreads. The market liquidity is better explained over four dimensions: immediacy, depth, width (bid-ask spread), and resiliency. All these dimensions of liquidity interact with each other and makes market liquidity a complex issue. A market is generally considered to be liquid if it is possible for a trader to sell or buy large amounts of securities in a minimum number of transactions with little impact on prices. Gravelle (1999a) explained liquidity according to four dimensions: (a) **immediacy,** or the speed of doing a transaction; (b) **depth,** which refers to the maximum amount of a security which can be traded at a given price; (c) **width,** or the bid-ask spread[3], which is the cost of accessing liquidity indicating a wider spread means lower liquidity; and (d) **resiliency,** which captures how fast prices revert to their equilibrium after a transaction.

Price impact explains the depth of the market. In a liquid market, large quantities of securities can be traded without affecting the price. But in many markets – specifically in emerging markets, it might be difficult to find a counterparty who is willing to buy or sell a specific security and the holder of the bond need to provide higher capital to maintain the inventory. The liquidity of a specific bond may affect the price. If the investor wants an immediate execution of a sell order, he will have either to sell at a discount, or take the risk of waiting to realize the price. Liquidity is an important determinant of bond yield and returns. The liquidity component of bonds can explain a larger fraction of the yield than the default component itself. The size and the turnover volume of the secondary market affect the liquidity of the bonds. If a market has sufficient buyers and sellers to facilitate trading of a bond, its ability to respond to market events is higher. Illiquid bonds respond less quickly to market events due to low depth and hence they

[3] Bid-Ask spread is the difference between Best Buy Price and Best Sell Price. The spread is the compensation received by a market maker for providing liquidity.

are more likely to see wide swings in prices. The traders will penalize higher volatility and demand high yield which will be reflected in the bond's price.

Liquidity in the bond market can be enhanced in a market with improvement in market's institutional structures by introduction of electronic dealing platforms, improving the depth of the market by bringing in new participants like Primary Dealers along with market making mechanism, improved disclosure standards, tax factors including withholding taxes, increasing floating stocks in the market, providing hedging instruments for risk management like derivatives, well-functioning clearing and settlement systems, introduction of STRIPS Program for government securities, Open Market Operations by the Central Bank, structured buyback programmes, regular re-opening of issues to ensure availability of comfortable level of floating stocks, etc. Size indicators like transaction volumes cannot be used as reliable liquidity measure as it does not capture any age-induced declines in liquidity. In many markets, introduction of electronic platforms have provided ease in trading and have helped in reducing cost of trading. In India, the experiment with the NDS-OM[4] trading system for Government bonds has paid rich dividend for all stake holders. However, market participants still preferred using conventional trading channel for off-the-run bonds and other sovereign securities like T-bills and State Development Loans[5] (SDL) even though NDS-OM provides better electronic order book options. In most countries, liquid secondary markets are based on the following cornerstones: (i) higher incidence of issuance in critical tenors like benchmark points; (ii) well-functioning repo and short sell markets; (iii) well-functioning derivatives (both OTC and exchange traded) markets to hedge risks; (iv) facilitating price discovery mechanism; and (v) supporting a network of primary dealers.

The concept of liquidity is complex, although empirically, a single dimension such the ability to trade a security with minimal impact on its price is considered while measuring liquidity in quantitative terms. The liquidity in Indian Government bond market could be enhanced to some extent in recent years by using the key building-blocks like: (i) sound institutions and macro

[4] Negotiated Dealing Platform – Order Matching (NDS-OM) system is owned by Reserve Bank of India and facilitates secondary market deals in Government Securities including T-Bills and State Development Loans (SDL) among banks and Institutions sans intermediaries.

[5] Federal States in India issue securities to fund the deficit of the respective States at market determined rates using usual Auction mechanism.

policies; (ii) an efficient and robust infrastructure; (iii) a well-functioning repo market; (iv) adequate information flows; and (v) a diversified investor base including facilitating foreign investment in Government bonds.

Indian Treasury bond market has gone through major changes during last one decade or so. Introduction of primary dealer system, well-structured auction mechanism with auction calendar, structured clearing and settlement mechanism with CCP[6] provisions, availability of OTC Rupee derivatives products, anonymous trading platform like NDS-OM providing efficient price discovery, well developed repo and repo-variant market[7], provisions of short selling, etc. have been instrumental in improving the market microstructure in Indian Government bond market. The Government bond market is a unique experiment with enabling provisions for execution of trades using brokers, directly talking to a counter party over telephone and online anonymous order matching mechanism.

The present paper makes an attempt to understand the issues related to liquidity behavior of Indian Government securities market as well as tries to find out how various indicators of liquidity is used in the market. It also tries to understand how realistically the liquidity indicators are used in the market and what factors are considered as determinants of the liquidity indicators. The paper is arranged into following – Section 1 deals with Indian market microstructure; Section 2 discusses some stylized facts; Section 3 deals in liquidity measurement and determinants; Section 4 deals with volatilities and Section 5 gives concluding remarks.

Indian Market Microstructure

Indian bond market is dominated by Government securities – in both primary and secondary markets. Government bond market includes the securities issued not only by the Government of India[8] but also the securities issued by various federal States. The primary market auctions for

[6] Central Counter Party (CCP) – providing guarantee of settlement of the trades executed by the traders.
[7] Collateralized Borrowing and Lending Obligations (CBLO) is a tradable repo but the security is held with third party (held-in-custody).
[8] Securities include T-Bills, dated coupon bearing securities, floating rate bonds, special securities.

both Government securities and Treasury Bills are conducted through electronic auction system and the said system also facilitates "When Issued Market".

Table – 1: Snapshot of the Indian Government Securities Market					
	M[9]2009	M2010	M2011	M2012	M2013
No. of Outstanding stock	132	128	122	121	118
Outstanding stock (₹ In billion)	17,061	20,335	23,500	27,830	32,445
Outstanding stock as ratio of GDP (%)*	38.63	42.44	44.37	49.42	56.28
Turnover/GDP (%)*	468.66	628.68	418.02	391.23	629.64
Average maturity of the securities issued during the year (Years)	13.82	11.17	11.63	12.67	13.60
Weighted average cost of the securities issued during the year (%)	7.69	7.23	7.91	8.52	8.36
Minimum and maximum maturities of stock issued during the year (Years)	4 - 30	2 - 30	2 - 30	5 - 30	4 - 30
PD's share in the Outright turnover - Secondary Market	18.77	15.84	18.98	26.35	17.22
Transactions on CCIL (Face value ₹ In billion)#	62,545	89,867	69,702	72,521	119,948
Turnover Ratio (%)	0.9606	0.6188	0.6450	0.6641	1.7881
10-Year Yield (%)@	7.01	7.79	7.98	8.53	7.96
Outstanding Treasury Bills (₹ In billion)	1,503	1,375	1,413	2,670	2,998
Issuances of Cash Management Bills (₹ In billion)	-	-	120	930	-
91 Day T-bill cut-off Yield (%)$	4.95	4.38	7.31	9.02	8.19
Notes: * - GDP at market price (at 2004-05 prices). Q4 of 2012-13 is the approximation of Q3 with 5% p.a. GDP growth.					
# - Transaction on CCIL comprises of total outright and repo value settled.					
@ - Last trading day of the financial year.					
$ - Last Auction of the financial year. Turnover ratio is daily average trades volume divided by Face Value outstanding for Gilts					

Source: CCIL

During last few years, Government of India has been steadily increasing its market borrowing and funds almost 90% of its fiscal deficit through such market borrowings. In FY2011-12, large amount were raised by issuing T-bills of various durations. During FY2011-11 and FY2011-12, some Cash Management Bills[10] were also issued to raise funds from the system. As these large borrowings have put pressure in the market liquidity, RBI has to resort to Open Market Operations (OMO) on various occasions to infuse liquidity to the system. This liquidity infusion is in addition to the daily LAF Repo conducted by RBI to moderate money supply in the system.

[9] March is the typical Financial Year End (FY 2011-12 mean Year ended March 2012).

[10] Unstructured short term T-Bills type instruments are issued to manage cash flow issues

Table -2: Government Borrowing Details (₹ Crore[11])						
FY	G-Sec		SDL		T-Bill	
	Gross	Net	Gross	Net	Gross	Net
2007-08	194050	146112	67779	56224	314496	-33155
2008-09	277000	219302	118138	103766	360912	31827
2009-10	428306	327369	131122	114883	385875	-13274
2010-11	437000	322677	104039	88398	343765	327
2011-12	510000	426025	158632	136643	630813	132193
2012-13	558000	467384	177279	146657	802830	32743

Source: CCIL

The high borrowing level has to be managed by the Reserve Bank of India (RBI) through uniform price based auctions as well as through infusion of liquidity to the system. The liquidity shortage has been continuing for a long time in India (since July'10) and this has resulted in RBI injecting good amount of liquidity to the system using daily LAF. On many occasions, OMOs have to be conducted just before the auctions for Government securities. This has helped to ensure smooth sailing of auctions as well as helping to moderate yield.

Unlike US and other developed markets, Government bond market in India is a wholesale market with very little or negligible participation from retail investors. The secondary market microstructure underwent dramatic change after introduction of NDS-OM system which facilitated anonymous trading in Government bonds like equities with an efficient price discovery mechanism but without any intermediary. Brokers or intermediaries which facilitated about 80% of the trading before introduction of NDS-OM system in Aug 2005 did not have access to the new system as the new system was owned by Reserve Bank of India and directly allows traders to trade accessing large market provided they have Constituent Gilts Accounts[12]. The web-based application within NDS-OM system allows direct market access to constituents to trade in the wholesale institutional market with efficient price discovery. The participants had three options to choose: (a) directly negotiating with each other for a deal; (b) taking the help of a broker to identify the counter party to trade a security; (c) directly becoming a member of the

[11] 1 crore is equivalent to 10 million.

[12] An electronic demat account maintained by an investor with a service provider like a bank to hold the balances of Government securities once purchased.

new order driven system which was STP[13] enabled from the start. However, the new system captured about 60% of the market immediately after its introduction. The market share of the new trading system is steady at about 80%. Broking companies have very little role with about 8% market share.

The new trading system, NDS-OM, provided higher liquidity to the system with an active order book management system and efficiency in price discovery. The traders could see the depth of the market anytime with buy and sell orders coming to the system with time stamp. Proprietary deals by Banks and Institutions accounted for about 87% in terms of value (90% in terms of number of deals). Participation in trading was also linked to a bank's total holding of Government securities. Typically a major part of a bank's holding of Government securities is in Held to Maturity (HTM) category as banks are allowed to put a part of the security (currently upto 23% of the Net Demand and Term Liabilities (NDTL) which is exactly equal to the Statutory Liquidity Ratio (SLR)) in the said category which does not envisage any provision for mark-to-market losses as it is expected to be held till its redemption. The remaining part of the securities holding balance can be held in Available for Sale or Held for Trading which will require regular provisioning and mark-to-market.

Table – 3: Descriptive Statistics of Indian Government Bond Market

	Volume Amount in ₹ crores[14]				3 Months Yield (%)			10 Year Yield (%)			Spread %
Year	No of trades	Volume	Avg. Trades	Avg. Volume	Average	Minimum	Maximum	Average	Minimum	Maximum	(10Y – 3M)
2002-03	191,843	1,076,147	646	3,623	5.9813	5.1917	8.0806	7.0501	5.8493	8.4697	1.0687
2003-04	243,585	1,575,133	820	5,303	5.0302	4.3606	6.9191	5.6381	5.1037	6.4264	0.6080
2004-05	160,682	1,134,222	550	3,884	4.9433	4.2186	6.0219	6.4411	5.2346	7.3300	1.4979
2005-06	125,509	864,751	467	3,215	5.4102	4.8806	6.4624	7.2099	6.8800	7.5500	1.7998
2006-07	137,100	1,021,536	562	4,187	6.2781	5.1527	7.3844	7.8410	7.3685	8.4699	1.5629
2007-08	188,843	1,653,851	765	6,696	6.6016	5.1327	7.5067	7.9436	7.3880	8.3657	1.3419
2008-09	245,964	2,160,233	1,047	9,192	6.6021	3.7268	8.8655	7.8347	5.5200	9.4591	1.2326
2009-10	316,956	2,913,890	1,332	12,243	3.2285	2.0748	5.7952	7.7447	6.7102	8.2553	4.5162
2010-11	332,540	2,870,952	1,346	11,623	5.7268	3.1328	6.9313	8.0827	7.7530	8.3197	2.3559
2011-12	412,266	3,488,203	1,732	14,656	8.1514	6.6040	8.9539	8.3410	8.0600	8.9300	0.1896
2012-13	658055	6,592,032	2731	27353	8.0608	7.8055	8.6757	8.1543	7.7924	8.5600	0.0935

Source: CCIL

Banks alone account for about 72%[15] of total trading in Government securities while Primary Dealers account for about 17% of trading and other Institutions like Mutual Funds and Insurance

[13] Straight Through Processing (STP) – a process through which a trade executed in the NDS-OM system will directly go for multilateral netting through the clearing house and final settlement in central bank money. Other deals have to be reported to RBI within a certain prescribed time after execution. Broker driven deals have to be reported by selling Bank to the RBI and Broker has also to report the same deal to the Stock Exchange.

[14] ₹1crore is equivalent of 10million.

companies account for about 9% of trading. Indian Government bond market is divided into two distinct systems – (i) an anonymous order driven system (NDS-OM) introduced in Aug 2005 and (ii) a trade reporting system where trades are executed over phone by market participants and then reported to the central server managed by Reserve Bank of India (RBI) within a particular time frame (30 minutes)[16]. Market participants, mainly institutions, are free to choose any of the above two systems for their deals in Government securities and T-bills. The NDS-OM system contributes a significant part of the market transactions in number of deals as well in terms of value of deals and has established itself as the most preferred platform for executing trades.

Table 4: Market Share of Trading Platforms

	Trades in NDS (%)	Value in NDS (%)	Trades in NDS-OM (%)	Trades in NDS-OM(%)
2005-06	50.36	56.98	49.64	43.02
2006-07	25.79	36.11	74.21	63.89
2007-08	16.43	27.42	83.57	72.58
2008-09	14.35	28.36	85.65	71.64
2009-10	12.87	27.41	87.13	72.59
2010-11	12.85	21.73	87.15	78.27
2011-12	10.89	20.96	89.11	79.04
2012-13	8.79	17.91	91.21	82.09

Source: CCIL

Some Stylized Facts

Liquidity Infusion

Liquidity in the market depends on many factors. The most important issue in liquidity is the support from the central bank to the banking system to access liquidity from the monetary system. RBI uses daily Liquidity Adjustment Facility (LAF) to moderate money supply in the system – if the banking system has excess liquidity, it can be parked at the central bank with a fixed return using policy reverse repo rate through LAF and if the banking system faces shortage of liquidity, RBI injects liquidity to the system using a fixed policy repo rate through LAF. In case the bank is not able to cover its position and still faces shortage, RBI supports the bank with a Marginal Standing Facility using a special LAF window at the end of the business day. The net LAF indicates the liquidity condition in the market. During financial crisis period, we find that liquidity shortage in the market resulted in RBI injecting funds to the system in mid-2008 and in

[15] As of Dec'12 statistics.

[16] Since April'13, all OTC deals executed by market participants need to be reported to the NDS-OM system.

Sep-Oct'08, the shortage was more than 1% of the NDTL. Further, in order to fight the effect of the financial crisis, RBI reduced the policy Repo Rate on multiple occasions, reduced CRR and SLR and infused liquidity in the system. This substantial injection of liquidity resulted in excess funds with the banking system as credit delivery started sinking due to the crisis. Banks started parking these excess funds with RBI at policy reverse repo rate. The liquidity infusion helped the market to increase their participation in bond market as interest rate started dipping due to infusion of huge liquidity to the system coupled with reduction in policy rates and drop in credit delivery.

Table 5: Actual/Potential Release of Primary Liquidity (since mid-September 2008 (till Mar 2009))	
Measure/Facility	Amount (₹. Crore)
Monetary Policy Operations (1 to 3)	
1. Cash Reserve Ratio (CRR) Reduction	1,60,000
2.Open Market Operations	68,835
3. MSS Unwinding/De-sequestering	97,781
Extension of Liquidity Facilities (4 to 8)	
4. Term Repo Facility	60,000
5. Increase in Export Credit Refinance	25,512
6. Special Refinance Facility for SCBs (Non-RRB)	38,500
7. Refinance Facility for SIDBI/NHB/EXIM Bank	16,000
8. Liquidity Facility for NBFCs through SPV	25,000
Total (1 to 8)	4,91,628
Memo:	
Statutory Liquidity Ratio (SLR) Reduction	40,000

Source: RBI

The liquidity infusion also helps banking system to invest in bonds thereby increasing the bond turnover in the market. Since mid-2010, Indian market is going through a tight liquidity condition for which RBI has been injecting liquidity through LAF repo window and occasional OMO. The proactive policy initiatives were taken by RBI to avoid contraction of the RBI balance sheet and the same aimed at ensuring non-inflationary growth of money supply in the economy to support the needs of the real economy. This resulted in stabilizing the bond turnover.

Table 6: LAF Support as a percentage of NDTL									
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
LAF	0.92%	0.90%	0.10%	-0.11%	2.23%	-0.13%	-1.12%	-1.44%	-1.49%
TR17	0.53	0.63	0.70	1.05	1.22	0.97	0.84	1.30	2.34

Source: CCIL, RBI

Trading Activity

Though there are large numbers of securities (there are 110 securities including special securities but excluding floating rate bonds as on March'13) extending maturity upto 30 years issued by the Government and available for trading in the market, trading is concentrated on few securities. Indian Government bond market faces high concentration in benchmark securities like 10-year and 5-year maturities. Though there are large number of securities issued by the Government, trading in 10 securities constitute about 95% of the trading in terms of value. Hence most of the securities are relatively illiquid. Trading level in the market is also sensitive to the net LAF level. The correlation between Net LAF and Trading volume is -0.39. There is liquidity concentration in few securities like 10-year benchmark. The concentration of liquidity in few securities has increased in recent years.

Table -7: Liquidity Concentration (in %)		
	Top 5	Top 10
2003-04	39.01	57.30
2004-05	49.97	66.31
2005-06	63.75	82.82
2006-07	74.88	88.82
2007-08	66.35	83.84
2008-09	61.07	73.89
2009-10	60.71	79.08
2010-11	71.77	88.03
2011-12	85.51	94.15
2012-13	77.05	95.05

Source: CCIL

[17] Turnover Ratio (TR) is the average daily trading in Government securities as a proportion to the outstanding Face Value of Issuance.

Trading concentration in benchmark securities has been hallmark of the Indian Government securities market. After the financial crisis, market interest in long term bonds have come down significantly.

Table – 8: Maturity Bucket Trading Distribution

Category	M2003	M2004	M2005	M2006	M2007	M2008	M2009	M2010	M2011	M2012	M2013	Current
upto 5 Years	7.08	9.07	23.64	26.44	27.68	22.81	19.46	27.15	19.57	3.49	6.81	15.29
5 to 10 Years	54.42	36.75	45.05	29.10	58.61	53.08	54.43	59.07	39.68	75.19	41.22	34.95
10 to 20 Years	35.54	52.53	29.35	39.78	4.62	8.88	13.69	11.58	39.20	20.34	49.81	48.53
20 to 30 Years	2.96	1.65	1.95	4.68	9.09	15.24	12.41	2.21	1.55	0.98	2.16	1.22

Source: CCIL

Liquidity Measurement and Determinants

Turnover Ratio

Bond Market liquidity can be measured by Bonds Turnover Ratio (TR). The ratio shows the extent of daily trading volume in the secondary market (buy and sell) relative to the amount of bonds outstanding measured in terms of Face Value. This ratio is computed for securities using only outright purchases / sales and excludes repo / repurchases transactions. A secondary market is said to be active when the TR is high.

Table – 9: Turnover Ratio & Yield

Parameters	Yield %	TR
Mean	7.8898	0.9609
Standard Error	0.0522	0.0487
Median	7.9998	0.8521
Standard Deviation	0.5117	0.4769
Sample Variance	0.2619	0.2274
Kurtosis	1.1708	1.8226
Skewness	-0.6058	1.2057
Range	3.0312	2.5342
Minimum	6.2265	0.3017
Maximum	9.2577	2.8358
Count	96	96

Source: CCIL

TR can be used as a relative measure to understand liquidity. The same widely varies among securities. For some of the on-the-run treasuries, the TR is very high as concentration of trading is observed in those securities while in some securities the TR is very low as these securities are

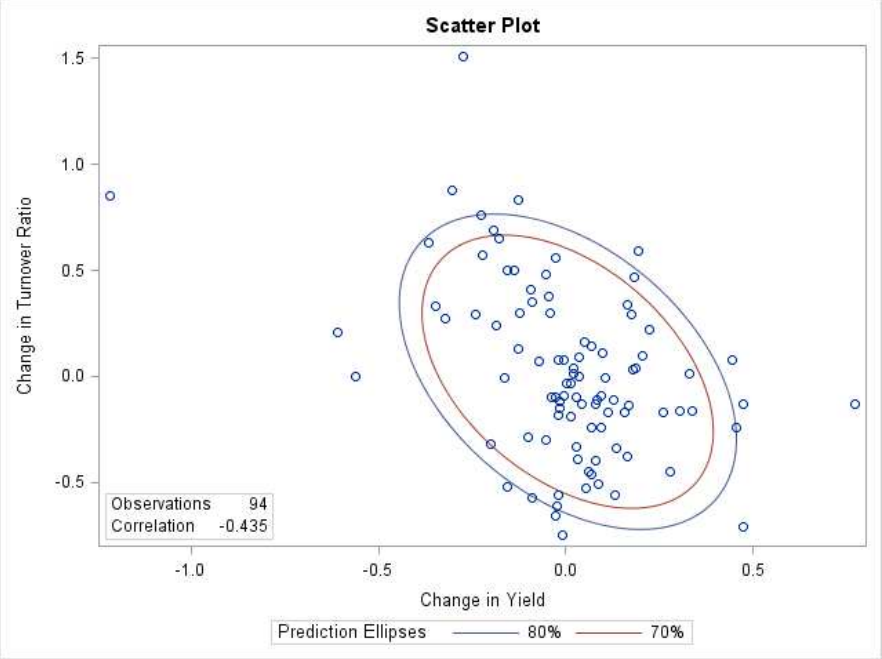
typically held in the books of the banks under "Held Till Maturity" category investment. Typically TR will be high when market liquidity is high. High market liquidity indicates lower interest rate scenario prevailing at that point in time (in relative term). TR is a very important and useful proxy for liquidity in the market. When interest rate level is lower, it encourages traders to build positions. At higher interest rate, traders do not want to keep high inventory of stocks and hence trading volumes takes a dip.

In India, TR and 10 year yield (monthly changes) are observed to have a negative correlation of 0.43 with each other indicating higher TR means lower Yield.

Table – 10: Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
DY	94	0.0069	0.2458	0.6505	-1.2167	0.7714
DTR	94	0.0197	0.4067	1.8500	-0.7500	1.51

Chart - 1: Scatter Plot - Yield and Turnover Ratio (Monthly Changes)



The Pearson Correlation (after Fisher's z transformation) between Yield and TR works out to be -0.43 and statistically significant.

Table –11: Pearson Correlation Statistics (Fisher's z Transformation)									
Variable	With Variable	N	Sample Correlation	Fisher's z	Bias Adjustment	Correlation Estimate	95% Confidence Limits		p Value for H0:Rho=0
DY	DTR	94	-0.4346	-0.4656	-0.0023	-0.4327	-0.5841	-0.2522	<.0001
Spearman Correlation Statistics (Fisher's z Transformation)									
Variable	With Variable	N	Sample Correlation	Fisher's z	Bias Adjustment	Correlation Estimate	95% Confidence Limits		p Value for H0:Rho=0
DY	DTR	94	-0.4062	-0.4311	-0.0022	-0.4044	-0.5610	-0.2198	<.0001

Graphically they follow a close trend. During financial crisis, there was substantial drop in TR. In order to understand the true relation between TR and Yield, we fitted a simple model using the TR and Yield (monthly changes). The regression R-sq was 0.19. The linearly fitted model showed that Yield and TR have statistically significant relationship. We re-specified the model with inclusion of the lagged yields as additional variables and found that the R-sq improved to 0.38.

Table – 9: Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.0198	0.0343	0.58	0.5658
DY	1	-1.0121*	0.1536	-6.59	<.0001
Lag 1 DY	1	0.789*	0.1639	4.81	<.0001
Lag 2 DY	1	-0.0158	0.1534	-0.1	0.918
R-Sq – 0.38, DW – 2.61 RMSE – 0.3282, * - significant at 1%					

Since most of the time series data has an autoregressive structure, we re-specified the regression model with inclusion of lagged variables of the TR in the equation upto 5 lags[18] along with the yields and lagged yields.

$$TR_t = \alpha + \beta_1 * DY1 + \beta_2 * DY2 + \gamma_1 * LTR1 + \gamma_2 * LTR2 + \gamma_3 * LTR3 + \gamma_4 * LTR4 + \gamma_5 * LTR5 + \varepsilon_t$$

[18] With only lagged variables of TR, the R-Sq was 0.22 and DW stat was 2.04.

Table – 10: Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.0475	0.032	1.48	0.1420
DY	1	-1.0343*	0.1449	-7.14	<.0001
LY	1	0.2002	0.1879	1.07	0.2900
LTR1	1	-0.5218*	0.1105	-4.72	<.0001
LTR2	1	-0.4858*	0.122	-3.98	0.0001
LTR3	1	-0.2797**	0.1154	-2.42	0.0176
LTR4	1	-0.2267	0.1018	-2.23	0.0287
LTR5	1	-0.0554	0.0983	-0.56	0.5749
R-Sq – 0.53, DW – 1.99[19] RMSE – 0.2965 * - significant at 1% and ** - significant at 5%					

The estimated equation shows that TR has a long memory and it gets influenced by lagged values of TR upto 4 months though lag 3 and 4 are week and statistically significant only at 5% level. It also showed that lagged yield is not statistically significant. We re-estimated the model with these lagged variables (OLS). The signs of the estimated equation show clearly that change in liquidity measured by TR is negatively related to the level of Yield and positively to previous months' TR. We also tried to re-estimate the model with an autoregressive process using only 4 lagged values of TR and DY.

Table – 11: Parameter Estimates					
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	0.0494	0.0313	1.58	0.1181
DY	1	-0.9911*	0.1351	-7.34	<.0001
LTR1	1	-0.5825*	0.0900	-6.47	<.0001
LTR2	1	-0.5435*	0.0942	-5.77	<.0001
LTR3	1	-0.2964*	0.0956	-3.10	0.0026
LTR4	1	-0.2172**	0.0934	-2.33	0.0224
R-Sq – 0.52, Durbin h – 1.11[20] RMSE – 0.2948 * - significant at 1% and ** - significant at 5%					

The total R-Sq statistic computed from the above autoregressive model is 0.52. The Regression R-Sq was the R-Sq statistic for a regression of transformed variables adjusted for the estimated autocorrelation. The parameter estimates gives the Maximum Likelihood (ML) estimates of the

[19] Since lagged values are included in the equation, DW stat is not strictly valid.

[20] Since lagged values are included in the equation, DW stat is not strictly valid. Durbin h is used to test for first-order autocorrelation

regression coefficients. The fitted model shows that turnover ratio has contemporaneous relationship with its own lagged information but has an instantaneous relationship with the yield.

Amihud Illiquidity Indicator

Amihud (2002) measured illiquidity of the stock using a measure called ILLIQ which is the daily ratio of absolute price change to its value traded. This is interpreted as the daily price response linked to trading value. This ratio works as a good measure for estimating price impact. There are other measures of liquidity but some of such measures will require high frequency microstructure data (e.g. for calculating bid-ask spread). The measure proposed by Amihud can be easily constructed with usual available data of daily prices for a longer period to test the effects over time of illiquidity on ex-ante and contemporaneous bond returns. This illiquidity measure can be linked with other simple measures of illiquidity. Amihud found that both across stocks and over time (for NYSE during 1964-1997), expected returns are an increasing function of expected liquidity. He found that ILLIQ has a positive and highly significant effect on expected returns. He found that higher realized illiquidity raises expected illiquidity that in turn raises expected returns.

Following Amihud, bond illiquidity is defined in this paper as the ratio of daily absolute return to the trading value on that day. Daily absolute return is calculated by taking the difference between closing price and opening price of the bonds. Since there are two distinct platforms for doing and/or recording a transaction in India, NDS-OM platform dominates with large market share. Though same security can be traded either in OTC market and gets reported in NDS system or it can be anonymously traded in NDS-OM system, it is necessary to adjust the scale factor (trading multiple) in ILLIQ ratio computed for NDS system vis-à-vis NDS-OM system. Since NDS-OM market is visible to all traders in the market on almost real time basis, deals in OTC market may be executed by dealers after comparing the price/yield in NDS-OM system. In order to have better understanding of the liquidity dynamics in Indian Government securities market, we divided the securities into three categories in terms of their number of deals in a day. If the number of deals exceeds 15 in a day, it is considered as “Liquid”, if the number of deals exceeds 5, then it is considered as “Semi-Liquid”, otherwise “Illiquid”. We dropped all trades where

High and Low prices are same – all deals are considered as "special" and might have taken place at the same price. These deals may be the ones which are executed by the same dealers (at least in one side of the deal) and hence executed at a single price. We constituted our dataset with securities that have at least 3 trades in a day and dropped all non-market lot deals (below 50million). However, the Amihud ILLIQ ratio that was computed for NDS are scaled (adjusted) using the trading value ratio (the ratio of value of deals in NDS-OM and NDS). This scaling is absolutely necessary to make them comparable in terms of their liquidity parameters. After scaling the ILLIQ ratio, both NDS and NDS-OM became comparable for analysis. It is observed that the scaling factor is less than 1 for semi-liquid and illiquid securities while for liquid securities, the scaling factor is greater than one and very high. The Amihud ratio has been multiplied by $10^{\wedge 7}$ for reporting results.

Table – 12: Trading Distribution in OTC and Anonymous Platform

Year	Source	Category	Deals	Value[21]	Source	Deals	Value	Scaling Factor
2005	NDS	ILLIQUID	3459	44412.34	OM	604	4425.00	0.0996
2005	NDS	LIQUID	13452	79334.68	OM	24360	133705.00	1.6853
2005	NDS	SEMI_LIQUID	4555	39817.98	OM	2346	14180.00	0.3561
2006	NDS	ILLIQUID	5457	71022.23	OM	1480	13720.00	0.1932
2006	NDS	LIQUID	14471	120452.60	OM	84230	522620.00	4.3388
2006	NDS	SEMI_LIQUID	8867	98480.36	OM	3794	27180.00	0.2760
2007	NDS	ILLIQUID	5249	90348.80	OM	1947	25811.07	0.2857
2007	NDS	LIQUID	7035	83365.54	OM	110730	767485.68	9.2063
2007	NDS	SEMI_LIQUID	8458	130414.45	OM	5623	53554.54	0.4106
2008	NDS	ILLIQUID	5355	117714.34	OM	2523	30098.43	0.2557
2008	NDS	LIQUID	11257	143203.63	OM	196821	1404082.05	9.8048
2008	NDS	SEMI_LIQUID	8355	151571.20	OM	7036	71675.78	0.4729
2009	NDS	ILLIQUID	6905	173391.08	OM	4811	77428.08	0.4466
2009	NDS	LIQUID	14059	241654.98	OM	262454	1889383.22	7.8185
2009	NDS	SEMI_LIQUID	11367	222748.96	OM	10384	124597.36	0.5594
2010	NDS	ILLIQUID	5197	111477.47	OM	3868	65120.65	0.5842
2010	NDS	LIQUID	18321	230024.97	OM	272050	2043296.97	8.8829
2010	NDS	SEMI_LIQUID	10082	164706.65	OM	7182	95861.22	0.5820
2011	NDS	ILLIQUID	4724	90192.21	OM	2939	42877.10	0.4754
2011	NDS	LIQUID	18681	253828.72	OM	300355	2137379.45	8.4206
2011	NDS	SEMI_LIQUID	9544	141557.70	OM	6185	75121.81	0.5307
2012	NDS	ILLIQUID	6994	132035.65	OM	5264	79485.50	0.6020

[21] All Values in ₹Crores (10 million Indian Rupees)

2012	NDS	LIQUID	25284	542747.61	OM	483858	3917165.57	7.2173
2012	NDS	SEMI_LIQUID	12573	180700.67	OM	11721	145392.90	0.8046
2013	NDS	ILLIQUID	515	7586.96	OM	454	5084.82	0.6702
2013	NDS	LIQUID	1807	64350.82	OM	52294	494768.69	7.6886
2013	NDS	SEMI_LIQUID	1106	14799.74	OM	473	4431.07	0.2994

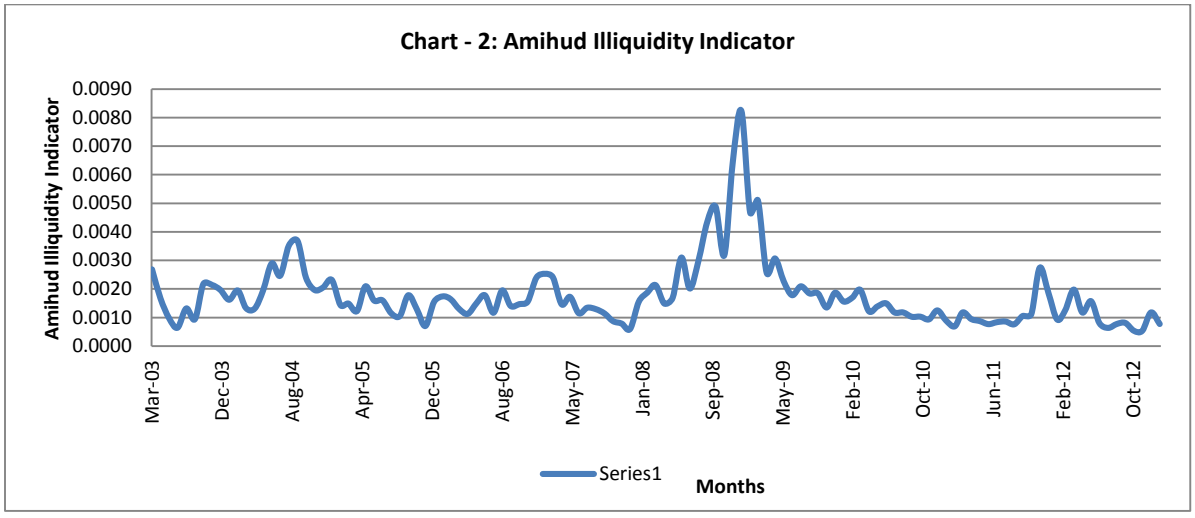
This scaling factors for illiquid and semi-liquid securities show that market participants prefer OTC market to negotiate the deals rather than going for the anonymous order driven market for these securities. NDS-OM has helped to create an efficient market for liquid securities with much finer pricing but for illiquid and semi-liquid securities, the dealers and their constituents must know the counter-parties who may be willing to trade a security.

Once we constructed the daily Amihud ILLIQ factor for all securities for our dataset consisting of trades from Jan'03 to Feb'13. The NDS-OM data had clear open and close prices as per the time of transaction while NDS data (both pre and post -NDSOM period) had information on time of receipt of the trade information by the server. As all traders are required to report their deals within a particular time to the central server, we assumed the arrival time at the server as the basis of opening and closing deal times. The NDS-OM system brought higher level of transparency to the market. In an OTC environment, information on market activity played very important role and smaller entities had very little bargaining power when striking a deal. These smaller entities depended heavily on the wisdom of brokers and other large traders. NDS-OM provided information of securities and the market activity on real time basis to all. Hence, trading securities become easier with people taking view on interest rate scenario rather than following their peers' activity in the market. Before starting of NDS-OM, the level of illiquidity was higher in 2003 and 2004. The same dropped almost 50% in 2005 and further in 2006. The onset of financial crisis brought the issue of market illiquidity into the forefront. In 2007, the Amihud illiquidity factor increased vis-à-vis 2006 but the same went up drastically (almost doubled) in 2008 and 2009 as the market was engulfed with high level of illiquidity. However, aftermath of the crisis saw large amount of liquidity being pumped to the system by central banks around the world. This increased the market liquidity in general. The market witnessed higher level of liquidity which resulted in drop in Amihud illiquidity factor as can be seen in the Chart (2010 onwards). The study clearly shows that the introduction of NDS-OM helped in

reducing illiquidity in the market significantly. The market has improved in terms of all parameters. The volatility has come down and liquidity has improved as Amihud ILLIQ factor shows a significant drop.

Table – 13: Amihud Illiquidity Indicator					
Period	Days	ILLIQ	STDEV	MAX	MIN
PREOM	756	0.00230	0.00259	0.02736	0.00006
POSTOM	1850	0.00159	0.00181	0.02353	0.00006

The Amihud ILLIQ indicator was aggregated for month specific analysis. The data very clearly indicates that the Amihud ILLIQ was very high during financial crisis period and soon after as liquidity dried up. However, the liquidity has improved considerably in recent months.

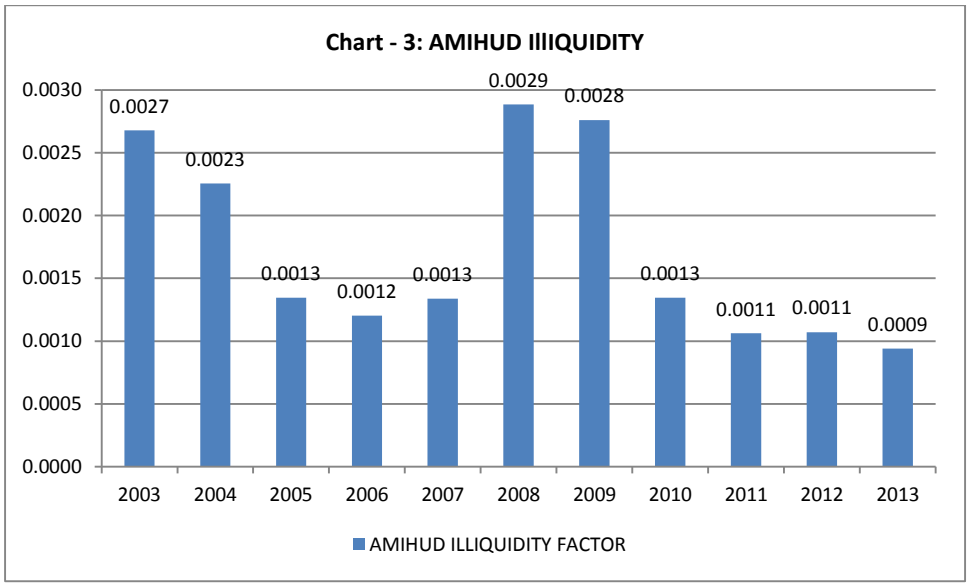


Amihud ILLIQ indicator was very high during financial crisis period indicating increasing illiquidity in the market.

Table – 14: Descriptive Statistics for Amihud Illiquidity Indicator (Apr'03 – Feb'13)	
Mean	0.001776
Standard Error	0.000105
Median	0.001501
Standard Deviation	0.001143
Sample Variance	1.31E-06
Kurtosis	10.49757
Skewness	2.736135

Range	0.007697
Minimum	0.000538
Maximum	0.008235
Monthly Observations	119

Year-wise analysis also indicates the drop in illiquidity after introduction of NDS-OM. As the liquidity improved due to introduction of NDS-OM, this must have resulted in savings for all market participants.



We wanted to test if there was any structural change in liquidity indicator after introduction on NDSOM system and used the Chow test for testing the said information for a data period of 122 months (Jan'03 to Feb'13). The Aug'05 is the 32nd data point for which structural break is tested. We included change in yield and the lagged values of Amihud ILLIQ in the equation to test for structural break significance.

Table – 15: Structural Change Test

Test	Break Point	Num DF	Den DF	F Value	Pr > F
Chow	32	4	113	7.8	<.0001

The Chow test very clearly indicated that there is a strong indication of structural break for data point no. 32 (introduction of NDSOM system) as F-Values indicates statistical significance at 1% level.

The period of our study was divided into 3 groups – (a) PREOM period (from 01-Jan-2003 to 31-Jul-2005); (b) NDSOM – deals executed using the anonymous trading platform from 01-Aug-2005 to 28-Feb-2013; (c) NDS – the OTC deals reported to RBI NDS system from 01-Aug-2005 to 28-Feb-2013). We estimated the daily average ILLIQ ratio for each group. The results show clearly that the liquidity has improved after introduction of NDSOM in both OTC as well as in anonymous order driven market as the mean IILIQ in PREOM period was relatively higher vis-à-vis the comparable values in post NDSOM. However, the volatility of ILLIQ has improved in NDSOM market but not in the OTC market. The results change quite significantly if we take only Government securities and drop other securities like T-Bills, SDLs, etc. The data for NDS-OM falls short by 4 days as the representative trading was not available in NDS-OM platform due to technical and other reasons while OTC trades were reported in NDS platform by traders. When we consider all securities, we find that NDS-OM has marginally higher liquidity vis-à-vis NDS system in post-NDSOM era. The transparency in NDS-OM system helped the market participants to have better price discovery in OTC market.

Table -16: Amihud ILLIQUIDITY Indicators

	GROUP	DAYS	Mean	SDTDEV	Skewness	Kurtosis
All Securities	PREOM	756	0.0023	0.0026	3.8507	22.1883
	NDS	1849	0.0017	0.0025	5.8015	56.5654
	NDSOM	1845	0.0016	0.0019	4.0139	23.9587
Only Dated Govt. Securities	PREOM	756	0.0025	0.0029	4.1329	25.9236
	NDS	1847	0.0019	0.0030	5.8240	57.7065
	NDSOM	1845	0.0016	0.0020	3.9982	22.8242
Non-Dated Government Securities	PREOM	691	0.0011	0.0038	15.7713	319.5941
	NDS	1449	0.0010	0.0026	6.6321	60.8577
	NDSOM	989	0.0018	0.0046	6.5331	54.4018

However, all the tests showed that there is a statistically significant difference between the mean of the variable Amihud ILLIQ and zero for all groups and it supports the relationship of price impact and liquidity.

Annual average ILLIQ factor was estimated using the daily average ILLIQ for both NDS and NDSOM transactions for all securities from 01-Aug-2005 to 28-Feb-2013. In most of the years, ILLIQ factor for NDSOM has performed better vis-à-vis OTC NDS deals implying higher liquidity in NDSOM vis-à-vis OTC NDS market. However, only in the initial phase of NDS-OM (2005 & 2006), OTC NDS market had higher level of liquidity vis-à-vis NDS-OM.

Table – 17: Year-wise Amihud ILLIQ Indicator for all Securities								
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
	PREOM							
2003	0.00268	0.00334	0.02736	0.00021				
2004	0.00225	0.00201	0.01941	0.00006				
2005	0.00172	0.00178	0.01047	0.00008				
	NDS Market (01-Aug-2005 onwards)				NDSOM Market (01-Aug-2005 onwards)			
2005	0.00044	0.0003	0.00180	0.00007	0.00125	0.00158	0.01553	0.00014
2006	0.00104	0.00113	0.00814	0.00002	0.00141	0.00123	0.00769	0.00005
2007	0.00152	0.00304	0.04039	0.00000	0.00126	0.00133	0.01299	0.00008
2008	0.00351	0.00414	0.02544	0.00005	0.00257	0.00273	0.02147	0.00010
2009	0.00263	0.00326	0.03186	0.00016	0.00284	0.00302	0.01923	0.00000
2010	0.00149	0.00133	0.00882	0.00008	0.00125	0.00132	0.00985	0.00009
2011	0.00109	0.00101	0.00607	0.00003	0.00102	0.00112	0.01121	0.00004
2012	0.00108	0.00098	0.00625	0.00003	0.00107	0.00092	0.00505	0.00011
2013	0.00096	0.00074	0.00315	0.00005	0.00095	0.00048	0.00268	0.00026

Since NDSOM trading platform accounts for a lion's share in dated Government securities while major trading in SDL and T-bills are reported to NDS system, we estimated daily Amihud ILLIQ factor by taking only Government dated securities into account. The result shows that in Government securities, NDSOM significantly scores over trades reported in OTC NDS platform. And in recent years, the liquidity in NDS-OM platform has increased significantly vis-à-vis the OTC NDS market.

Table – 18: Year-wise Amihud ILLIQ Indicator for Government Securities								
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
	PREOM							
2003	0.00278	0.00369	0.03179	0.00018				
2004	0.00253	0.00230	0.02228	0.00007				
2005	0.00210	0.00217	0.01695	0.00006				
	NDS Market (01-Aug-2005 onwards)				NDSOM Market (01-Aug-2005 onwards)			
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
2005	0.00054	0.00039	0.00259	0.00008	0.00124	0.00158	0.01553	0.00014
2006	0.00126	0.00139	0.00840	0.00006	0.00138	0.00125	0.00794	0.00005
2007	0.00191	0.00384	0.05030	0.00000	0.00127	0.00128	0.01299	0.00008
2008	0.00414	0.00516	0.03134	0.00008	0.00259	0.00273	0.01702	0.00010
2009	0.00275	0.00344	0.03170	0.00022	0.00296	0.00328	0.02171	0.00000
2010	0.00153	0.00145	0.00882	0.00014	0.00119	0.00129	0.01108	0.00009
2011	0.00126	0.00135	0.01185	0.00002	0.00100	0.00114	0.01239	0.00004
2012	0.00118	0.00113	0.00692	0.00006	0.00100	0.00089	0.00505	0.00002
2013	0.00100	0.00085	0.00354	0.00007	0.00078	0.00044	0.00211	0.00026

We did a t-test (independent groups) to understand if the Amihud illiquidity factor is statistically different in their mean for NDS and NDSOM platforms (taking all data). This *t*-test is designed to compare means of same variable (Amihud ILLIQ) between two groups – NDS and NDSOM. The *p*-value for the difference in means between NDS and NDS-OM is more than 0.05 for the entire period, so we conclude that the difference in means is not statistically significantly different from 0. However, for the *F*-test (two-tailed significance probability), the probability is less than 0.05. So there is evidence that the variances for the two groups, NDS and NDSOM, are different. Therefore, we report Satterthwaite variance estimator for the *t*-test. Satterthwaite is an alternative to the pooled-variance *t*-test and is used when the assumption that the two populations have equal variances seems unreasonable. It provides a *t*-statistic that asymptotically approaches a *t* distribution, allowing for an approximate *t*-test to be calculated when the population variances are not equal.

The same *t*-test was extended to year-wise analysis. For 2005, 2006 and 2008, we find that the difference in means of the variable ILLIQ for both NDS and NDSOM are statistically and significantly different from 0 at 1% level and for 2010 the same is at 5% level. For other years, the *p* values are not significant and hence the difference in means for NDS and NDSOM is

statistically 0. The transparency in NDSOM has helped to improve liquidity in OTC market in general. For 2005, 2007, 2008 and 2013, the *F*-test, *p*-values were significant at 1% evidencing that the variances for the two groups are different. For other years, the test statistics are not significant.

Table – 19: t-test results for Year-wise Amihud ILLIQ Indicator for all Securities

	Mean Procedure					t-Test Results					F-Test Results				
Sample	Type	N	Mean	Std Dev	Std Err	Method	Variances	DF	t Value	Pr > |t|	Equality of Variances				
Full	NDS	1849	0.0017	0.0025	0.0001						Method	Num DF	Den DF	F Value	Pr > F
	NDSOM	1845	0.0016	0.0019	0.0000	Satterthwaite	Unequal	3462.8	0.96	0.3346	Folded F*	1848	1844	1.7	<.0001
	Diff (1-2)		0.0001	0.0022	0.0001						significant at 1%				
2005	NDS	113	0.000436	0.0003	0.000028						Folded F*	112	112	27.74	<.0001
	NDSOM	113	0.00125	0.00158	0.000149	Satterthwaite*	Unequal	120.06	-5.37	<.0001	significant at 1%				
	Diff (1-2)		-0.00081	0.00114	0.000151	significant at 1%									
2006	NDS	246	0.00104	0.00113	0.000072	Pooled*	Equal	490	-3.52	0.0005	Folded F	245	245	1.18	0.1855
	NDSOM	246	0.00141	0.00123	0.000078										
	Diff (1-2)		-0.00037	0.00118	0.000107	significant at 1%									
2007	NDS	244	0.00152	0.00304	0.000194						Folded F*	243	243	5.17	<.0001
	NDSOM	244	0.00126	0.00133	0.000085	Satterthwaite	Unequal	333.54	1.21	0.2286	significant at 1%				
	Diff (1-2)		0.000256	0.00235	0.000212										
2008	NDS	240	0.00351	0.00414	0.000267						Folded F*	239	240	2.3	<.0001
	NDSOM	241	0.00257	0.00273	0.000176	Satterthwaite*	Unequal	413.79	2.95	0.0033	significant at 1%				
	Diff (1-2)		0.000945	0.00351	0.00032	significant at 1%									
2009	NDS	237	0.00263	0.00326	0.000212	Pooled	Equal	472	-0.74	0.4607	Folded F	236	236	1.16	0.2538
	NDSOM	237	0.00284	0.00302	0.000196										
	Diff (1-2)		-0.00021	0.00314	0.000289										
2010	NDS	246	0.00149	0.00133	0.000085	Pooled**	Equal	490	1.97	0.0492	Folded F	245	245	1.01	0.9139
	NDSOM	246	0.00125	0.00132	0.000084										
	Diff (1-2)		0.000235	0.00132	0.000119	significant at 5%									
2011	NDS	240	0.00110	0.00101	0.000065	Pooled	Equal	473	0.83	0.4054	Folded F	234	239	1.23	0.113
	NDSOM	235	0.00102	0.00112	0.000073										
	Diff (1-2)		0.000081	0.00106	0.000097										
2012	NDS	242	0.00108	0.000977	0.000063	Pooled	Equal	482	0.11	0.9152	Folded F	241	241	1.12	0.3681
	NDSOM	242	0.00107	0.000922	0.000059										
	Diff (1-2)		0.00001	0.00095	0.000086										
2013	NDS	41	0.000962	0.000738	0.000115						Folded F*	40	40	2.39	0.007

	NDSOM	41	0.000949	0.000478	0.000075	**Satterthwaite**	Unequal	68.489	0.09	0.9271	significant at 1%
	Diff (1-2)		0.000013	0.000622	0.000137						

We did the same set of tests with Amihud ILLIQ taking into account only Government securities and dropping T-Bills and other securities. The results are significantly different from the earlier one (with all securities). When we considered only dated Government securities, we find that for full period, the *t*-stat is significant at 1%. The *p*-value for the difference between NDS and NDS-OM is less than 0.05 for the entire period, so we conclude that the difference in means is statistically significantly different from 0. For the F-test (two-tailed significance probability), the probability is less than 0.05. So there is evidence that the variances for the two groups, NDS and NDSOM, are different. The same t-test was extended to year-wise analysis. For 2005, 2007, 2008 and 2010 we find that the difference in means of the variable ILLIQ are statistically significantly different from 0 for both NDS and NDSOM at 1% level, for 2011 at 5% level and for 2012 at 10% level. For other years, the *p* values are not significant and hence the mean is statistically 0 for NDS and NDSOM. For 2005, 2007, 2008, 2011, 2012 and 2013, the F-test, p-values were significant at 1% evidencing that the variances for the two groups are different. For 2006 and 2010, the same is significant at 10%. For only 2009, the test statistics are not significant. Hence, NDSOM scores over NDS platform in term of liquidity when we consider only Government securities.

Table – 20: t-test results for Year-wise Amihud ILLIQ Indicator for all Government Securities

	Mean Procedure					t-Test Results					F-Test Results				
Full	**NDS**	1847	0.00189	0.00299	0.00007						**Folded F***	1846	1844	2.26	<.0001
	NDSOM	1845	0.00158	0.00199	0.000046	**Satterthwaite***	Unequal	3211.3	3.67	0.0002	significant at 1%				
	Diff (1-2)		0.000307	0.00254	0.000084	significant at 1%									
2005	**NDS**	113	0.000539	0.000385	0.000036						**Folded F***	112	112	16.87	<.0001
	NDSOM	113	0.00124	0.00158	0.000149	**Satterthwaite***	Unequal	125.23	-4.6	<.0001	significant at 1%				
	Diff (1-2)		-0.0007	0.00115	0.000153	significant at 1%									
2006	**NDS**	245	0.00126	0.00139	0.000089						**Folded F***	244	245	1.23	0.0998
	NDSOM	246	0.00138	0.00125	0.00008	**Satterthwaite**	Unequal	483.25	-0.98	0.3254	significant at 10%				
	Diff (1-2)		-0.00012	0.00132	0.000119										
2007	**NDS**	243	0.00191	0.00384	0.000246						**Folded F***	242	243	8.93	<.0001
	NDSOM	244	0.00127	0.00128	0.000082	**Satterthwaite***	Unequal	295.32	2.46	0.0146	significant at 1%				
	Diff (1-2)		0.000638	0.00286	0.000259	significant at 1%									

	NDS	240	0.00414	0.00516	0.000333						**Folded F***	239	240	3.57	<.0001
	NDSOM	241	0.00259	0.00273	0.000176	**Satterthwaite***	Unequal	362.92	4.12	<.0001	significant at 1%				
2008	**Diff (1-2)**		0.00155	0.00413	0.000376	significant at 1%									
	NDS	237	0.00275	0.00344	0.000223	**Pooled**	Equal	472	-0.66	0.5083	**Folded F**	236	236	1.1	0.4786
	NDSOM	237	0.00296	0.00328	0.000213										
2009	**Diff (1-2)**		-0.0002	0.00336	0.000309										
	NDS	246	0.00153	0.00145	0.000092						**Folded F*** **	245	245	1.27	0.066
	NDSOM	246	0.00119	0.00129	0.000082	**Satterthwaite***	Unequal	483.36	2.75	0.0062	significant at 10%				
2010	**Diff (1-2)**		0.00034	0.00137	0.000124	significant at 1%									
	NDS	240	0.00126	0.00135	0.000087						**Folded F**	239	234	1.41	0.0084
	NDSOM	235	0.001	0.00114	0.000074	**Satterthwaite****	Unequal	462.63	2.3	0.0219	significant at 1%				
2011	**Diff (1-2)**		0.000264	0.00125	0.000115	significant at 5%									
	NDS	242	0.00118	0.00113	0.000073						**Folded F***	241	241	1.63	0.0001
	NDSOM	242	0.001	0.000886	0.000057	**Satterthwaite***	Unequal	455.55	1.92	0.055	significant at 1%				
2012	**Diff (1-2)**		0.000178	0.00102	0.000092	significant at 10%									
	NDS	41	0.001	0.000846	0.000132						**Folded F***	40	40	3.78	<.0001
	NDSOM	41	0.000785	0.000435	0.000068	**Satterthwaite**	Unequal	59.785	1.46	0.1494	significant at 1%				
2013	**Diff (1-2)**		0.000217	0.000673	0.000149										

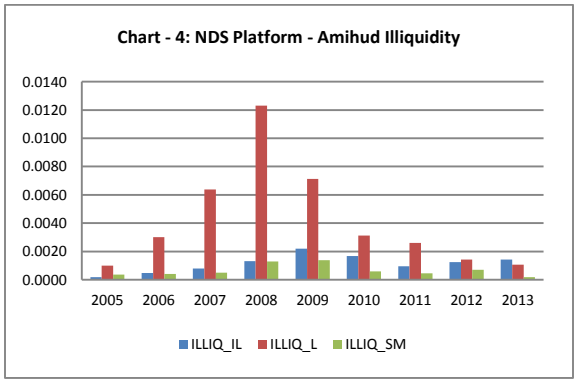
As we have divided our trades into three different groups – liquid, semi-liquid and illiquid, we wanted to test if there is any difference in liquidity for the same group of securities in different platforms. We considered all securities for the analysis while calculating the Amihud ILLIQ factor. Pre-NDSOM era had remarkably higher illiquidity.

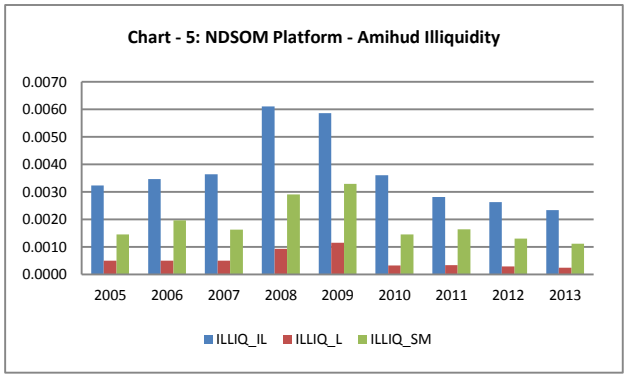
Table – 21: Group-wise Amihud ILLIQ Indicator for all Securities

		ILLIQUID			LIQUID			SEMI-LIQUID		
	Year	ILLIQ	SDEV	MAX	ILLIQ	SDEV	MAX	ILLIQ	SDEV	MAX
PREOM	2003	0.0048	0.0060	0.0433	0.0011	0.0014	0.0134	0.0032	0.0054	0.0571
	2004	0.0038	0.0050	0.0581	0.0009	0.0009	0.0055	0.0020	0.0018	0.0095
	2005	0.0027	0.0040	0.0297	0.0006	0.0006	0.0036	0.0016	0.0018	0.0106
NDS - POSTOM	2005	0.0002	0.0003	0.0028	0.0010	0.0007	0.0033	0.0003	0.0005	0.0042
	2006	0.0005	0.0005	0.0030	0.0030	0.0030	0.0188	0.0004	0.0004	0.0022
	2007	0.0008	0.0012	0.0114	0.0064	0.0083	0.0630	0.0005	0.0008	0.0070
	2008	0.0013	0.0018	0.0110	0.0123	0.0153	0.0924	0.0013	0.0019	0.0166
	2009	0.0022	0.0028	0.0164	0.0071	0.0115	0.0822	0.0014	0.0019	0.0138
	2010	0.0017	0.0033	0.0370	0.0031	0.0032	0.0238	0.0006	0.0007	0.0035
	2011	0.0010	0.0013	0.0104	0.0026	0.0028	0.0149	0.0005	0.0005	0.0041
	2012	0.0012	0.0015	0.0145	0.0014	0.0019	0.0193	0.0007	0.0010	0.0071

	2013	0.0014	0.0013	0.0050	0.0011	0.0010	0.0050	0.0002	0.0002	0.0015
NDSOM	2005	0.0032	0.0054	0.0424	0.0005	0.0004	0.0025	0.0014	0.0017	0.0129
	2006	0.0035	0.0039	0.0333	0.0005	0.0005	0.0041	0.0020	0.0020	0.0129
	2007	0.0036	0.0055	0.0445	0.0005	0.0005	0.0043	0.0016	0.0020	0.0160
	2008	0.0061	0.0111	0.1167	0.0009	0.0011	0.0130	0.0029	0.0035	0.0226
	2009	0.0059	0.0083	0.0567	0.0011	0.0016	0.0136	0.0033	0.0035	0.0247
	2010	0.0036	0.0073	0.0867	0.0003	0.0003	0.0019	0.0015	0.0018	0.0179
	2011	0.0028	0.0037	0.0335	0.0003	0.0003	0.0018	0.0016	0.0027	0.0290
	2012	0.0026	0.0033	0.0327	0.0003	0.0003	0.0020	0.0013	0.0014	0.0114
	2013	0.0023	0.0014	0.0071	0.0002	0.0002	0.0014	0.0011	0.0010	0.0056

A graphical representation of the data clearly shows that OTC deals reported to NDS platform has higher level of illiquidity for stocks classified as "Liquid" vis-à-vis securities classified as "Illiquid" or "Semi-liquid"[22].





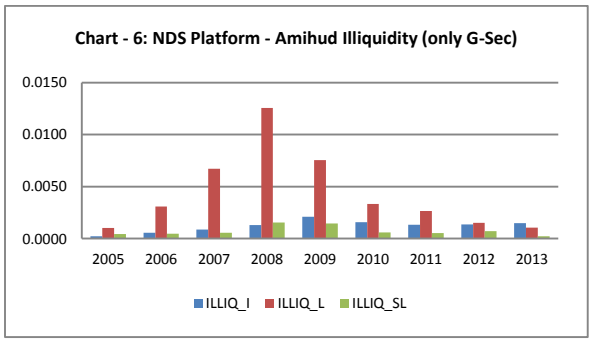
We conducted similar analysis for dated Government securities and dropped all T-Bills, special and State securities.

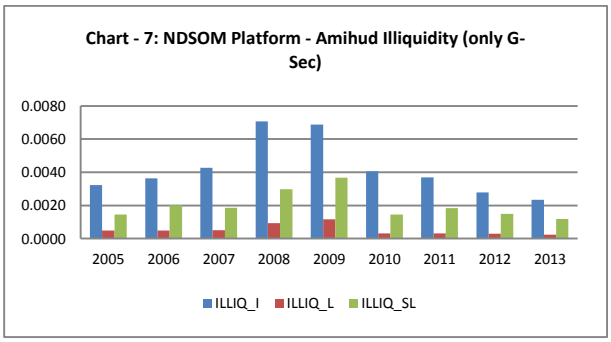
Table – 22: Group-wise Amihud ILLIQ Indicator for Government Securities										
		ILLIQUID			LIQUID			SEMI-LIQUID		
	Year	ILLIQ	SDEV	MAX	ILLIQ	SDEV	MAX	ILLIQ	SDEV	MAX
PREOM	2003	0.0058	0.0079	0.0696	0.0011	0.0014	0.0134	0.0033	0.0058	0.0571
	2004	0.0049	0.0064	0.0811	0.0009	0.0009	0.0057	0.0024	0.0023	0.0189
	2005	0.0041	0.0056	0.0336	0.0006	0.0006	0.0036	0.0022	0.0023	0.0156
NDS - POSTOM	2005	0.0002	0.0003	0.0028	0.0010	0.0007	0.0033	0.0004	0.0007	0.0070
	2006	0.0006	0.0006	0.0035	0.0031	0.0030	0.0188	0.0005	0.0005	0.0039
	2007	0.0009	0.0013	0.0114	0.0067	0.0084	0.0630	0.0005	0.0009	0.0070
	2008	0.0013	0.0020	0.0109	0.0126	0.0154	0.0924	0.0015	0.0025	0.0201
	2009	0.0021	0.0031	0.0261	0.0076	0.0121	0.0822	0.0015	0.0019	0.0123

[22] Illiq_L is for liquid securities; Illiq_IL if for illiquid securities and Illiq_sm is for Semi-liquid securities.

	2010	0.0016	0.0034	0.0370	0.0033	0.0033	0.0238	0.0006	0.0007	0.0039
	2011	0.0013	0.0029	0.0316	0.0026	0.0028	0.0149	0.0005	0.0006	0.0041
	2012	0.0014	0.0017	0.0130	0.0015	0.0020	0.0193	0.0007	0.0011	0.0096
	2013	0.0015	0.0015	0.0059	0.0010	0.0010	0.0050	0.0002	0.0003	0.0015
NDSOM	2005	0.0032	0.0054	0.0424	0.0005	0.0004	0.0025	0.0014	0.0017	0.0129
	2006	0.0036	0.0044	0.0333	0.0005	0.0005	0.0041	0.0020	0.0021	0.0129
	2007	0.0043	0.0058	0.0445	0.0005	0.0005	0.0043	0.0019	0.0023	0.0160
	2008	0.0071	0.0129	0.1167	0.0009	0.0012	0.0130	0.0030	0.0036	0.0226
	2009	0.0069	0.0099	0.0675	0.0012	0.0016	0.0136	0.0037	0.0040	0.0247
	2010	0.0041	0.0081	0.0867	0.0003	0.0003	0.0019	0.0015	0.0016	0.0120
	2011	0.0037	0.0042	0.0335	0.0003	0.0003	0.0018	0.0018	0.0028	0.0290
	2012	0.0028	0.0028	0.0200	0.0003	0.0003	0.0020	0.0015	0.0015	0.0114
	2013	0.0023	0.0018	0.0093	0.0002	0.0002	0.0014	0.0012	0.0010	0.0056

A graphical representation of the data clearly shows that OTC deals in dated Government securities reported to NDS platform has higher level of illiquidity for stocks classified as "Liquid" vis-à-vis securities classified as "Illiquid" or "Semi-liquid".





We estimated daily Amihud ILLIQ factor by taking only liquid securities into account. The result shows that the Amihud illiquidity factor is very low for liquid securities in NDS-OM platform.

Table – 23: Amihud Illiquidity Indicator for Liquid Securities								
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
	PREOM							
2003	0.00117	0.00090	0.00320	0.00029				
2004	0.00088	0.00049	0.00197	0.00044				
2005	0.00059	0.00006	0.00068	0.00054				
	NDS Market				NDSOM Market			
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
2005	0.00102	0.00022	0.00132	0.00079	0.00050	0.00014	0.00066	0.00034

2006	0.00303	0.00063	0.00416	0.00200	0.00050	0.00012	0.00072	0.00030
2007	0.00626	0.00313	0.01400	0.00254	0.00051	0.00027	0.00110	0.00021
2008	0.01233	0.00579	0.02270	0.00450	0.00094	0.00051	0.00197	0.00050
2009	0.00693	0.00558	0.01748	0.00190	0.00115	0.00104	0.00361	0.00025
2010	0.00307	0.00093	0.00446	0.00115	0.00032	0.00009	0.00053	0.00020
2011	0.00265	0.00100	0.00415	0.00088	0.00033	0.00012	0.00062	0.00016
2012	0.00140	0.00082	0.00356	0.00059	0.00029	0.00015	0.00056	0.00010
2013	0.00104	0.00025	0.00121	0.00086	0.00024	0.00001	0.00025	0.00023

We also estimated daily Amihud ILLIQ factor by taking only semi-liquid securities into account. The result shows that the Amihud illiquidity factor is very relatively high for semi-liquid securities in NDS-OM platform.

Table – 24: Amihud Illiquidity Indicator for Semi-Liquid Securities								
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
	PREOM							
2003	0.00325	0.00315	0.01095	0.00067				
2004	0.00200	0.00080	0.00343	0.00099				
2005	0.00161	0.00056	0.00222	0.00082				
	NDS Market				NDSOM Market			
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
2005	0.00035	0.00012	0.00055	0.00027	0.00147	0.00063	0.00242	0.00068
2006	0.00040	0.00009	0.00057	0.00028	0.00195	0.00045	0.00308	0.00142
2007	0.00050	0.00027	0.00103	0.00024	0.00168	0.00068	0.00275	0.00066
2008	0.00128	0.00108	0.00418	0.00025	0.00290	0.00141	0.00635	0.00159
2009	0.00140	0.00103	0.00429	0.00071	0.00330	0.00226	0.00839	0.00132
2010	0.00059	0.00020	0.00096	0.00034	0.00144	0.00048	0.00233	0.00075
2011	0.00046	0.00018	0.00093	0.00026	0.00160	0.00113	0.00496	0.00072
2012	0.00069	0.00038	0.00139	0.00023	0.00129	0.00060	0.00246	0.00042
2013	0.00017	0.00008	0.00023	0.00012	0.00111	0.00011	0.00119	0.00103

We also estimated daily Amihud ILLIQ factor by taking only illiquid securities into account. The result shows that the Amihud illiquidity factor is very relatively high for illiquid securities in NDS-OM platform.

able – 25: Amihud Illiquidity Indicator for Illiquid Securities								
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
	PREOM							
2003	0.00497	0.00382	0.01287	0.00140				
2004	0.00384	0.00162	0.00806	0.00184				
2005	0.00265	0.00074	0.00395	0.00188				
	NDS Market				NDSOM Market			
Year	ILLIQ	SDEV	MAX	MIN	ILLIQ	SDEV	MAX	MIN
2005	0.00017	0.00007	0.00027	0.00008	0.00326	0.00205	0.00621	0.00135
2006	0.00046	0.00011	0.00064	0.00031	0.00347	0.00067	0.00445	0.00224
2007	0.00081	0.00039	0.00150	0.00031	0.00387	0.00228	0.00798	0.00095
2008	0.00130	0.00067	0.00288	0.00039	0.00609	0.00406	0.01580	0.00167
2009	0.00219	0.00138	0.00608	0.00089	0.00589	0.00383	0.01470	0.00164
2010	0.00167	0.00080	0.00315	0.00089	0.00358	0.00142	0.00587	0.00216
2011	0.00094	0.00046	0.00195	0.00050	0.00268	0.00155	0.00742	0.00173
2012	0.00124	0.00056	0.00205	0.00068	0.00261	0.00118	0.00483	0.00117
2013	0.00141	0.00030	0.00162	0.00120	0.00230	0.00097	0.00299	0.00162

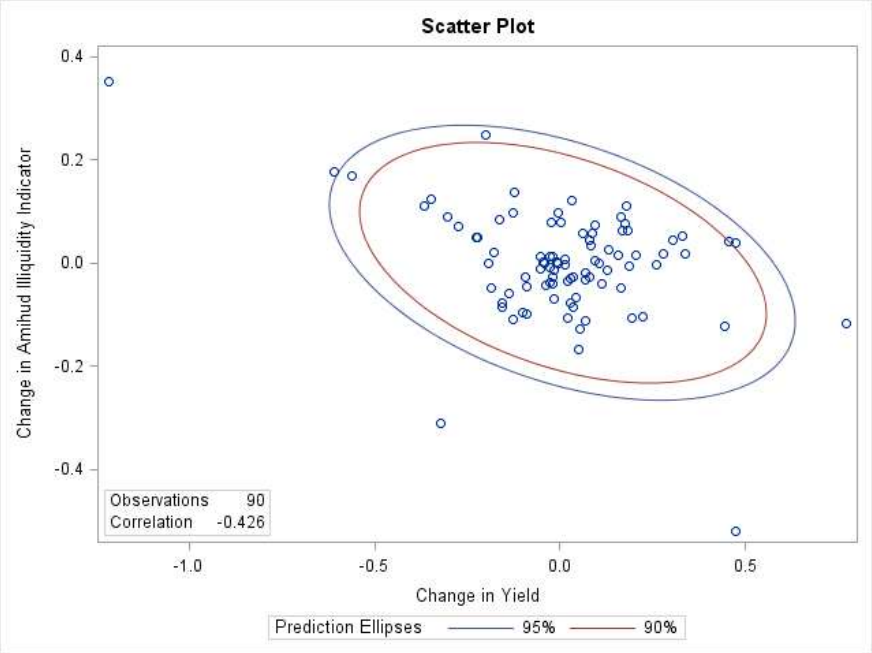
It has been proved beyond reasonable doubt that NDS-OM has improved liquidity in the market and specifically, the on-the-run Government securities has very low Amihud ILLIQ factor. However, for illiquid and semi-liquid securities, NDS reporting platform provides higher level of liquidity vis-à-vis NDS-OM.

Liquidity is generally a function of yield – high yield will force traders to avoid selling off their stocks and low yield will enthuse buyers to procure the stock. Change in Yield has an impact on liquidity measured by TR and Amihud ILLIQ. For this purpose, we only considered the data from Aug'05 to Feb'13 from NDS-OM system. As the NDS-OM system had anonymous order book system with exact time stamp, it was easy to record opening and closing price of the trades.

Table – 26: Simple Statistics							
Variable	**N**	**Mean**	**Std Dev**	**Sum**	**Minimum**	**Maximum**	**Label**
DY	90	0.0081	0.2492	0.7311	-1.2167	0.7714	Change in Yield
DI	90	-0.0005	0.1060	-0.0414	-0.5202	0.3519	Change in Amihud Illiquidity Indicator

The change in yield and change in Amihud ILLIQ indicator had a negative correlation of 0.43 indicating strong relationship.

Chart - 8: Scatter Plot - Yield and Amihud ILLIQ (Monthly Changes)



However, the relationship between Amihud ILLIQ and TR was weak with correlation coefficient of 0.20.

Table – 27: Pearson Correlation Coefficients (Prob > |r| under H0: Rho=0)			
Variables	**DY**	**DI**	**DT**
DY (Change in Benchmark yield)	1	-0.43 (<.0001)	-0.44 (<.0001)
DI (Change in Amihud Illiquidity Indicator)	-0.43 (<.0001)	1	0.20 (0.065)
DT (Change in Turnover Ratio)	-0.44 (<.0001)	0.20 (0.065)	1

With Fisher's z Transformation, the correlation coefficients show that there is a positive relation between liquidity indicators like Turnover Ratio and Amihud ILLIQ indicator but the same is significant only at 10% level. However, with respect to yield the liquidity indicators have strong negative relationships (significant at 1% level).

In order to understand the true relation between Amihud ILLIQ and Yield, we fitted a simple model using Yield with the lagged values of Amihud ILLIQ .

$$ILLIQ_t = \alpha + \beta * DY10_t + \gamma_1 * ILLIQ_{t-1} + \gamma_3 * ILLIQ_{t-2} + \gamma_3 * ILLIQ_{t-3} + \varepsilon_t$$

The results show that yield has a very significant role in the determination of liquidity in the market. The estimated equation shows that 10-year yield[23] is statistically significant at 1% level with lagged values of Amihud ILLIQ being significant at 1% level (other lags were not significant). This result is in line with the TR test results.

Table – 28: Parameter Estimates						
Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|	Variable Label
Intercept	1	0.0006	0.0094	0.06	0.9515	
DY	1	-0.1704	0.0375	-4.55	<.0001	Change in Benchmark Yield
LI1	1	-0.4056	0.0932	-4.35	<.0001	Lag1 value of ILLIQ indicator
LI2	1	-0.2750	0.0935	-2.94	0.0042	Lag2 value of ILLIQ indicator
R-Sq – 0.35 Durbin's h – (-0.94) (0.17 – *p value*) RMSE - 0.08784 * - significant at 1% and ** - significant at 10% level						

The signs of the estimated equation show clearly that liquidity measured by ILLIQ is negatively related to Yield. We used yield and the lag values of ILLIQ assuming that illiquidity of today has its root in the past – past illiquidity might affect present liquidity. We found that only first two lags of ILLIQ is statistically significant while other lags are not. This implies the illiquidity has a short memory.

Impact Cost

Impact Cost (IC) is another important measure of liquidity in the financial market where trading happens through an order book mechanism. In Indian Government bond market, NDS-OM provides the order book for securities trading in the system. Using the order book, we estimated impact cost for executing standard 250million (FV)[24] worth of bond for both buy and sell side positions separately. IC is estimated for 5 most liquid bonds at every 30 minutes interval. We ignored semi-liquid and illiquid securities as it was difficult to get the orders filled for the required standard value. For some bonds on some days for some time intervals, the order book was not filled for standard execution and the hence IC was not estimated for that time slot for the security on that day. At the end of the day, IC was averaged for both bid and offer side separately

[23] 10 year yield is used as it represents the most liquid basket in India.
[24] Bonds are traded in Face Value (FV)

and then averaged together for the day. The IC was estimated from 01-Aug-2006 to 30-Apr-2013.

The data shows that the average daily Bid IC is typically higher than the Offer IC. Bid IC is likely to be used by a trader having an open Buy position in the market – as she has an open buy position and would like to close the same; and if she has to take an offsetting sale deal to close out her open position, she will have to trade (take the price) with the price offered by a buyer (bidder). The Offer IC is likely to be used by a trader having an open Sale position. As the market data shows higher Bid IC vis-à-vis Offer IC, the market makers must be charging some premium for enabling sell of securities. This is plausible as most of the entities dealing in the market have excess holding of Government stocks – specifically banks having more securities holding than the Statutory Liquidity Ratio (SLR) requirement of 23% of Net Demand and Time Liabilities (NDTL) at present and may have less appetite for holding more securities in their portfolio. However, the difference in the spread is not substantially large.

Table – 29: Yearly Impact Cost (%)

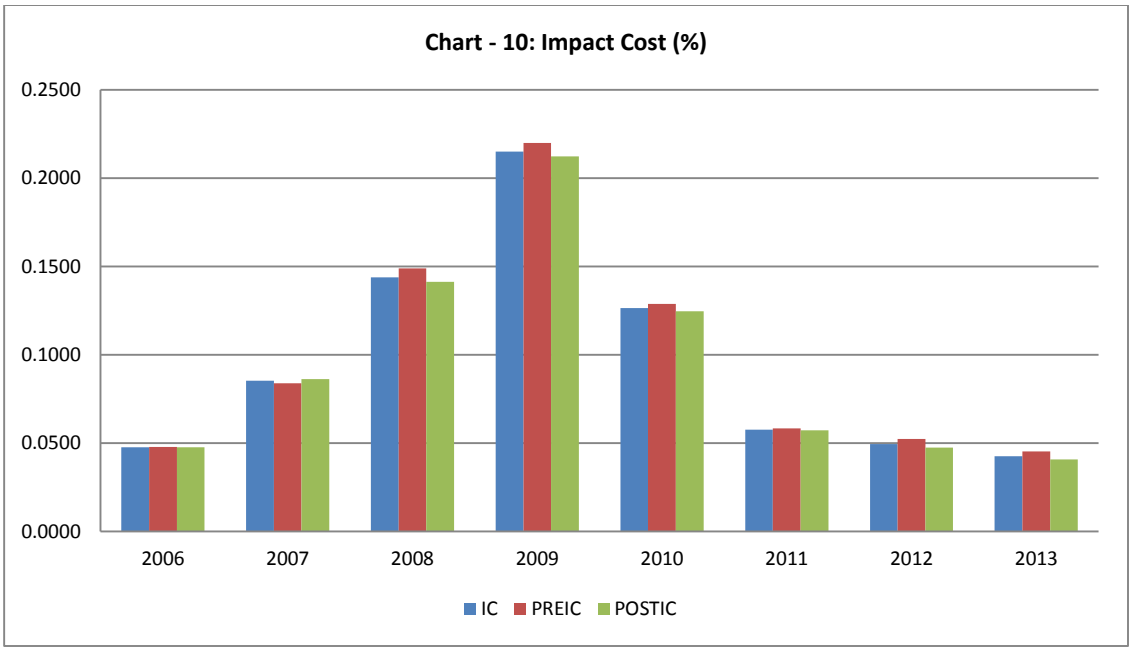
Year	Days	OFFER IC	Bid IC	Average IC	Spread
2006	85	0.0433[25]	0.0513	0.0473	0.0080
2007	235	0.0808	0.0907	0.0857	0.0099
2008	235	0.1351	0.1480	0.1415	0.0129
2009	233	0.2092	0.2186	0.2139	0.0094
2010	232	0.1258	0.1267	0.1262	0.0009
2011	234	0.0555	0.0596	0.0575	0.0041
2012	238	0.0468	0.0522	0.0495	0.0054
2013	77	0.0374	0.0480	0.0427	0.0106

The average daily IC in 2006 was relatively lower. The onset of financial crisis in 2007 started liquidity problem in the market and hence the IC started moving up. It reached its record high in 2009 – almost 4.5 times of 2006 level. After 2010, it started to fall and in 2013, the same is at its record low – close to 2006 level.

[25] 0.0433 means 0.0433%

Table – 29: Year-wise Daily Descriptive Statistics of Intra-day Impact Cost (%)								
Year	Days	Params	OFFER IC	Bid IC	Pre Midday Offer	Pre Midday Bid	Post Midday Offer	Post Midday Bid
2006	85	Mean	0.0433	0.0513	0.0425	0.0524	0.0439	0.0506
		Std Dev	0.0153	0.0183	0.0162	0.0202	0.0169	0.0198
		Max	0.0962	0.1364	0.1041	0.1277	0.1096	0.1421
		Min	0.0193	0.0233	0.0203	0.0226	0.0160	0.0222
2007	235	Mean	0.0808	0.0907	0.0779	0.0907	0.0826	0.0906
		Std Dev	0.0389	0.0382	0.0379	0.0390	0.0436	0.0418
		Max	0.2566	0.2368	0.2389	0.2348	0.3137	0.2835
		Min	0.0221	0.0229	0.0178	0.0249	0.0182	0.0216
2008	235	Mean	0.1351	0.1480	0.1400	0.1525	0.1324	0.1457
		Std Dev	0.0994	0.1161	0.1264	0.1429	0.0933	0.1102
		Max	0.7820	1.0351	1.0845	1.4070	0.6004	0.8120
		Min	0.0285	0.0291	0.0204	0.0254	0.0323	0.0313
2009	233	Mean	0.2092	0.2186	0.2089	0.2281	0.2104	0.2136
		Std Dev	0.1464	0.1381	0.1502	0.1468	0.1585	0.1482
		Max	1.2098	0.9751	0.9032	0.8198	1.4659	1.1397
		Min	0.0283	0.0307	0.0184	0.0307	0.0275	0.0307
2010	232	Mean	0.1258	0.1267	0.1249	0.1321	0.1265	0.1231
		Std Dev	0.0977	0.0912	0.1081	0.1116	0.1018	0.0932
		Max	0.5455	0.4583	0.6026	0.6566	0.6033	0.5873
		Min	0.0179	0.0223	0.0169	0.0186	0.0190	0.0218
2011	234	Mean	0.0555	0.0596	0.0545	0.0618	0.0561	0.0580
		Std Dev	0.0253	0.0275	0.0293	0.0358	0.0263	0.0258
		Max	0.1651	0.2123	0.2227	0.2887	0.1861	0.1783
		Min	0.0202	0.0227	0.0173	0.0154	0.0194	0.0223
2012	238	Mean	0.0468	0.0522	0.0485	0.0565	0.0457	0.0493
		Std Dev	0.0212	0.0247	0.0247	0.0335	0.0214	0.0229
		Max	0.1489	0.1849	0.1992	0.3469	0.1390	0.1806
		Min	0.0132	0.0138	0.0105	0.0111	0.0150	0.0157
2013	77	Mean	0.0374	0.0480	0.0387	0.0519	0.0366	0.0454
		Std Dev	0.0129	0.0165	0.0157	0.0224	0.0129	0.0153
		Max	0.0775	0.1045	0.0973	0.1267	0.0829	0.1123
		Min	0.0172	0.0228	0.0160	0.0204	0.0180	0.0229

The average IC in different periods – between 9.00AM and 12.30PM (Pre-Midday) and between 1.00PM and 5.00PM (Post-Midday) show some variation. Typically IC in Post-Midday is higher than the Pre-Midday. As markets are very active in the morning, the market makers may possibly be demanding higher cost for executing deals.

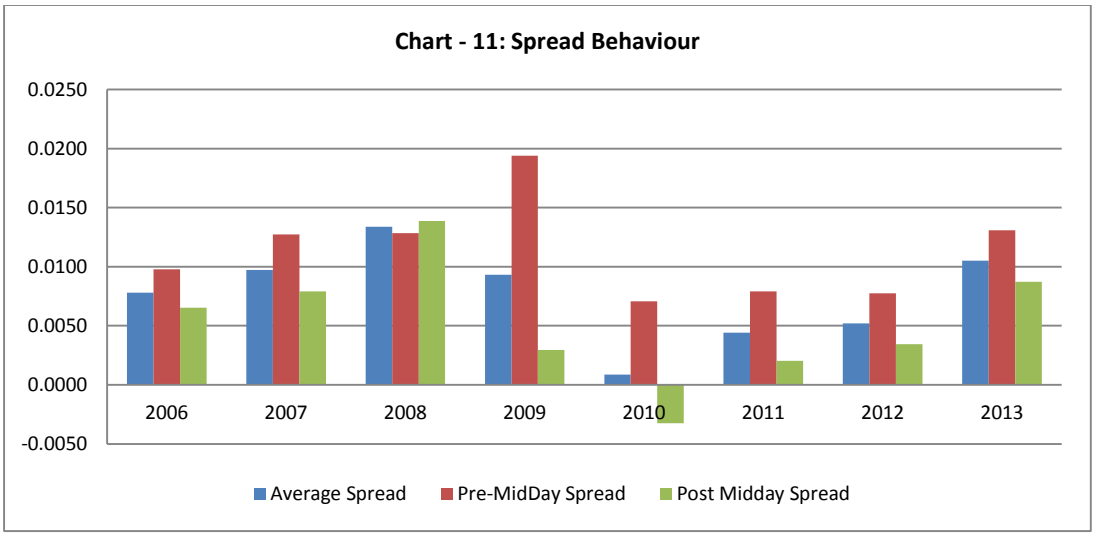


The difference between Bid IC and Offer IC represent the spread. The spread is generally positive as Bid IC has been generally higher than the Offer IC. The Bid IC was higher in about 69% of the days (1569 days between 03-Aug-2006 and 30-Apr-2013). In case of Pre-Midday sessions, Bid IC was higher in case of 91% instances while in Post-Midday, the same was higher for about 75% of instances.

Table 30: Descriptive Statistics of Impact Cost Spread (%)

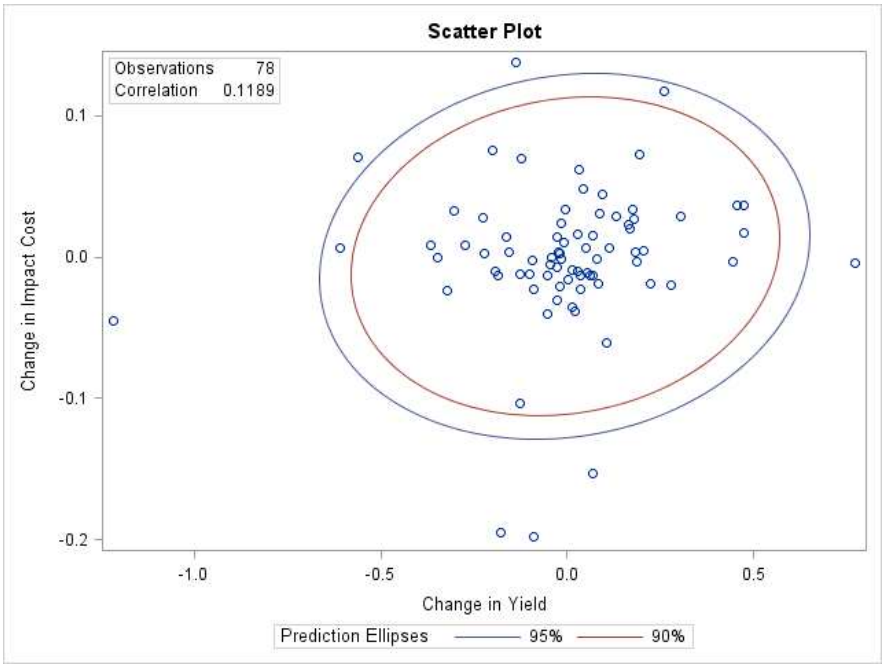
Average Spread				Pre-Midday Spread				Post-Midday Spread			
N	81	**Sum Weights**	81	**N**	81	**Sum Weights**	81	**N**	81	**Sum Weights**	81
Mean	0.0074	**Sum Observations**	0.5961	**Mean**	0.0113	**Sum Observations**	0.9141	**Mean**	0.0048	**Sum Observations**	0.3907
Std Deviation	0.0122	**Variance**	0.0001	**Std Deviation**	0.0134	**Variance**	0.0002	**Std Deviation**	0.0140	**Variance**	0.0002
Skewness	-0.0171	**Kurtosis**	1.7528	**Skewness**	0.6989	**Kurtosis**	3.2367	**Skewness**	-0.2289	**Kurtosis**	3.2959
Uncorrected SS	0.0163	**Corrected SS**	0.0119	**Uncorrected SS**	0.0246	**Corrected SS**	0.0143	**Uncorrected SS**	0.0176	**Corrected SS**	0.0157
Coeff Variation	165.4767	**Std Error Mean**	0.0014	**Coeff Variation**	118.3747	**Std Error Mean**	0.0015	**Coeff Variation**	290.7277	**Std Error Mean**	0.0016

The variability of the spreads is stable except during the financial crisis period. However, the pre-Midday spread is generally higher in comparison to the post-midday spread.



Liquidity indicators like Impact Cost, Turnover Ratio and Amihud ILLIQ should rationally have direct relationship with the yield. Higher yield should indicate lower liquidity (hence higher impact cost and higher Amihud Illiquidity factor). However, we found a very low correlation between change in yield and change in impact cost. The positive sign indicates high yiled is related to high impact cost (low liquidity).

Chart - 12: Scatter Plot - Yield and Impact Cost (Monthly Changes)



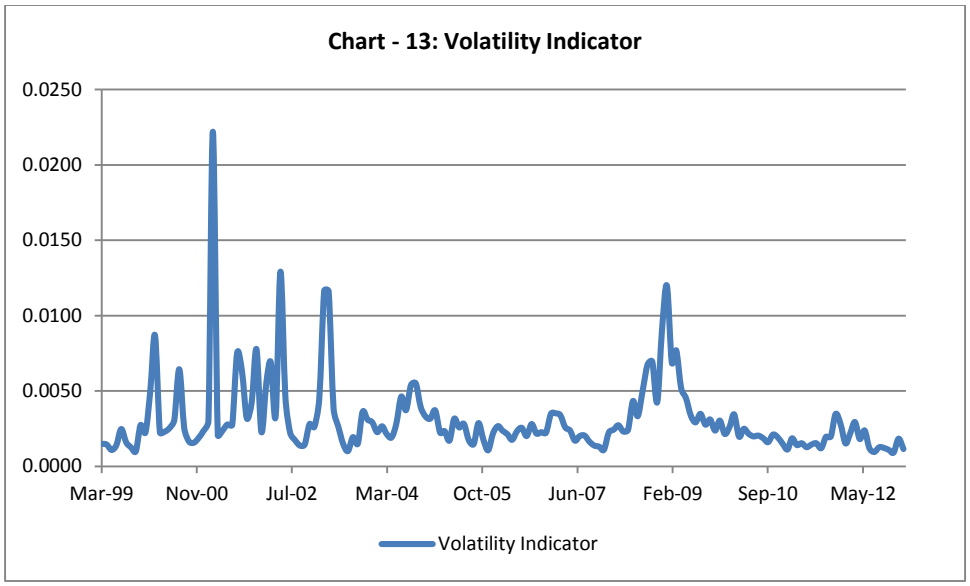
We looked at a linear equation to understand the dependence of yield on impact cost. We did not find any significant relationship between them. However, we found that lagged values of Impact cost changes have some influence in the current impact cost.

Price Volatility structure

In order to understand the price volatility structure of the Government securities market, we analysed trading data from April 1999 to Feb 2013 (167 months of trade information). Two important market microstructure changes took place during these years– setting up a clearing and settlement system in Feb'02 and starting of an order driven trading system for Government debt in Aug'05. The volatility indicator has been computed as a ratio of price range and trade value for individual stocks on daily basis with the condition that the stock has at least 3 trades in a day. In some cases, we found that all trades have been executed at the same price in the OTC market and hence we dropped these trades assuming that it is likely that two traders might have agreed to deal at a particular price in an OTC market for specific reason and might have unbundled the deals into various lots as per their operational flexibility.

Table 31: Descriptive statistics of Volatility Structures	
Mean	0.0031
Standard Error	0.0002
Median	0.0024
Standard Deviation	0.0026
Kurtosis	19.6340
Skewness	3.7013
Range	0.0213
Minimum	0.0009
Maximum	0.0222
Sum	0.5199
Count	167
Confidence Level (95.0%)	0.0004

The data shows that volatility indicator was higher before the introduction of structured clearing and settlement systems as well as before the introduction of NDSOM system in Government securities market. The same came down and became more stable afterwards. The volatility indicator was high during the financial crisis period (identified with RBI's action for softening or hardening policy rates) but in recent months the same has been substantially lower.



An order driven system might have helped in reducing the volatility in the market because of its transparency level. Given the order book system and anonymous trade matching provisions coupled with straight through processing capabilities, the NDSOM could be used by the traders to execute deals with each other. Hence the new system could have brought some significant change to the entire environment. In order to understand the role of NDSOM system in volatility spectrum, we used a dummy variable for testing the same.

The equation estimated is

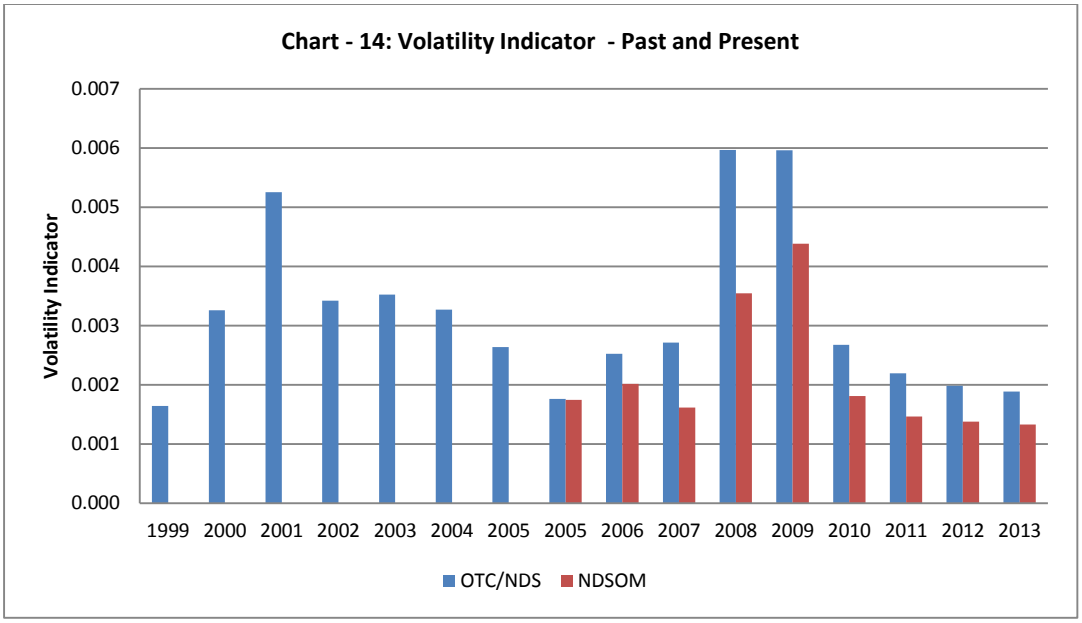
$$Vol_t = \alpha + \beta * Vol_{t-1} + \gamma * Dummy1 + \tau * Dummy2 + \epsilon_t$$

Table 31: Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	**1**	0.0027*	0.00039	7.02	<.0001
Lag (Vol)	Lagged Value of Volatility Indicator	**1**	0.2683*	0.07511	3.57	0.0005
DM1	DUMMY for NDSOM	**1**	-0.0013*	0.00041	-3.1	0.0022
DM2	DUMMY for Financial Crisis	**1**	0.0019*	0.00058	3.27	0.0013
R-Sq - 0.21, RMSE – 0.0023, DW stat – 2.03						
1st Order Autocorrelation = -0.017						
*Significant at 1% level						

We used to dummy variables, one for introduction of NDSOM system in August'05 and the other one to control the effect of financial crisis Indian market experienced during 2008/2009. Both these dummies are significant at 1%.

The volatility indicator in period t depends on the volatility indicator of period t-1 (we tried with other lags but found them to be not statistically significant). The dummy variables used became significant at 1% indicating that introduction of NDSOM system has an impact on volatility. As the sign is negative, the relation is inverse – the volatility indicator has come down after the introduction of NDSOM system; other dummy variable has the positive sign meaning that the higher volatility indicator was due to financial crisis.



There seems to be a structural break in 2005 as the volatility structure is changing towards a lower level. This structural break is possibly due to introduction of NDSOM system in Indian Government securities market. In order to understand if there is a structural break in the volatility structure represented by volatility indicator after introduction of NDSOM, we conducted a Chow test for the said dataset. We also included lagged values of volatilities in the regression model.

Table – 32: Structural Change Test					
Test	**Break Point**	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Chow	**77**	3	160	4.87	0.0029

The Chow test clearly accepts the hypothesis that there was a structural break in volatility structure after introduction of NDS-OM

Table – 33: Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**	**Variable Label**
Intercept	1	0.002691	0.000478	5.63	<.0001	
LV1	1	0.3439	0.0733	4.69	<.0001	Lag 1 Value of Volatility Indicator
Time	1	-7.605E-6	3.9609E-6	-1.92	0.0566	
R Sq - 0.16, DW Stat – 2.07						

Concluding Remarks

The study finds that Turnover Ratio and Amihud Illiquidity indicator are important market liquidity indicators for Indian sovereign bond market. Though, impact cost is used as an indicator for liquidity, the same does not have an explanatory relationship with yield. It has been found that NDS-OM system has helped in improving liquidity in the system substantially. It has also helped in reducing volatility in the market to a large extent.

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